Physical Soil Testing

Testing by accredited laboratories can have a positive impact on the profitability, playability, and longevity of a golf course.

BY SAM FERRO

Physical testing labs provide a variety of soil testing and agronomic consulting services that can offer valuable insight when evaluating the current condition of your turf. Labs are also commonly used during construction and renovation projects to provide assurance that proper materials are being used. This article describes some common testing procedures, when testing should be performed, and how testing can benefit the golf course.

PARTICLE SIZE ANALYSIS

Particle Size Analysis (PSA) is one of the most versatile and descriptive analyses performed on soil materials. The PSA should be the first test performed when evaluating the potential for a sand or soil to be used in fairways, greens, bunkers, rootzone mixes, and topdressing. It is also an excellent diagnostic tool. Particle size results can provide an indication of a soil's stability/potential for compaction, tendency to drain/retain moisture, and compatibility with existing site soils.

During a construction project, PSA testing is used as an indicator of whether a supplier's materials (greens, tees, and bunker sands, topdress, capping sand) are consistent. The PSA test is usually performed on every lot of sand/soil delivered to the golf course. If the PSA results are consistent from lot to lot, then the sand is considered consistent and acceptable. If the PSA results show excessive variance, then it may be grounds for rejection.

The PSA includes a determination of the sand, silt, and clay content, and the sand grain distribution. Parameters such as the D_{15} (particle diameter at which 15% of the particles present are finer) and D_{85} (particle diameter at which 85% of the particles present are finer) are determined. A textural classification based on the United States Department of Agriculture (USDA) can also be provided.

The PSA is composed of two distinct phases. One phase is the textural analysis of a soil where the sand, silt, and clay contents are determined. Another phase of the PSA is the sand grain distribution analysis. The sand grain distribution is determined via the use of a stack of sieves with decreasing sized openings from the top sieve to the bottom, and it is based on the USDA sand distribution definition. Sand grain distributions should be determined on the sand component that has had all of the silt and clay removed.

For most high-performance turf systems, it is desirable to have a minimal amount of silt and clay present. The sand particle sizes should be distributed over a range of 0.05mm to 2.00mm, with most of the particles being between 0.25 and 1.00mm. Significant quantities of particles greater than 2mm can cause problems later if the same sand is used for topdressing. Significant quantities of particles smaller than 0.15mm can negatively affect drainage. The uniformity coefficient (Cu), which is a calculation indicating the distribution of the particle sizes of the soil, is usually in the range of 2 to 4. Cu values higher than 4 suggest that the soil particles may pack too tightly and produce a hard surface and poor drainage. Cu values lower than 2 suggest that the materials may not pack well enough, producing a loose surface and a lack of moisture retention.

PHYSICAL PERFORMANCE EVALUATION

Building new greens? Then a physical performance evaluation (PE) should be performed along with the particle size test. The physical performance evaluation is used when designing and evaluating rootzone mixes. It is the key test for determining the need for rootzone amendments, and for determining how much amendment is needed to optimize performance.

Having problems with drainage or moisture retention with your current greens? Want to benchmark the performance of your greens? The PE test is an excellent source of information regarding the performance of existing rootzones. It is often used as part of a diagnostic profile core assessment. The results of the diagnostic core evaluation can be used to provide recommendations regarding green reconstruction, green modification (removal of surface layers), and modification and verification of maintenance practices such as topdressing and core aeration.

The physical performance evaluation provides information about the saturated hydraulic conductivity (which is often referred to as K-Sat or infiltration rate), bulk density, particle density, and porosity characteristics of a proposed rootzone material. The methods used for determining the parameters are based on standard agronomic test methods and the USGA protocol. Testing involves compaction of a sample at field capacity (or undisturbed cores for

existing rootzones), followed by determination of the listed parameters.

The PE analysis is a useful tool for determining the suitability of submitted materials for use in turf systems such as the USGA putting green system. Important parameters that aid in this assessment are the K-Sat and capillary porosity values. The PE is performed on a compacted sample (samples are compacted using a 14.3 ft.-lbs./in^2 force) and represents a worst-case scenario in regard to the rootzone performance.

Infiltration Rates as determined in the lab are a measurement of how fast water penetrates and drains through the test sample. Infiltration rates are determined using a constant head saturated hydraulic conductivity (K-Sat) method. K-Sat results are useful when evaluating greens, tees, bunkers, and even fairway performance.

The desired K-Sat on any given project is dependent on a variety of factors, including usage, typical rainfall and evaporation conditions, and water quality. The USGA recommends that K-Sat values greater than 6 inches/hour are acceptable for golf greens. Other construction methods suggest that higher or lower rates are desirable. Regardless of the desired rate, care should be utilized when evaluating this result. Reproducibility of results within a single laboratory is typically around +/- 3 in./hr. Results among different labs can show a high amount of variability.

