GCTS is committed to designing accurate testing systems by integrating innovative software engineering with advanced hardware. GCTS systems perform at the highest levels of reliability, providing efficient systems that satisfy customer needs and expectations.

**USTX-2000**

**Unsaturated Soil Triaxial Test System**

- Fully integrated system with multi-directional automatic valves, volume change & diffused air flushing devices; de-airing tank; & vacuum pump
- Direct control/measurement of pore water pressure (uw) and pore air pressure (ua)
- Performs static and dynamic tests (Sat/Unsat Triaxial Shear with stress/strain path, Hydraulic Conductivity Measurements with suction control, Resilient Modulus, Cyclic Strength, etc.)
- Frequencies up to 5 Hertz (higher with electro-hydraulic option)
- Closed-loop digital servo control
- Double cell wall construction for accurate volume change measurements
- Easily exchangeable HAEV ceramic stones
- Complete 'turn-key' systems

**DESCRIPTION**

The GCTS Unsaturated Soil Triaxial System is an electro-pneumatic system with closed-loop digital servo control. Electro-hydraulic option is available for performing tests at higher frequencies or amplitudes. This system is developed for performing fully automated static and dynamic triaxial tests on saturated or unsaturated soil specimens. The system includes all the software modules and electrical valves required for automatic testing. The axial loader, cell pressure, pore air pressure, and pore water/back pressure are servo controlled using any system sensor as feedback. All of the recharge and flush valves are controlled by the computer for fully automated testing.

The system software provides over 20 parameters for real time display and/or control. These parameters include stresses, strains, suction, etc. (see CATS-TRX brochure for a complete list). The Graphical User Interface enables laboratory personnel to conduct more complex, but realistic, testing programs at substantially lower operating cost with minimal operator error.
The triaxial cell is constructed of stainless steel and accommodates cylindrical specimens up to 75-mm in diameter with length to diameter ratio between 2 to 2.5. The system features see-through Plexiglas external double cell wall and a stiff loading piston with a low friction graphite seal. The advantage of the double external cell wall is that once the specimen is ready, the cell wall is lowered over the cell and fastened in place with a minimum of disturbance to the specimen. The adoption of double cell walls essentially eliminates the compliance errors associated with single cell when measuring overall; specimen volume changes.

Even though the piston friction is small, an internal load cell option is provided if desired to fully eliminate the friction. This system performs unsaturated soil testing with a degree of automation not presently found in any other commercially available system. The GCTS USTX-2000 includes motorized ball valves to automatically recharge the pressure volume controllers; flush air bubbles diffused through the ceramic stone; and reverse the direction of the volume change device that enables infinite volume measurement range as required by the on-going test. This is a true “turn-key” system as it also includes all the necessary support components such as a de-airing water reservoir and vacuum pump to perform saturated or unsaturated soil triaxial tests. All the pressure control elements, volume change devices, and supporting components are housed within a rack mount cabinet providing a “clean” easy-to-understand and use system.

The accompanying software not only commands these valves as necessary but also accounts for any flow direction, reversal or recharging action, accurately keeping track of actual volume changes. Intrusion or extrusion of the loading shaft into the inner cell chamber that could affect volume change measurements is also accounted for automatically. The multi-directional valves, which direct flow as necessary, do not need user intervention during the course of testing. The pressure control panel contains all valves, precision gages, sensors, and air/water interfaces for control of cell pressure and both top/bottom pore pressures. This unit also includes an internal Venturi vacuum pump.

Suctions are applied to the specimen using the axis-translational technique. Pore water pressures ($u_w$) from -100 kPa to 2,000 kPa can be applied with the pressure/volume controller. Pore air pressure ($u_a$) can be computer controlled up to 2,000 kPa. Note: ($u_a - u_w$) can never exceed the air entry value of the ceramic stone. Application of $u_a$ can result in diffused air bubbles collecting beneath the ceramic stone. These bubbles should be flushed out of the system and used as a correction for accurate water volume change measurements. An automatic flushing device (DAF-200) and associated accessories are provided with the system for this purpose. It is important to periodically flush the diffused air from the pore water lines in order to measure and calculate the correct water content throughout the test. The amount of diffused air can also be calculated during the flushing procedure by subtracting the pore water volume before and after the flushing procedure.
For unsaturated soil testing, the volumetric strains can be measured directly from the Cell Pressure Volume Controller and/or the included Volume Change Device. In addition, an optional circumferential deformation device mounted directly onto the specimen can also be used to calculate volumetric strains.

