Development of a New High-suction Tensiometer

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Background

• Suction-controlled triaxial test for unsaturated soil behavior characterization is very time consuming,
• Direct measurement of matric suction on unsaturated soils in laboratory is still a great challenge for researchers,
• Suction measurement on unsaturated soils during undrained triaxial testing under confined and unconfined conditions, and
• Very few commercial high-suction tensiometers are available.
Principle

\[ S_u = u_a - u_w \]
Literature Review

• Ridley and Burland 1993
• Guan and Fredlund 1997
• Meilani et al. 2002
• Tarantino and Mongiovi 2002
• Take and Bolton 2003
• Lourenco et al. 2006
• Cui et al. 2008
High-suction Tensiometer Design

![Diagram of High-suction Tensiometer Design]

- Ceramic Disc
- Water Reservoir
- Epoxy
- Diaphragm
- Housing
- EPXO Pressure Transducer
- Cables
High-suction Tensiometer Fabrication
High-suction Tensiometer Fabrication
Grommet Fabrication

(a) Silicone rubber
(b) Mold
(c) Curing
(d) Grommet
(e) Grommet after trimming
(f) Tensiometer with Grommet on
Saturation

Triaxial cell

Water

High-suction tensiometers
Calibration

\[ y = 0.0067x + 0.1286 \]

\[ y = 0.0076x + 1.1444 \]
Maximum Attainable Pressure

![Graph showing the pressure vs time for two tensiometers. The x-axis represents time (s) from 0 to 3000, and the y-axis represents suction (kPa) from 0 to 1500. Two lines are plotted: green for Tensiometer 1 and red for Tensiometer 2. Tensiometer 1 shows a gradual increase in suction, while Tensiometer 2 increases sharply and then drops back to 0 suction.]
Application

Membrane

High-suction tensiometers

O-ring

Grommet

Triaxial cell
Results (Shear load)
Results (Isotropic load)

Matric suction (kPa) vs. Mean net stress (kPa)

- 15.57%
- 14.23%
- 13.62%
- 12.58%
- 12.05%
- 11.84%
Results (Isotropic load)

Matric suction, \( s \) (kPa)

Specific volume, \( v \)

- \( W = 15.57\% \)
- \( W = 14.23\% \)
- \( W = 13.62\% \)
- \( W = 12.58\% \)
- \( W = 12.05\% \)
- \( W = 11.84\% \)
Conclusions

• A new high-suction tensiometer for matric suction measurement on unsaturated soils was developed,
• After saturation and a careful calibration, the tensiometers were proved to have a maximum attainable suction at of around 1100 kPa (with 15 bar ceramic disc), and
• The undrained unconfined compression test results indicated that tensiometer is reliable and can provide repeated suction measurement results.
Questions ?