Research *You Can Use*

Physical Analysis of Sands for Golf Course Bunker Use

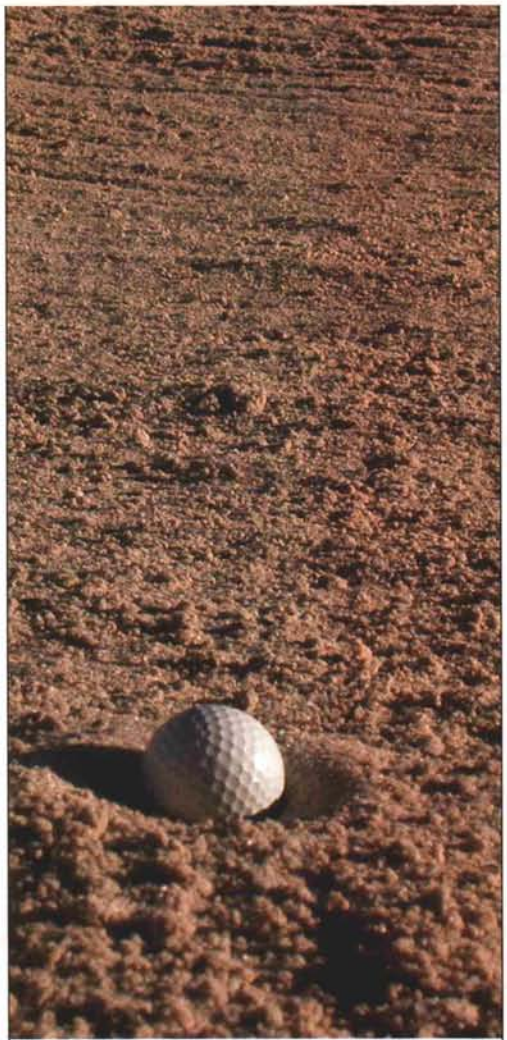
Are current laboratory tests good predictors for bunker sand performance in the field?

BY JIM SKORULSKI

Bunker sand can be a frustrating topic as more emphasis is placed on the playability and consistency of sand bunkers. Many problems with bunkers can be traced back to poor sand selection. More golf courses are realizing the value of using an accredited physical soil testing laboratory to help analyze prospective sands and help predict their playing qualities in the field. Dr. Cale Bigelow, assistant professor of agronomy, Purdue University, and Dr. Douglas Smith, associate professor, USDA-ARS, National Soil Erosion Research Laboratory (West Lafayette, Ind.), recently completed a study that evaluated the physical characteristics of more than 20 commercially available bunker sands to determine if any single physical test currently used by accredited soil testing laboratories is a good predictor of bunker sand firmness in the field. I recently had an opportunity to discuss the project with Dr. Bigelow, and the following article is based on our interview.

1. This research project was timely considering the increasing scrutiny that is being given to sand bunker maintenance and playability. What specific concerns caused you to initiate this project?

Golf course superintendents face increasing demands to provide consistently firm, smooth bunker surfaces. We felt it was important to try to understand the similarities and differences among a wide variety of commercially available bunker sands.



Proper sand selection is crucial in the quest for near-perfect conditioning and consistency demanded by golfers today.

Additionally, I was interested in trying to determine if a simple measurement could be related to surface firmness.

2. What tests are currently used in laboratories to analyze the physical characteristics and predict the playing qualities of bunker sands?

Generally, bunker sands are evaluated by using measurements typically used for rootzone sands, including particle size distribution analysis, particle shape/angularity, and testing for calcium carbonates. The only test currently being widely employed for sand firmness is the modified pocket penetrometer test. The modified penetrometer method was developed and introduced by James Thomas and Dr. Kirk Brown of Texas A&M University. It is the best method currently available for measuring firmness, but it does not account for some factors that affect firmness in a field situation. The test is conducted in a wooden box with static sidewalls and a relatively small quantity of oven-dried sand. Normally the penetrometer is pushed into the sand surface by hand, which may result in uneven pressures and variable measurement values. Most labs replicate this process at least five times and arrive at an average value. I have been told that some labs attach the penetrometer to a drill press-like assembly to minimize pressure variations. Regardless, the process is not ideal, but it is the best procedure currently available.