For permeability testing of unsaturated soils, the top pedestal is replaced with an optional platen that includes both, a porous stone and a HAEV ceramic stone. The porous stone is connected to the pore air pressure controller and the HAEV ceramic stone is connected to the top backpressure line. The bottom HAEV ceramic stone is connected to the pore water pressure controller. A pore water pressure gradient can be applied by setting different pressures at the top and bottom HAEV ceramic stones.

The GCTS USTX-2000 software provides the necessary tools for the automatic refilling of water reservoirs and keeping track of the volume of water associated with the specimen volume change and drained/absorbed volume of water by the specimen during testing.

Also available with the USTX-2000 are combination platens for unsaturated soil testing with embedded ultrasonic sensors to measure P and S wave velocities. GCTS offers two different alternatives to measure the S wave velocity: a bender element or 3 shear crystals embedded within the specimen platen. The advantage of the Bender element is that it provides a better energy transmission but with the embedded shear crystals there is nothing penetrating the soil specimen and typically the sensors last longer.

The USTX-2000 triaxial System is the result of many years of research and experimentation with different designs and approaches for solving numerous problems encountered when testing unsaturated soils.

**SPECIFICATIONS**

1.1) **FRM-10-P Load frame**

Two-column vertical standing assembly with threaded columns for crosshead adjustment. Includes:

- 50-mm (2 inch) stroke.
- ±10 kN Actuator load capacity.
- 8-mm peak-to-peak amplitude @ 5 Hertz frequency.
- SR-DF-NVT-50 Deformation sensor 50-mm range. 0.25% precision.
- SR-LC-SSM-10k Load cell ±10 kN range. 0.05% precision.
- Manifold including on/off pressure control solenoid.
- High-Frequency pneumatic servo valve.
- Maximum vertical daylight opening: 940 mm.
- Horizontal daylight opening: 340 mm.

**NOTE:** Requires a 1,000 kPa clean, dry air supply.

1.2) **TRX-100-2C Double Wall Triaxial Cell**

Three column stainless steel construction with double external acrylic plastic cell wall and metal reinforced rings. 2,000 kPa lateral confining pressure capacity. Includes ports for top specimen air pressure, bottom specimen water pore pressure, bottom specimen flushing drainage, internal cell fluid confining pressure, and external cell fluid confining pressure. Also includes spherical seat loading connection set, Rigid loading connection for stress reversal, stainless steel loading piston, ball bushing guide, and low-friction (under 10 N) graphite seal. Accepts samples having a diameter of up to 75 mm with a length of 2.0 to 2.5 times the diameter.

1.3) **TRX100-ACC-070 Test Specimen Accessories**

Set of test specimen accessories and end platens with top and bottom pore water pressure ports including the following:

- (1) Top & Bottom 70 mm platen.
- (1) Set of porous stones (top/bottom) for 70 mm end platens.
- (2) Set of O-rings for sealing membranes to platens for 70 mm specimens.
1.4) TRX100-ACC-070-UNS
Set of 70-mm diameter specimen end platen for TRX100 with pore water and pore air pressure ports for unsaturated soil testing. (1) Top platen with porous stone for air pressure.
• (1) Bottom platen with recess for a HAEV stone and spiral diffused air flushing line for pore water pressure.
• (1) 5-bar HAEV ceramic stone mounted on stainless steel ring for quick installation/removal.

1.5) VCD-400A Volume Change Device
Stiff stainless steel construction with frictionless rolling diaphragm and ball bearing guide to minimize differential pressures and hysteresis. Includes internal (sealed) LVDT and computer-controlled automatic 4-way flow reversal valve with a 400 cc net volume capacity.

1.6) DAF-200A Diffused-Air Flushing Device
Cast acrylic and anodized aluminum construction. Includes dual area flushing reservoir and level sensor with 200 cc flushing capacity and 0.02 cc resolution. Also includes motorized ball valve with 24 VDC operation.

