Sand Penetrometer - PN5-S
Instructions

1. The red ring on the barrel of the Sand Penetrometer holds the maximum reading of the scale for easy reading.
2. Slide the ring down against the instrument handle.
3. Grip the knurled portion of the handle and place the golf ball over the sand that you will be testing. Ideally sand should be dry and at least four inches thick.
4. Press downward evenly on the sand Penetrometer until the golf ball reaches the line located at the center of the ball.
5. Read the unconfined strength in Tons per Square Foot or Kilograms per Centimeter Squared. The reading is located on the lower side of the red ring - (side closest to the knurled handle).
6. Test an average of three times and disregard results that are too far away from the average.

Use the chart below to determine the likelihood of having fried egg lie development.

Potential for Fried-Egg Lies	
Penetrometer Reading	**Fried-Egg Potential**
Greater than 2.4 kg/cm^2	Very Low tendency to bury
2.2 to 2.4 kg/cm^2	Slight tendency to bury
1.8 to 2.2 kg/cm^2	Moderate tendency to bury
Less than 1.8 kg/cm^2	High tendency to bury

Particle Size Analysis and Sand Distribution.

A sieve analysis should also be performed on the sand to be sure it is in the following specification range.

Sand Particle Size	
Gravel	No more than 3%
Very Course Sand	No more than 15%
Coarse and Medium Grade Sand	At least 65%
Medium Fine and Very Fine Sand	No more than 25%
Silt and Clay	No more than 3%

Turf-Tec International

1471 Capital Circle NW, Ste # 13
Tallahassee, FL. 32303 USA
Order Line (800) 258-7477 - Phone (850) 580-4026 - Fax (850) 580-4027
Website: www.turf-tec.com

Sand Particle Shape

The shape of the sand particles has a strong influence on playing quality and maintenance. A sand particle's shape is classified by examining both the relative sharpness of the particle's edges and the overall shape of the particle itself. The surface of particles can range from very angular (many sharp, well-defined edges) to well rounded (smooth surfaces). The shape of the particle can range from low sphericity (an elongated particle) to high sphericity (a particle that is nearly round).

The angularity and sphericity of the particles have a strong influence on the playing quality of the sand. For example, a low-sphericity, very angular sand generally has high resistance to fried-egg lies. Such sands also tend to stay in place better on the face of the bunker. However, this same sand would produce very firm bunkers that some players may find objectionable. Well-rounded, high-sphericity sands can produce fried-egg lies and are more likely to move off the bunker face during maintenance and irrigation rainfall.

Sands usually consist of a mixture of particle shapes and sizes. This is important to the stability and playing quality of the sand. Again, as a general rule, sands that are highly uniform in size range and shape (particularly if rounded with high sphericity) tend to be less stable than a sand that has a wider range of particle dimensions.

Crusting and Set Up

Crusting is the formation of a layer of dried, stiff sand on the surface of the bunker. Such layers typically are 1/8 to 1/4 inch in thickness, and they severely decrease the playing quality of the bunker. Sands that are prone to crusting require more frequent raking to maintain good playing quality. If the crusting potential is high, the bunkers will require raking following each irrigation and rainfall event. This greatly increases the labor required to keep the bunkers in good condition.

Crusting is directly related to the percentage of silt and clay in the sand. As silt and clay increase, the severity of crusting increases as well. To test for crusting potential, simply wet a thin layer of sand and allows it to dry overnight. Then attempt to lift the layer on the edges using a spatula.

Credits

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Dr. K. W Brown & Mr. J. C. Thomas, Golf Course Management, Vol 54, July 1986

For engineering use

It should be noted that OSHA requirements applicable to excavation work, but not contained in the excavation standard, also have been included in this worksheet. Information on the different types of soil manual field tests is contained in Appendix A of 29 CFR 1926.652 and should be read prior to attempting. If soil field classification will be performed, a pocket penetrometer should be purchased for use in determining the unconfined compressive strength.

A copy of the standard " **Soil Classification - 1926 Subpart P App A**" should be reviewed at the U.S. Department of Labor Occupational Safety & Health Administrations website at www.osha.gov

Unconfined Compressive Strength (Ref. 3.1)

Instructions:

1. Within five minutes after a sample of broken soil is exposed to the open air, remove one or more of the largest clumps and analyze it with a pocket penetrometer.
2. Slice each clump with a spatula to provide a smooth surface for analysis.
3. Press the penetrometer cylinder against the sample and compress the soil and the calibrated spring of the instrument to the marked ring on the cylinder.
4. Read the position of the ring on the calibrated scale of the cylinder.
5. Record the unconfined compressive strength reading in tons per square foot (tsf) or kilograms per square centimeter (kg/cm2).
6. Report the average of at least three readings if possible.
7. Note all samples that break apart and do not provide a positive analysis.

References

3.1 Code of Federal Regulations, Title 29, Part 1926, Subpart P, 1999, pp. 372-409. U.S. Government Printing Office, Washington, D.C. 20402-9328