3. So, is it your feeling, based on this project, that the penetrometer test remains the best means to predict the firmness of bunker sand in the field?

As a relative laboratory measurement, yes, it is the best means to measure

This laboratory study at Purdue University evaluated the physical properties and visual characteristics of more than 20 bunker sand materials. No single sand physical property or combination of properties was able to accurately predict sand firmness or resistance to golf ball penetration.

surface firmness. One situation that I can see being a mistake, however, is if someone were to try to replicate the laboratory data under field conditions, where lower penetrometer values would likely be observed. This is related to several factors. First, due to the large quantity of sand in a real bunker, the static sidewall forces are reduced. Even if you measured adjacent to a bunker edge, the surrounding soil would likely have some degree of "give." Additionally, there are natural variations in moisture content, which functions as a lubricant, promoting particle slippage. This will certainly vary with individual sand particle size distributions and sand depth.

EDITOR'S NOTE: *An extensive effort is underway to replace the penetrometer with equipment that is more reliable and less subject to user-induced variables. A test procedure using the USGA TruFirm™ device is being developed by Sam Ferro of Turf Diagnostic & Design (Linwood, Kansas) to measure depth of penetration and coefficient of restitution of bunker sands. The laboratory testing procedures are being reviewed by the accredited laboratories and will soon be submitted to ASTM for adoption as a standardized test.*

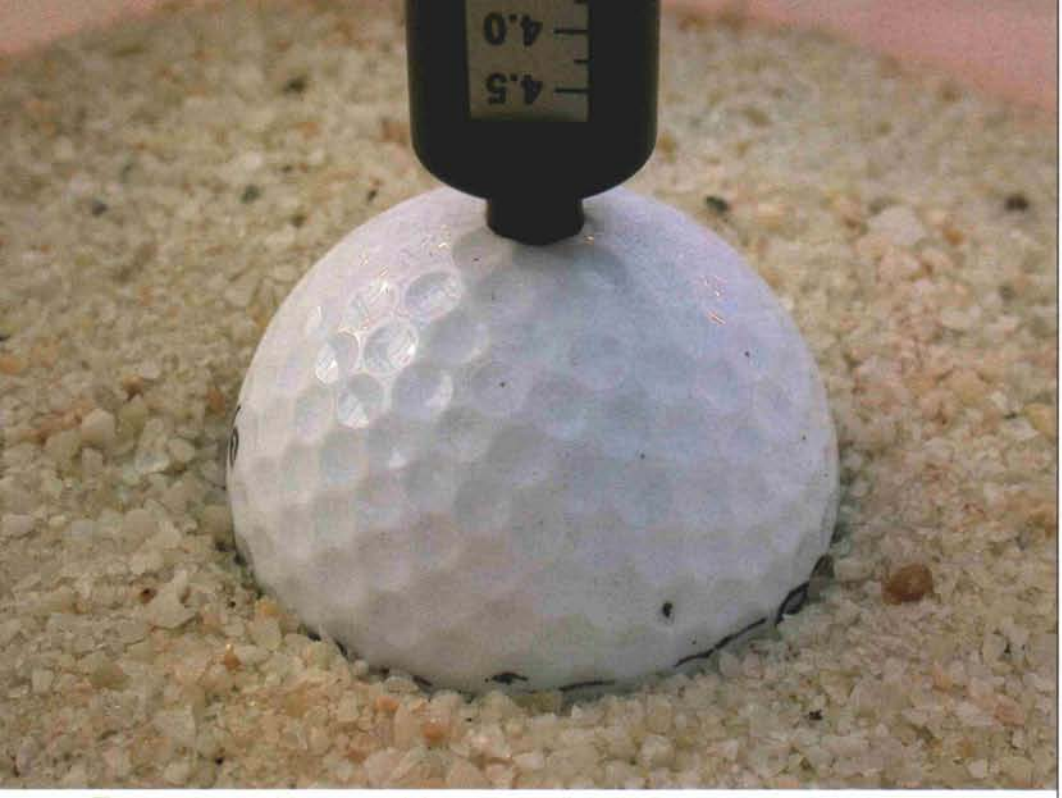
4. From your limited testing, did you find any single physical sand characteristic that can be used with confidence to predict the performance of bunker sand?

