MADE IN USA

GCTS
TESTING SYSTEMS

*Accuracy Is The Underlying Strategy*

# Advanced Soil Testing Systems

GCTS is committed to designing accurate testing systems by integrating innovative software engineering with advanced hardware.


*ISO 9001:2015 Certified*

## Company Vision

GCTS is internationally renowned for its high quality testing systems and client care. The design approach GCTS has utilized emphasizes the importance of the customer's needs. It is this approach that has dictated the level of success we have achieved to this date.

GCTS does not just offer testing equipment; we provide complete solutions for advanced material characterization. All of our systems are proudly designed and manufactured in the United States of America.

Our systems are designed to maximize client productivity by acquiring and processing testing data, then presenting the results in a simple and coherent format.

## GCTS: Global Presence

# Product Overview

# Resonant Column Device

## SRC-100

- Capable of performing modulus damping resonant column and torsional tests on soils (solid and hollow specimens)
- Stiff, half-circle reaction support (allows easy and fast specimen setup)
- Precise laser sensor to measure angular deformations from 1% to $2x10^{-5}$% strain
- External (through cell wall) measurements (no re-positioning necessary)
- Torque motor suspended on springs (does not rest on top of specimen) and guided on precise linear bearings
- External torque motor (not susceptible to corrosion while using water as confining medium inside the cell)
- Load frame to apply axial loads through torque motor for anisotropic consolidation
- Easy-to-use software to automatically perform resonant column and torsional shear tests


## Specifications

| | |
|---|---|
| Load Capacity | 10 kN |
| Torque Capacity | 2.3 N-m |
| Max. Frequency | 500 Hz |
| Confining Pressure | 1,000 kPa |
| Max. Specimen Diameter | 70 mm |

## Accessories

1. Platens with compressive and bending elements for P- and S-wave velocity
2. Platens with HAEV discs for unsaturated soil testing
3. Upgrade for resilient modulus testing

For more accessories, please contact GCTS.

## Description

The new SRC-100 Resonant Column Device introduces several innovations (bulleted above) over existing test systems to greatly simplify the performance of resonant column and torsional shear tests. These innovations include features to measure the dynamic soil properties more accurately, reliably and without the complexities of existing systems. The system provided a level of automation requiring minimum user interaction and technical competency, reducing the operation cost. All the necessary components are included in the SRC-100 device to perform complete tests and fully characterize the dynamic properties of a soil specimen including the effects of effective stress, stress path, and strain amplitude.

The SRC-100 automatically performs frequency sweeps to find the specimen resonant frequency used to calculate the shear modulus and half-power ration damping. Free-vibration decay damping is also performed at resonant frequency. The desired effective stresses and shear amplitudes are preprogrammed on the GCTS Application software. The system automatically performs the consolidation stage for each prescribed effective stress and the frequency sweeps at specified shear strain amplitudes after each completed consolidation stage. The software automatically produces PDF or Excel reports including all the calculations and graphics ready for presentation.

The time to perform a full test has been reduced greatly as it is not necessary to install delicate instrumentation to setup each soil specimen. In addition, the testing procedures with this device have been greatly simplified requiring only a minimum of operator training to obtain meaningful results.

These improvements greatly increase productivity and minimize operator training effort, significantly reducing the life cycle cost of the GCTS SRC-100 Resonant Column Device.

# Resonant Column/Torsional Shear Testing System

## TSH-200/300

- Capable of performing modulus damping resonant column and torsional tests on soils and asphalts (both solid and hollow specimens)
- Easy-to-use software to automatically perform resonant column and torsional shear tests
- Floating drive and measurement system to allow for large angular and axial specimen deformations
- 1,000 kPa (150 psi) maximum confining pressure. Larger capacities available upon request using a metallic cell wall
- Platens with ultrasonic transducers for P- and S-wave velocity measurements are also available
- Available loading frame to perform test at anisotropic stress conditions in addition to conventional static and dynamic tests


## Specifications

| | |
|---|---|
| Electrical | 110 or 220 VAC / 50-60 Hz (specify when ordering) |
| Max. Frequency | 500 Hz |
| Confining Pressure | 1,000 kPa |
| Max. Specimen Diameter | 150 mm |

## Accessories

1. Triaxial Loading Frame
2. Platens with compressive and bending elements for P- and S-wave velocity
3. Platens with HAEV discs for unsaturated soil testing

For more accessories, please contact GCTS.

