PENNSTATE

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Using Cubical Triaxial Testing for Determining the Bulk Mechanical Behavior of Sand for Rootzone Mixtures

by

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OVERVIEW OF PRESENTATION

1. Introduction
2. Objectives
3. Design of Experiments
4. Cubical Triaxial Tester
5. Results
6. Summary
7. Timeline

INTRODUCTION

- **Appropriate particle size distribution and mechanical properties are important for preparing putting green sands.**
- **Sand size, shape and moisture content are key factors in determining the mechanical properties of a rootzone mixture.**
- **A precursor study using monosize and binary sand mixtures demonstrated the usefulness of PSU's fundamental tester, i.e., cubical triaxial tester.**
- **No systematic study has been undertaken on USGA sand rootzone mixtures using a fundamental tester.**

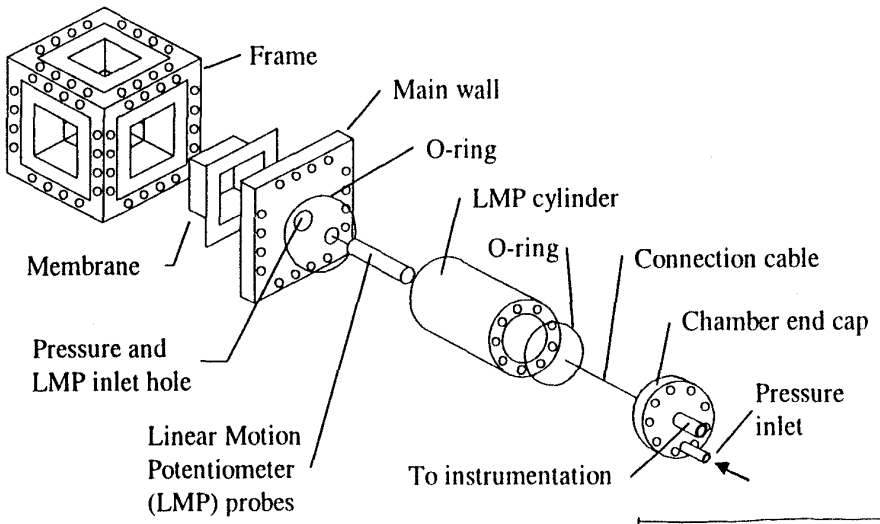
OBJECTIVES

1. To determine the mechanical behavior of four rootzone sands (having different shapes) with and without peat under air-dried conditions.
2. Repetition of objective 1 under –30 cm tension soil moisture conditions.

DESIGN OF EXPERIMENTS

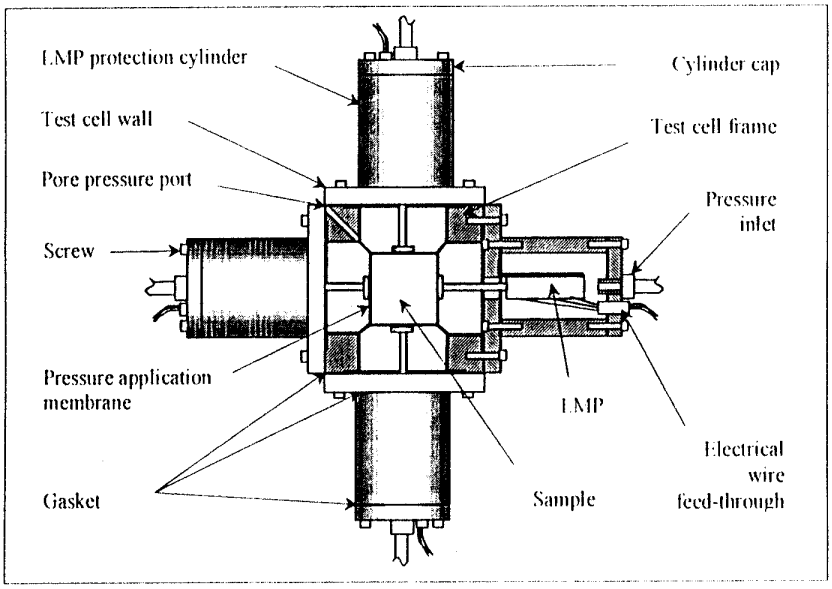
Sand Shape	Condition	Total Tests
Round	[illegible]	[illegible]
	[illegible]	[illegible]
	Dry with peat	9
	Wet with peat	9
Angular	[illegible]	[illegible]
	[illegible]	[illegible]
	Dry with peat	9
	Wet with peat	9
Sub-angular	[illegible]	[illegible]
	Wet	9
	Dry with peat	9
	Wet with peat	9
Sub-round	[illegible]	[illegible]
	Wet	9
	Dry with peat	9
	Wet with peat	9
Total Tests		144
[illegible] completed		[illegible]