1.7) PVC-250PC Cell Pressure/Volume Controller
For control and/or direct measurement of pressure and volume change. Capable of applying cyclic wave forms at up to 5 Hertz. Includes:
• 800 cc stroke and 0.01 cc resolution.
• 2,000 kPa pressure capacity and 0.1 kPa resolution.
• High-Frequency electro-pneumatic servo valve.
• 5-Hertz maximum frequency.
• SR-PR-OM-2000 Pressure Transducer 2,000 kPa range. 0.25% Linearity and 0.1 kPa resolution.
• SR-DF-750-5000 AC Deformation sensor 250 mm range with 0.25 linearity.
• Computer controlled automatic dump/recharge ball valve.

1.8) PVC-200PP Pore Water Pressure/Volume Controller
For control and/or direct measurement of pressure and volume change. Capable of applying cyclic wave forms at up to 5 Hertz. Includes:
• 300 cc stroke and 0.005 cc resolution.
• 2,000 kPa pressure capacity and 0.1 kPa resolution.
• High-Frequency electro-pneumatic servo valve.
• 5-Hertz maximum frequency.
• SR-PR-OM-2000 Pressure Transducer 2,000 kPa range. 0.25% Linearity and 0.1 kPa resolution.
• SR-DF-750-5000 AC Deformation sensor 250 mm range with 0.25 linearity.
• Computer controlled automatic dump/recharge ball valve.

1.9) PVC-250PA Pore Air Pressure/Volume Controller
For control and/or direct measurement of pressure and volume change. Capable of applying cyclic wave forms at up to 5 Hertz. Includes:
• 800 cc stroke and 0.01 cc resolution.
• 2,000 kPa pressure capacity and 0.1 kPa resolution.
• High-Frequency electro-pneumatic servo valve.
• 5-Hertz maximum frequency.
• SR-PR-OM-2000 Pressure Transducer 2,000 kPa range. 0.25% Linearity and 0.1 kPa resolution.
• SR-DF-750-5000 AC Deformation sensor 250 mm range with 0.25 linearity.
• Computer controlled automatic dump/recharge ball valve.

1.10) PCP-2000 Pressure Control Panel
Pressure/Volume Control System for testing of saturated soil specimens. Includes cabinet mounted on casters to house the confining pressure and back pressure / volume controllers and control panel. Requires input of clean, dry compressed air. Also includes the following:
• Evacuation chamber with fine spray nozzle and vacuum/vent port for preparing and storing de-aired water.
• Venturi vacuum pump, vacuum gage and regulator for applying low vacuum to evacuation chamber.
• Pressure test gauge with ±0.25% accuracy.
• Pressure regulator, and air/water interface for manual control of specimen top back pressure.
• All necessary plumbing and zero-volume-change valves.

1.11) SCON-2000 Digital Servo Controller & Acquisition System
Microprocessor based digital servo controller, function generator, data acquisition, and digital I/O unit. Advanced servo control from any system sensor with “on-the-fly bump-less” transfer switching between any connected transducer or calculated input. Can be configured to read up to 28 transducers or inputs and control up to 8 outputs.
• 850 MHz micro-processor with 64 MB RAM and 128 MB solid state disk.
• 6 kHz maximum loop rate (250 kHz conversion rate between channels).
• Sample & Hold to eliminate data skew.
• Accepts up to 8 DSB-12X series control boards.
• 16-bit resolution.
• Accepts up to 24 DSB-111 Universal Signal Conditioning boards.
• Readout for controller internal temperature, pump oil temperature, pump oil level, & external temperature.
• 8 digital inputs and 8 digital outputs
• 48-bit digital counter.
• Watchdog timer to detect control program status for automatic interlock shutdown.
• TCP/IP and RS-232 Communications.

1.12) Ten DSB-111 Universal Signal Conditioning Boards
Universal signal conditioning module for load cells, LVDTs (AC and DC), pressure sensors, thermocouples, or other analog input signals. Each module includes digital (computer) controlled offset and gain.

1.13) Four DSB-124 Servo/Proportional Amplifier Board
16-bit resolution, ±10 volt output board with 25 mA maximum current and 24 VDC supply (1 amp. Maximum) to drive servo and/or proportional valves requiring 24 VDC supply. Includes null, and gain adjustments.

