The Keys to Success With Sand-Based Turf Systems

By Charles R. Dixon

The development of the proper application of defined sand technology has resulted in a general acceptance of the substantial benefits of high-performance sand-based systems. Sand is used to modify soils and construct turf systems for various sports turf applications to promote proper air and water management. Without a doubt, sand is the most extensively used amendment, on a weight basis, for modifying turf systems.

The use of sand has been extensively reviewed by the United States Golf Association regarding putting-green construction. A wide range of sports turf applications such as football, baseball, race tracks, and soccer, utilize the concepts of USGA putting-green construction guidelines to design and build turf systems for high performance demands. Not all sports programs have the budget for sand-based athletic fields, but use sand in other ways to improve field performance.

Sand is often used in conjunction with the native soil in what is known as a bypass system, such as the Cambridge™ system, which uses sand in trenches and for creating a permeable sand cap over the trenches to remove water during periods of heavy rainfall. There are several designs that use a bypass approach with sand. At Turf Diagnostics & Design, we are often approached about mixing sand with native soils to improve permeability and to lower excess water-holding values.

The mixing of sand with soil is not as effective as one might think. If the proper sand particle size is used and the correct amount of sand is added, some benefit can be realized. However, the amount of sand necessary to increase the overall sand content of the root zone is so great that the money and energy are better spent on by-pass approaches or maintenance.

The amount of sand particles in relation to the size of the particle is critical to how a sand will function in various applications. Many sports turf managers are familiar with particle size analysis. It's important to understand the definition of particle sizes and how they are determined.

Table 1
Definition of USGA and USDA Sand Sizes

	USDA	USDA	USGA	USGA
Definition	**Metric Size (mm)**	**U.S. Size**	**Metric Size (mm)**	**U.S. Size**
Fine Gravel	2.0 to 10.0	10 to 1/2"	2.0 to 3.4	10 to 6
Very Coarse Sand	1.0 to 2.0	18 to 10	1.0 to 2.0	18 to 10
Coarse Sand	.0 to 1.0	35 to 18	0.5 to 1.0	35 to 18
Medium Sand	0.25 to 0.5	60 to 35	.25 to 0.5	60 to 35
Fine Sand	0.15 to 0.25	140 to 60	0.10 to .25	100 to 60
Very Fine Sand	0.05 to 0.15	270 to 140	0.05 to 0.10	270 to 100
Silt	0.002 to 0.05	< 270	0.002 to 0.05	<270
Clay	< 0.002		< 0.002	

To accurately assess the particle size distribution of a sand or soil, a full mechanical analysis should be performed. This involves extracting the silt and clay from the sample and sieving the resulting sand fraction. By removing the silt and clay, the sand distribution is accurately assessed. If a sieve analysis (known as a "drop sieve") is performed without removal of silt and clay, small aggregates of silt and clay can be perceived as sand particles and a false impression of the material may be generated. If you are in the market for a sand for any agronomic purpose, make sure a full mechanical analysis has been performed.

Reaching Definition

Most sand suppliers provide contractors with materials that meet building construction codes. Sand is used in asphalt, concrete, and filtration media. The definition of sand size, silt, and clay will vary with the end user.

There are three common definitions of sand size, as well as silt and clay, in this country. Regional regulations may add to the definition, but the basic definition sources for building and road construction are from the American Society for Testing and Materials. In agriculture, the United States Department of Agriculture has definitions on how soil is classified regarding crop production and soil conservation. In the March/April issue of the USGA *Green Section Record*, another sand size definition was published that pertains to the USGA putting green construction recommendations (USGA 1993).

Prior to the recent USGA definition, the USDA criteria and methodology had been used to evaluate materials for determining suitability in turf systems. The USGA and USDA definitions are quite similar in sand size criteria, as well as the silt and clay size range. The ASTM definition is very different, especially in defining silt and clay. Since clay and silt can have a profound impact on the drainage characteristics of a sand, the definition used is crucial to making a good decision.

If material selections are being made for turf systems, you definitely want an analysis that accurately assesses the sizes of materials and is also based on agronomic definitions such as the USGA or USDA size schemes. Since the new USGA recommendations and laboratory protocol were published, an adequate definition and test method available for most field designers and turf managers exist.