EXPLODED VIEW OF ONE SIDE OF CUBICAL TRIAXIAL TESTER



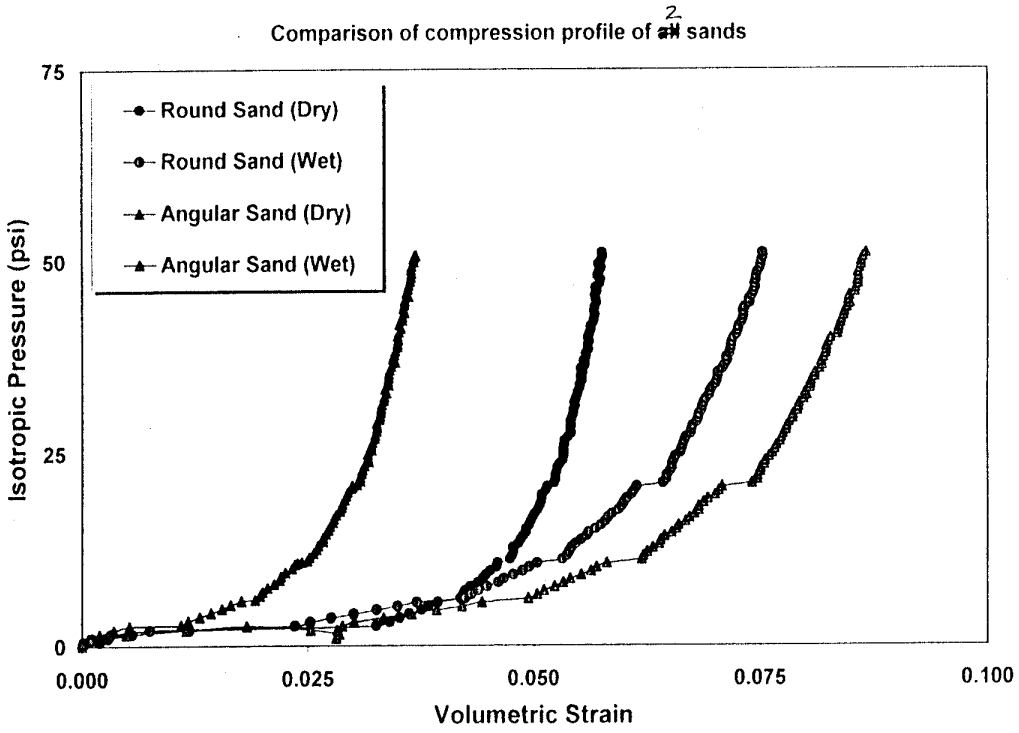
PATENT DISCLOSED

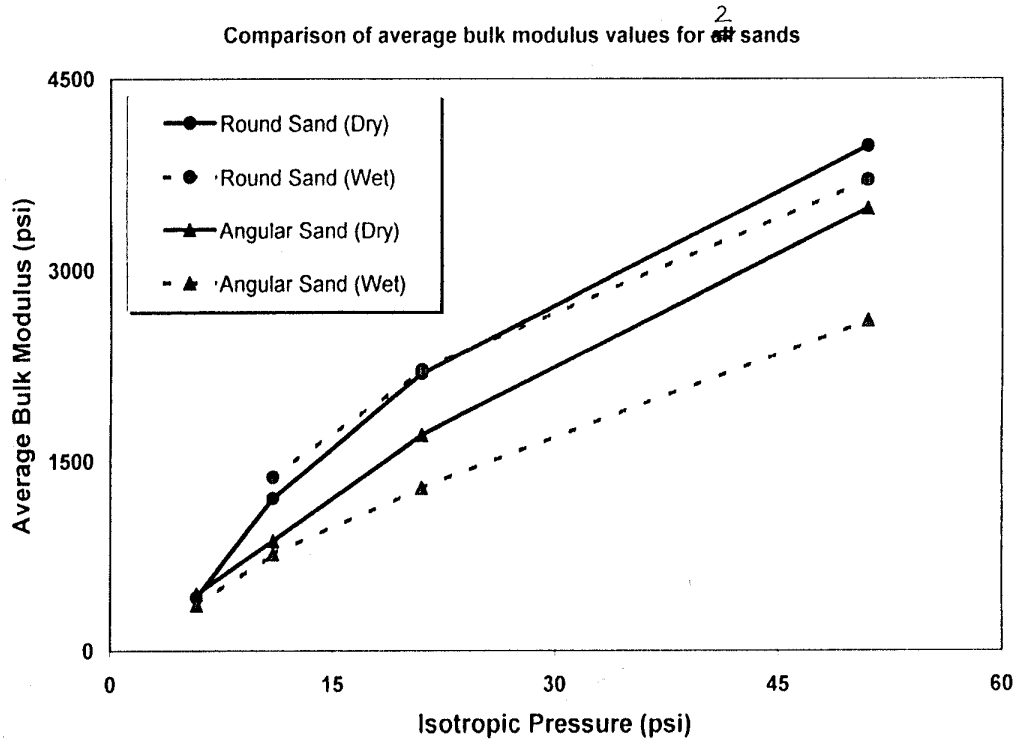
CUBICAL TRIAXIAL TESTER (CTT)



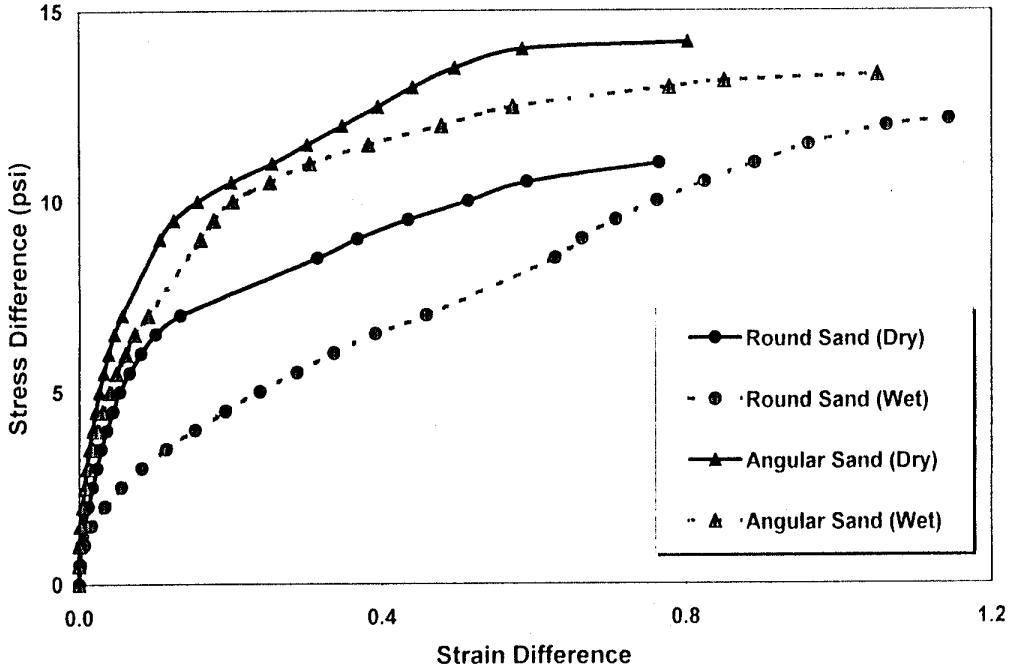
PROJECT HIGHLIGHTS

- **Test Materials:**
  - Sixteen different rootzone mixtures (with varying quantities of moisture and peat contents)
- **Test Apparatus:**
  - Medium pressure Cubical Triaxial Tester (CTT)
- **Parameters Determined:**
  - Shear modulus
  - Failure profile
  - Failure strength
  - Compression profile
  - Bulk modulus

