# *Engineering Characteristics and Maintenance of Golf Putting Greens*

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**Objectives:**

1. Create an experimental design matrix of various sands.
2. Determine friction angles for each of six sands.
3. Detemine the bearing capacity for each of six sands.
4. Develop a model relating grain size and gradation to friction angle and ultimate bearing capacity.

**Start Date:** 1996
**Project Duration:** 5 years
**Total Funding**: $115,000

*The California Bearing Ratio test is used to test the stability of putting green rootzones at Michigan State University.*

**P**utting green stiffness increases with sands that have higher coefficients of uniformity. In addition, it has been shown the turfgrass roots add significant strength and stiffness to the root-zone sand.

A deformation model was developed. It models the golf putting green as a soft spring layer (thatch) over a stiff elastic base (sand-based rootzone). The model predicts vertical deformation of soil as a function of load pressure. The required stiffness values can be estimated by field-testing. Values are selected by trial and error until the model prediction matches the observed pressure displacement curve.

The testing conditions in the lab are different than those in the field. In the lab there is no thatch layer and the sand is contained in a rigid mold that will not allow lateral deformation. This leads to a well defined peak stress at failure and a non-ambiguous bearing capacity.

In the field, the thatch layer applies a tensile confinement that allows large magnitudes of deformation to occur at increasingly greater pressures without producing a well-defined peak stress at failure. The sand-based rootzone also can strain or deform laterally, reducing the tendency to exhibit a peak. The ultimate bearing capacity for the confined lab bearing test is approximately 198 psi, occurring at a vertical displacement of 0.15 inches. The field bearing test results shows no peak value failure and does not reach a specific ultimate strength. In fact, had the test been continued for larger pressures the soil would continue to deform at approximately the same rate and would not reach a distinct failure point.

The sand-based root zone does not reach a distinct failure point because of the tensile confinement applied by the thatch layer. Also, the root zone material has the freedom to deform laterally and redistribute the pressure to the adjacent soil. Although the field and lab tests are not exactly equivalent, it is noted that the lab results with and without surcharge tend to act as upper and lower bounds, bracketing the field results.

Pressure increases, with increasing displacement, were highest for the confined lab bearing test and lowest for the field bearing test. The high rate of increase in pressure for the confined lab test occurs because the sand is confined from both lateral deformation (due to the rigid mold) and vertical deformation (due to the applied surcharge). The rootzone material is allowed to deform laterally, thus leading to its lower rate of increase in pressure due to increasing displacement.

The ultimate bearing pressure of the soil is determined by the physical properties of the soil and the degree of confinement. A second important property of soils often used by engineers is the stiffness of the soil, a measure of how much pressure can be put on a soil at a certain limiting deformation.

The typical bearing results show that the confined lab bearing test yields the greatest stiffness and the field bearing test yields the lowest stiffness when comparing the three typical bearing test results. We are more concerned about the behavior of the soil and golf putting green before failure occurs. An advantage to measuring or predicting the soil stiffness is that the deformation characteristics at pressures below the ultimate bearing capacity may be analyzed. Those greens with greater stiffness deflect less under load.

## Summary Points

- Researchers applied civil engineering principals to the evaluation of sands.
- Field test show that firmness of greens depends on soil properties and thatch layer effects.
- Recommendations will likely show needed adjustments to specifications that allow more particles in the 0.05 -0.25 mm range to increase stiffness and resistance to deformation.