Table 2
ASTM Particle Size Definition

Definition	Metric Size (mm)	U.S. Size
Fine Gravel	4.76 to 10.0	4 to 3/4"
Course Sand	2.0 to 4.76	10 to 4
Medium Sand	0.42 to 2.00	40 to 10
Fine Sand	0.074 to 0.42	200 to 40
Silt & Clay	< 0.074	< 200

As we now have definition concerning the size range of various particles, the concentration of sizes can be examined in relation to the sand selection criteria.

Table 3
Particle Size Distribution of USGA Root Zone Mix

Fraction Size Name	U.S. Standard Sleve Mesh	Diameter of Sleve (mm)	Allowable Range % Retained on Sleve	
Gravel	10	2.00	≤3%	No more than 10% including 3% fine gravel.
Very Coarse	18	1.00	57% to 10%*	
Coarse	35	0.50	At least 60% particles in this range	A miminum of 80% in these combined sand fractions.
Medium	60	0.25		
Fine	100	0.15	20% Maximum	Combined Fractions No more than 10%
Very Fine	270	0.05	5% Maximum	
Silt		0.002	5% Maximum Allowable	
Clay		<0.002	3% Maximum Allowable	

The new USGA recommendations are a good start for systems that are designed like USGA putting greens. For use in selection of sands in a bypass system or topdressing of native fields, however, it may be too specific.

The particle ranges listed in Table 3 are designed for a specific purpose and are a good guide for putting greens. For use in sports field construction, additional parameters should be considered. We have found criteria published by Dr. George Blake to be helpful in adding to the USGA criteria or for offering a less stringent guide for sands to be used as topdressing for native fields, or to be used in by-pass systems.

Understanding Measures

The Fineness of Modulus (Fm) and Uniformity Coefficient (Cu), as seen in Table 4, are determined from a graph of the concentration of particles versus size. The grain size graph is a useful tool in comparing sands and also determining Fu and Cu. Grain size graphs are used to design and select materials for drain systems. Most sand suppliers who work with concrete or Department of Transportation specifications determine the Fm. We have found the Fm value to be useful in communicating the general class of sand we seek. The Cu of a sand, along with particle size analysis, has been the most useful information we have regarding performance estimates.

The Cu is a numeric estimate of how a sand is graded. The term graded relates to where the concentration of sand particles is located. A sand with all particles in two size ranges would be termed a narrowly graded sand and would have a low Cu value. The Cu is a dimensionless number; in other words, it has no units. Filtration sands for water treatment usually have a low Cu to promote water movement. Concrete sands usually have a high Cu to pack and offer strength and stability. For turf applications, the Cu values we are looking for range from 1.8 to 4.0.

Widely graded materials usually offer firm turf surfaces and will be less prone to developing divots and ruts. Soccer pitches are firmer with higher Cu materials. The goal is to balance physical stability with the desired drainage characteristics. The materials with higher Cu values also have a more tortuous path for water to move through and will have lower infiltration rates or permeability. Usually, the water retention is greater with sands that haver a higher Cu.

We recently performed a study using a plastic fiber for Synthetic Industries Corporation. The goal of the study was to examine the effect of the fibers in three different sands representing three divergent Cu values. The idea was to promote good drainage as is found in low Cu sands and offer stability with the fiber. The grain size graph in Figure 1 shows the three very different curves and their Cu values. The particle size distribution data is also presented in Table 5. The Cu is calculated from the grain size graph by determining the diameter in millimeters at which 60 percent (D60) of the material passes through the sieve, and at which 10 percent (D10) of the material passes. Hence, Cu = D60/D10.

continued on page 40

Table 4 – Dr. G. Blake's Selection Criteria

Parameter	Recommended Value
Fineness of Modulus (F_m)	1.7 to 2.5
Uniformity Coefficient (C_u)	<4
Particles <0.1 mm	<3.0%
Particles > 2.0 mm	<3.0%
Particles 0.25 mm to 1.0 mm	>60.0%