No single measurement was a good indicator for firmness. However, particle size distribution, as expressed as coefficient of uniformity (Cu), and angularity are important data. For example, I would be very hesitant to recommend a rather fine, round, uniform sand, particularly for bunkers with steep erosion-prone slopes where moderate to heavy rainfall events are likely. Sands with these characteristics would also likely produce soft conditions and a greater chance for buried lies when used at greater depths. The penetrometer data are helpful, but as I mentioned, the laboratory data are not going to be identical to field performance. There would, however, be some relativity between sands, meaning firmer sands in the lab will likely produce firmer field conditions. I would caution a golf course manager or construction project manager from trying to exactly replicate the laboratory's measurements. There are simply too many variables and factors in field conditions.

5. In your opinion, are the laboratory tests alone a good predictor of how bunker sand will perform in the field?

Just like choosing an appropriate grass cultivar for greens, tees, and fairways, the laboratory research data are merely a starting point in the selection process. The end user needs to carefully consider utility (the importance of the playing characteristics), long-term maintenance, bunker architecture (size, severe slopes, etc.), and appearance before making a sand selection. The lab data simply provide information for comparing sands. The sand particle size distribution and information regarding uniformity and angularity are the most useful data provided by the test. Let's not forget the value of developing a test bunker that will allow golfers an opportunity to play and see several prospective sands before a final decision is made.

6. Do you have a single take-home message or recommendation based on this limited study that you would like to pass on to superintendents and course officials



The penetrometer device pictured above is currently the best means to quantify the firmness of bunker sand in the laboratory. The penetrometer device and laboratory test may soon be replaced by a new procedure that will reduce the variability of the current measurement.

One additional measurement that may help laboratories predict sand firmness is the angle of repose. This measurement is a calculation expressed as degrees, derived from measuring the mean diameter of the base and apex height of a dry sand cone. Coarser textured, more angular sands with wider particle size distribution are more likely to stack higher, resulting in a narrower base and taller cone apex and ultimately a greater angle of repose.

who are dissatisfied with their current bunker sands or are in the process of selecting a new sand?

Many agronomists have been saying this for years, and philosophically I agree. Overall, the industry is spending way too much time and money on bunkers and bunker maintenance. There is no reason that bunker maintenance dollars should be equivalent to putting green maintenance. Bunkers are hazards and golfers should pay a price for being in them. That having been said, however, many golfers have expectations for the finest, most pristine conditions possible (e.g., firm, smooth, aesthetically pleasing sand bunkers that complement the well-manicured turf). Proper sand selection is crucial to achieve this goal on a consistent basis. In some cases, it makes sense to spend a premium price to ship in a coarser textured, angular material rather than settling for a lower-priced locally available sand that is more likely to wash or create conditions that are softer than desired.

During our study, we were impressed by the crushed or manufactured products, including the limestone materials. Instinctively, the limestone products are potentially unsuitable due to their soft mineralogical nature compared to silica materials. In my observations under field conditions, however, these products seem to perform very satisfactorily. The long-term questions regarding issues related to any plugging of drainage tile still remain. The other concern with the crushed products is mower pickup of large particles. Our research is continuing and moving on to the next phase, erosion potential using various sands, but that discussion will have to be the subject of another article.

A more in-depth version of this research project can be found at Turfgrass and Environmental Research Online (TERO), http://usgatero.msu.edu/v07/n03.pdf.

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