The **Porosity** data are broken up into three sub-categories: total porosity (the amount of space between the soil particles), capillary porosity (the pore space that is water-filled), and non-capillary porosity (the pore space that is air-filled). It is desirable for a rootzone to have approximately half of its volume solid and half pore space. The amounts of air-filled and water-filled pore spaces ought to be present in roughly equal amounts. This should provide advantageous conditions for root growth, proper oxygen levels, and good mineral and water holding.

Bulk Density is a measurement of the mass of the bulk rootzone material per unit volume. Bulk density results can be an indication of excess compaction or loose or unstable soil. Most turf systems will have a bulk density between 1.3 and 1.6 grams/cubic centimeter. Higher values may indicate the turf system is too hard, and lower values may indicate the turf system is too soft.

Particle Density is a measurement of the mass of the individual rootzone particles per unit volume. The primary use for particle density is in calculation of the porosity values. Caution should be used to avoid confusing particle density with bulk density. Bulk density is a measurement of the particles plus the air space between them, while the particle density excludes the air. Particle density for sand is around 2.65 g/cc.

Organic Matter (OM) is reported on a dry weight basis in order to provide the most accurate assessment of the rootzone. Soils and rootzone mixes used in sand-based golf and sports turf usually contain less than 2% organic matter by dry weight.

Organic matter testing is used as an indicator of whether the rootzone mix is consistent during construction projects. The OM test (along with particle size) is usually performed on every lot of rootzone mix that is to be delivered to the golf course. If the OM, PSA, and performance results are consistent from lot to lot, then the mix is considered consistent and acceptable. If there is excessive variance, then it is grounds for rejection.

BUNKER EVALUATION

Choosing a bunker sand can be like trying to hit a moving target. Bunker sand preference among golfers is highly personal and often inconsistent. What's thought of as a good bunker by one golfer may be despised by others. Laboratory testing can help to provide a consistent guide during the bunker sand selection process.

Bunker sand evaluation in the laboratory is a process that involves several tests. Sand is tested for particle size, penetrometer value, infiltration rate, crusting, setup, shape, and color. This evaluation process provides a good indication of how the sand will perform in the bunker and affect nearby greens.

The performance aspects of bunker sand involve ball impact/ball lie characteristics as well as maintenance factors. The performance of a particular bunker sand is largely the result of the sand size distribution and particle shape. Infiltration rate, crusting, and setup are negatively affected by very fine sand, silt, and clay. Thus, a minimal amount of these particles is usually desirable. Sand shape has an effect on ball lie. Angular sands usually provide a better lie than round sands.

GRAVEL DISTRIBUTION

Gravel testing is usually performed almost in conjunction with some type of construction. It is only occasionally used for diagnostic purposes. Gravel is typically used to aid the drainage and/or water-holding capabilities of a drainage system. The gravel is at the bottom of the turf system or sand bunker, with the sand or rootzone medium on top.

Drainage gravel is often selected after choosing the rootzone materials. This is because of concern about the "bridging and permeability" between the rootzone material and the gravel.

Bridging refers to using rootzone material and gravel of the proper sizes so that the rootzone mix will stay suspended over the gravel. If the rootzone particles are too small in comparison to the size of the gravel, there is a potential for these materials to migrate down into the gravel over time. Permeability also refers to using rootzone material and gravel of the proper sizes. However, the goal of proper permeability is to ensure that there is a distinct difference in sizes between the gravel and rootzone layers. Proper permeability indi-