1.14) WIN-CATS Windows Based Software
32-bit Windows 98/2000/NT/XP software for advanced digital servo control from any system sensor or calculated channel with “on-the-fly” bump-less transfer. Includes calculated channels for stress, strain, etc. and user defined equations.
• Third degree polynomial conversions from sensor output in real time.
• Ability to define user defined inputs as a function of other inputs and correct by another input via a third degree polynomial to view or control in real time.
• Configurable unit library to automatically perform unit conversions.
• Linear, log, and semi-log plotting capability with user specified plot parameters.
• Unlimited user configurable view tools (meters, gages, bars, etc.)
• Signal analysis option that will give FFT of any system signal.
• Advanced PID control with adaptive control.
• Peak/Valley compensation on system control.
• Stabilization by any associated input in control, not only the feedback control sensor.

1.15) WIN-TRX-STATIC
Triaxial test module to automatically perform conventional triaxial static tests (UU, CU, and CD) as well as other advanced tests such as Stress-Path, Ko-Consolidation, etc. Includes procedures for automatic back pressure saturation, consolidation, and static shear loading.

1.16) WIN-TRX-UNSAT
Triaxial Unsat module to perform triaxial tests on unsaturated soils including static and dynamic tests. Automatic procedures for flushing the diffused air and calculation of test parameter such as suction.

1.17) WIN-TRX-DYNAMIC
Triaxial dynamic module to perform simple cyclic test such as liquefaction, modulus measurement, cyclic strength, etc. includes sine, triangular and rectangular wave forms.
• User defined procedures with up to 100 stages.
• Timed, Level Crossing, and Peak/Valley data acquisition modes.
• Independent and simultaneous synchronized control of up to 16 channels of digital servo control (Close or Open loop).
• Automatic “smooth or bump-less” control transfer from/to any sensor or calculated channel.
• Waveform library including Ramp, Ramp + Dwell, Sine, Haversine, Triangular, Square, Random, and User Defined.
• Frequency and amplitude sweeping.
• Allows creation of an unlimited variety of waveforms including user-generated profiles such as a digitized earthquake record

OPTIONS

2) TRX-100-ACC-050 Test Specimen Accessories for Saturated 50 mm Diameter Specimens

3) TRX-100-ACC-050-UNS Test Specimen Accessories for Unsaturated 50 mm Diameter Specimens
Set of 50-mm diameter specimen end platens for TRX100 with pore water and pore air pressure ports for unsaturated soil testing. Includes the following:
• (1) Top platen with porous stone for air pressure.
• (1) Bottom platen with recess for a HAEV stone and diffused air flushing line for pore water pressure.
• (1) 5-bar HAEV ceramic stone mounted on stainless steel ring for quick installation/removal.

4) PDH-070-01
1-bar HAEV ceramic stone mounted on stainless steel ring.

5) PDH-070-03
3-bar HAEV ceramic stone mounted on stainless steel ring.

6) PDH-070-05
5-bar HAEV ceramic stone mounted on stainless steel ring.

7) PDH-070-15
15-bar HAEV ceramic stone mounted on stainless steel ring.

8) TRX-ACC-050-UH
Top platen for 50-mm diameter specimens to perform hydraulic conductivity on unsaturated soils with controlled suction. Includes platen with a ring porous stone (ua) and central 5-bar HAEV ceramic disk (uw).

9) TRX-ACC-070-UH
Top platen for 70-mm diameter specimens to perform hydraulic conductivity on unsaturated soils with controlled suction. Includes platen with a ring porous stone (ua) and central 5-bar HAEV ceramic disk (uw).

10) SR-LC-LFH-5
± 5 kN (1 kip) Submersible load cell. 0.15% precision.

11) DEF-SRCP Circumferential Measurement Device
For the measurement of radial strains inside the triaxial cell. 2,000 kPa water service. Includes Circumferential gauge assembly to measure average radial strain. Includes integrated submersible proximity sensor with 5 mm range. Accommodates specimens with an initial diameter from 35 mm to 75 mm.

12) USTX-MR Resilient Modulus Upgrade

13) USTX-ULT Bender Element System
For the measurement of Compression and Shear wave (Gmax) velocities. Includes Amplifier, Digital scope, platens and Windows software to automatically measure compression and shear wave velocities. See ULT-100 brochure.

14) USTX-2000-HYD Electro-Hydraulic Upgrade for loads up to 100 kN and testing frequencies up to 50 Hz

WARRANTY

One (1) year parts and labor.

SHIPPING

Approximated Volume of Standard System: 8 m³
Approximated Weight of Standard System: 3,800 kg.