SAND FIELDS

continued from page 39

Table 6 – Physical Performance Data for The Various Cu Values			
Sand Cu	**Sand Only**	**90:10**	**90:10 Filter**
INFILTRATION RATE (IN/HR)			
1.5	41.1	26.7	21.9
2.3	34.9	20.6	16.1
4.6	12.7	5.4	6.6
BULK DENSITY (G/CC)			
1.5	1.5	1.5	1.4
2.3	1.6	1.6	1.6
4.6	1.8	1.8	1.7
TOTAL PORE SPACE (%)			
1.5	42.4	43.5	46.6
2.3	39.5	38.9	41.4
4.6	32.3	32.6	35.1
CAPILLARY PORE SPACE (%)			
1.5	5.0	8.5	9.5
2.3	4.6	9.0	14.4
4.6	14.4	20.0	21.0
SATURATION (%)			
1.5	11.8	19.5	20.3
2.3	11.6	23.1	34.9
4.6	14.4	20.0	21.0
TURF DIAGNOSTICS & DESIGN, INC. JUNE/93			

No doubt, this information requires some thought to fully understand. It may not be as important to know *how* to determine the values, as it is to know the *process* and *impact* of the numbers generated. Because of the value of Cu in making material selection in relation to a specific application, we have routinely generated the Cu data on particle size determination for sand.

The performance data for each sand was generated in the lab using the USGA protocol. The sands and a sand/peat mix were evaluated. The 90:10 sand/peat mix (90 percent sand to 10 percent peat volume basis) was also mixed with the Synthetic Industries fibers and physically evaluated. Table 6 presents the data from the physical evaluation.

The value of the Cu has an obvious impact on the infiltration rate, as well as the bulk density. Sand-based sports fields need higher Cu values to have firmer surfaces (higher bulk density). The infiltration rate is dramatically impacted by the Cu. Sands that are intended for use in French drains and water by-pass systems will need lower Cu values than sands to be used as the complete growing medium and surface. Placing a layer of sand over sloped native soils has been used to allow a faster rate of water movement to catch basins. Sands that depend on lateral movement should have lower Cu values to promote drainage.

Sands have different physical attributes and should be evaluated in the lab for suitability for their intended application. The Cu is one component that should be determined, as well as basic physical performance criteria. Most lab-generated data, if properly interpreted, supports an assessment to attain the anticipated performance expectation.

Evaluations we have performed concerning the additions of soil to sand increased the Cu of a root zone well above the 4.0 level. Often, these mixes have been reported to us as poorly drained, hard, and difficult to maintain turf cover. We have often seen implemented field designs that placed a sand/soil mix with low permeability and compaction problems over an extensive and expensive drainage system. The drainage system was rendered useless by the compacted, impermeable root zone above it. Every evaluation we have performed on these types of fields had Cu values well above 30. One facility spent $100,000 for a field with full under drains, but the field itself is hard and has no drainage. The money would have been better spent to make a sand cap and cut drains into the field at intervals based on cost.

How much you spend is not terribly important; rather, it is *how* you spend what is available. Whether you manage a small baseball complex for Tee Ball or care for professional athletic fields, liability issues are a factor to consider. To best utilize your financial resources and achieve your objectives, you need technical information that accurately assesses the performance of the field design. The technical information is also vital in developing a turf management program for the completed turf system.

The single most important tool available to a turf manager is a properly performed particle size analysis, because it is the foundation on which we build the technical platform for the assessment of turf systems. The price of the particle size analysis data is irrelevant given the interpretive ability of the data for the construction of agronomically sound turf systems. However, the data must be generated using accepted testing protocols that are relevant to supporting agronomic decisions. Otherwise, the testing is worthless. ❑

Table 5 – Sand Particle Size Distribution for Synthetic Study

Particle Size Distribution

	Gravel	Very Course	Coarse	Medium	Fine	Very Fine
USDA (mm)	2.0	1.00	0.5	0.25	0.15	0.05
U.S. Sieve (mesh)	1.0	18	35	60	100	270
SAMPLE ID	**% MATERIAL RETAINED ON SIEVE**					
Cu = 1.5	0.0	0.0	0.5	93.9	5.2	0.0
Cu = 2.3	0.3	3.0	23.0	56.7	13.6	2.7
Cu = 4.6	11.9	12.6	12.4	17.8	25.3	18.4

Editor's Note: Charles Dixon is president of technical operations for Turf Diagnostics & Design, Inc., in Olathe, KS. A member of the national Sports Turf Managers Association, Turf Diagnostics & Design is an agronomic consultant to leading sports complex architects and a recommended consultant by the National Football League, National Association of Professional Baseball Leagues, and the PGA Tour.