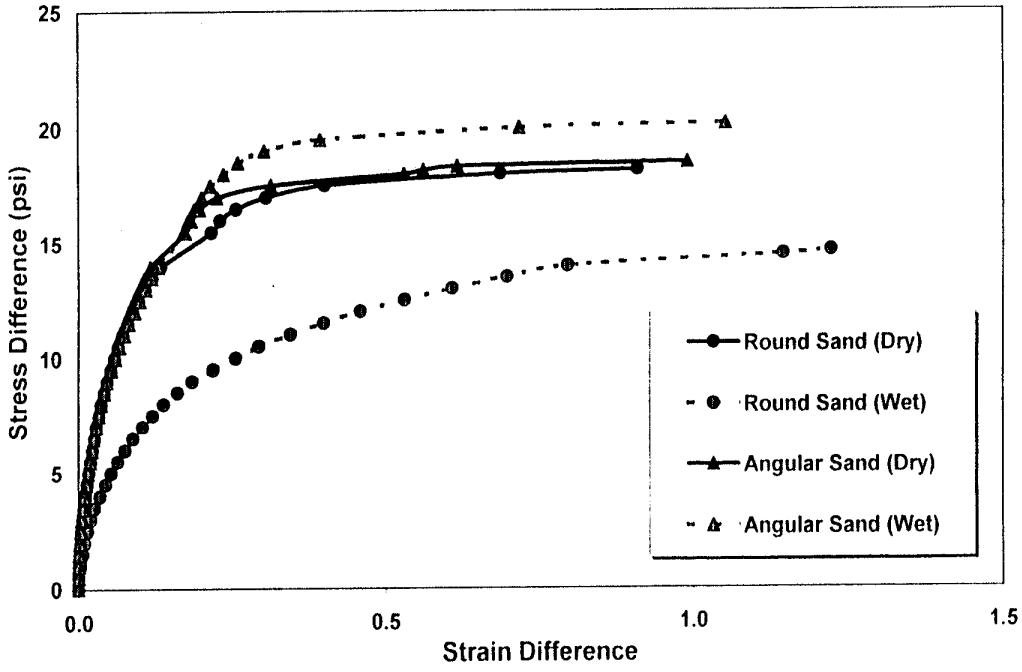

Comparison of compression profile of all sands
Round Sand (Dry)
Round Sand (Wet)
Angular Sand (Dry)
Angular Sand (Wet)
Isotropic Pressure (psi)
75
50
25
0
0.000
0.025
0.050
0.075
0.100
Volumetric Strain