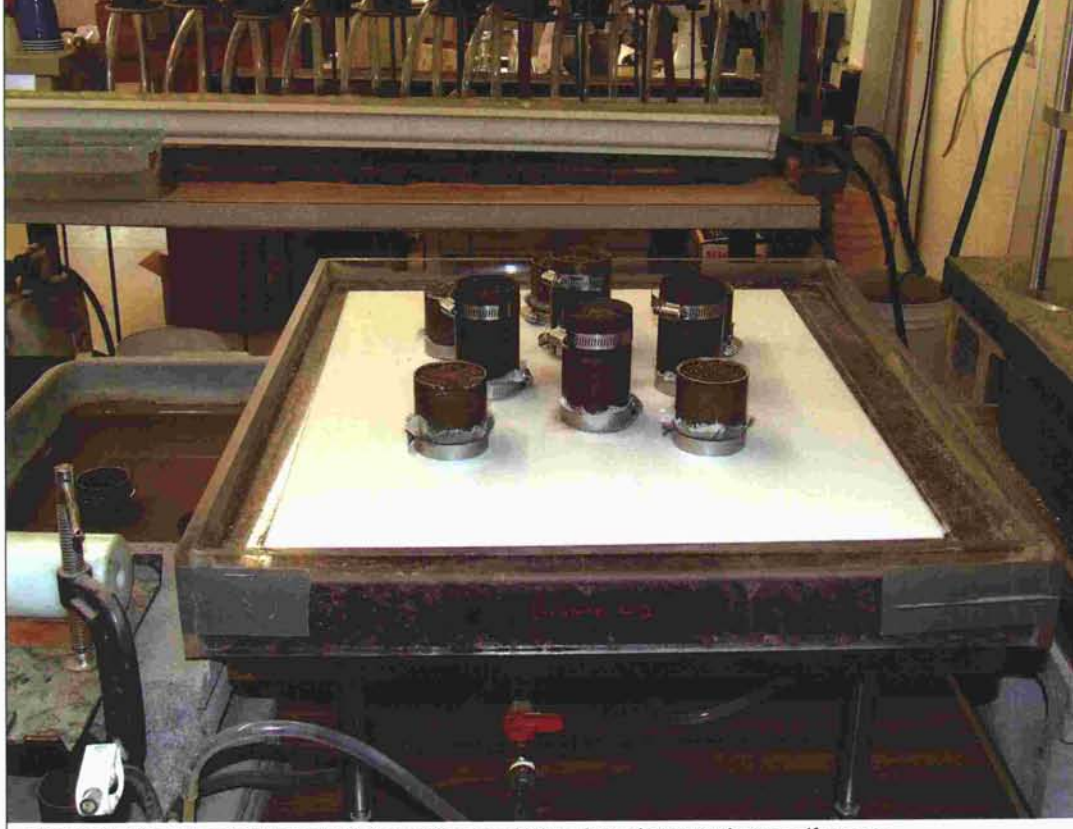
cates that there will be a capillary break between the finer rootzone mix and the coarser gravel. The calculations for checking the bridging and permeability are:

Bridging: $D_{15gravel} \leq 8 \times D_{85rootzone}$

Permeability: $D_{15gravel} \geq 5 \times D_{15rootzone}$

Proper bridging and permeability are required for adequate water movement. Using properly sized gravel increases rootzone moisture retention, aids in maintaining uniform moisture levels across the rootzone, and ensures that excess water will move rapidly to the drains.

The gravel distribution test is analogous to the sand grain distribution. It is a measurement of the size distribution of gravel particles. Gravel used in greens and bunkers typically ranges in size from 1mm to 12.5mm.



Physical testing labs provide critical information on which to base decisions during golf course construction and renovation. A wide variety of soil testing can be done to offer valuable insight when evaluating the current condition of your turf and also provide assurances that proper materials are being used during on-course projects.

WATER RELEASE CHARACTERIZATION

Water release characterization testing is used for moisture release and retention evaluation. This test is especially useful for determining the water holding and drainage capabilities for systems in which the USGA protocols aren't applicable, such as fairways, native materials construction, and straight sand systems. Water release data can be used to evaluate the suitability of a soil or amendment to a particular turf system. A common use for water release testing is to aid in determination of sand/soil capping depths for fairways. It can also be directly related to moisture readings taken in the field and provide useful information for irrigation timing and water management practices.

The water release testing can be performed over a range of soil tensions from 15 bars (permanent wilt point), to ⅓-bar pressure (field capacity for continuous soil profile), to 30cm (tension at which USGA performance evaluation is performed), to 0cm (saturation). Water release testing involves obtaining water moisture measurements at several tensions. A series of moisture release points is then plotted to determine at which pressures a soil or amendment product releases moisture. This testing determines the depth of the rootzone necessary to hold the proper amount of moisture for plant growth.

TEST WITH THE BEST

Physical testing should be an important element in the management of an agronomically sound golf course. However, not all lab testing and reporting is created equal. Make sure to use a lab that is accredited for physical soil analysis for the golf industry. An accredited lab will have the knowledge and capabilities to ensure that the proper test procedures are performed and performed correctly. Some of the benefits of using an accredited testing lab include:

- Provides valuable information in determining the need for modifying, renovating, or rebuilding of existing golf courses.
- Provides assurance to turf managers, owners, and builders that quality materials are being used in construction projects.
- Provides a tool for assessment of the current condition of a turf system, and can aid in diagnosis of turf problems.
- Provides the information needed to help select good bunker sands based upon performance rather than appearance.
- Accredited labs provide data, reporting, and consulting that are an excellent resource for the turf manager.

In this magazine (and on the USGA Web site), there is a list of laboratories that are accredited by the American Association for Laboratory Accreditation (A2LA). These labs specialize in physical soil analysis for the golf industry and have demonstrated ongoing competency in testing materials specified in the USGA's Recommendations for Putting Green Construction. The USGA recommends that only A2LA-accredited laboratories be used for testing and analyzing materials for building greens according to USGA guidelines.

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