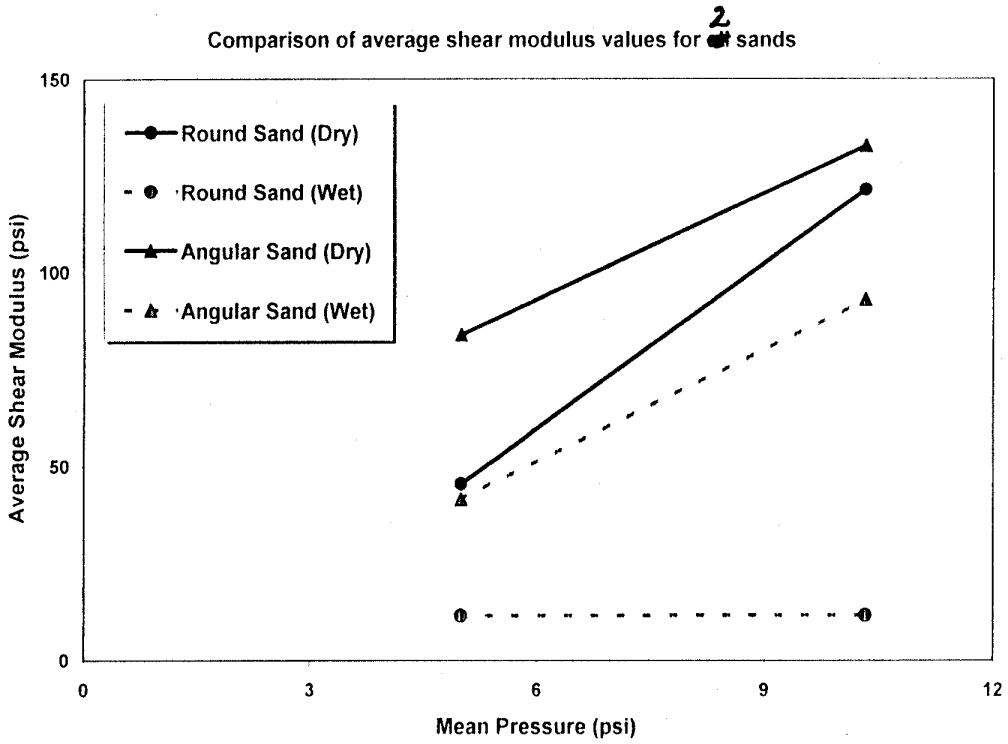

Comparison of average bulk modulus values for all sands
Round Sand (Dry)
Round Sand (Wet)
Angular Sand (Dry)
Angular Sand (Wet)
Average Bulk Modulus (psi)
4500
3000
1500
0
0
15
30
45
60
Isotropic Pressure (psi)

Comparison of failure profile of ~~all~~ 2 sands at 2.5 psi CP



Comparison of failure profile of ~~all~~ 2 sands at 5.5 psi CP





TYPICAL VALUES

Sand	IBD (g/cc)	BM (psi) (at 50 psi)	SM (psi) (at 10 psi)	FS (psi) (at 5.5 psi CP)
Round (Dry)	1.7	3982	121	18
Round (Wet)	1.5	3719	12	15
% Change	-11	-7	-91	-19
Angular (Dry)	1.6	3492	133	19
Angular (Wet)	1.2	2610	93	20
% Change	-21 (DRY → WET)	-25	-30	+9

IBD = Initial bulk density, BM = Bulk modulus, SM = Shear modulus, FS = Failure stress

SUMMARY OBSERVATIONS FROM TEST RESULTS

- Dry samples had higher initial bulk density compared to the wet samples.
- A linear increase in bulk modulus was observed with isotropic pressure.
- Wet sand samples have greater volumetric strain compared to dry samples at any given isotropic pressure.
- Shear modulus values of wet samples were lower than the dry samples.
- The dry samples exhibited a brittle-type behavior whereas the wet samples exhibited a ductile-type response.

OVERALL SUMMARY

- Data collection -- Completed six out of sixteen sands (~ 40%).
- Presentation -- 2000 International ASAE Annual Conference, Milwaukee, WI.
- Technical Paper -- Mittal, B., V. M. Puri and C. F. Mancino. 2000. Measurement of bulk mechanical properties of sand for rootzone mixtures at different moisture contents. ASAE Paper No. 00-4011. ASAE, St. Joseph, MI.

TIMELINE FOR FUTURE ACTIVITIES

Task	Deadline Dates
First phase (without peat)	
Finish triaxial testing on sub-angular sand (moist)	09/20/2000
Finish triaxial testing on sub-round sand (moist)	09/27/2000
Second phase (with peat)	
Finish triaxial testing on round sand (dry)	10/06/2000
Finish triaxial testing on angular sand (dry)	10/13/2000
Finish triaxial testing on round sand (moist)	10/20/2000
Finish triaxial testing on angular sand (moist)	11/04/2000
Finish triaxial testing on sub-angular sand (dry)	11/14/2000
Finish triaxial testing on sub-round sand (dry)	11/30/2000
Finish triaxial testing on sub-angular sand (moist)	12/09/2000
Finish triaxial testing on sub-round sand (moist)	12/15/2000
Final report for CTT results	**12/27/2000**