## Description

The Resonant Column/Torsional Shear Testing System (TSH-200/300) combines the features of both resonant column and torsional shear devices into one elegant system, enabling it to evaluate the effects of a number of soil parameters, such as void ratio, confining pressure, strain amplitude, number of load cycles on shear modulus and material damping. By utilizing all available options, this system is capable of the full spectrum of modulus measurement, ranging from ultra-low strains to high strains with significant overlap.

For the resonant column test, a torsional drive is used to vibrate the top of the soil specimen at first-mode resonance at frequencies of up to 500 Hz while the bottom is fixed. A non-contacting rotational transducer is attached to the top platen monitor the torsional motion directly. The non-contacting sensor is located on extended arms to amplify the rotational deformation and provides a shear strain resolution of 10-6. An optional accelerometer can also be installed to measure large shear strains.

The TSH-200/300 can also perform closed-loop torsional shear tests (stress or strain controlled) on the same soil specimen, either statically or dynamically, at up to 50 Hz.

With this system, soil specimens can be tested under isotropic (hydrostatic) or anisotropic conditions. The driving and measuring system are mounted on a "floating" frame, which allows large vertical specimen deformations throughout the complete test. Its unique configuration also allows for very large shear deformations of up to ±20°.

Standard systems are available for 70 mm, 100 mm, or 150 mm diameter specimens. Hollow cylinder platens, molds, and preparation equipment are also available.

# Pneumatic Soil Triaxial Testing System

## STX-050

- Closed-loop digital servo control
- Automatic cell lift and locking mechanism
- Automatically perform saturation, consolidation and shear stages
- Static and dynamic loading
- Loading frequencies up to 10 Hertz
- Stress/strain path testing included
- Automatic multi-stage testing included
- Confining and pore pressure capacities of 1,000 kPa
- Affordably priced
- Optional unsaturated soils testing upgrade
- Optional resonant column upgrade
- Optional resilient modulus upgrade


## Specifications

| | |
|---|---|
| Load Capacity | 10 kN |
| Stroke | 50 mm |
| Max. Specimen Diameter | 70 mm |
| Max. Specimen Length | 175 mm |

## Accessories

1. Ultrasonic sensors for P- and S-wave velocity measurement
2. Unsaturated soil testing package
3. Resonant Column upgrade
4. Resilient Modulus upgrade

For more accessories, please contact GCTS.

## Description

The GCTS Pneumatic Soil Triaxial Testing System (STX-050) was designed to perform conventional triaxial tests as well as more advanced procedures, such as the $K_o$ test, stress/strain path tests, and multi-stage tests. Additionally, this system provides the necessary versatility to easily perform dynamic tests for liquefaction, resilient modulus, and cyclic strength. The triaxial testing system includes all of the necessary software modules to perform these tests.

The system integrates automatic cell wall lift/close mechanism to minimize the test preparation time and minimize disturbance of the specimen. With the push of a button, the triaxial cell wall is lowered and locked with the base to allow the water to fill the cell. The advanced hardware and design eliminate the need to manually assemble the triaxial cell.

The triaxial test app helps the user select the proper testing parameters and provides the necessary information required to automatically execute the desired test. The triaxial app helps minimize learning time and enables laboratory personnel to conduct more complex, but realistic, testing programs at substantially lower operating cost and with minimal operator error. The system manages all the instrumentation and continuously monitors sensor outputs to accurately account for uplift pressures acting on the loading piston, area changes, deformation and volume change sensors setup and re-positioning, etc.

Summary results for individual test specimens can be generated in report format and files can be merged to produce a Mohr envelope plot for up to five specimens. Data acquired from all the software modules can be easily transferred to other programs like spreadsheets, databases, etc.

# Cyclic/Stress-Path Soil Triaxial System

## STX-100/200/300

- Closed-loop digital servo control
- Specimen diameter from 70 mm to 150 mm
- Allows both dynamic and static triaxial tests
- Frequencies up to 30 Hz
- Electro-hydraulic system
- Axial loads up to 100 kN
- Cell pressures up to 2,000 kPa
- Meets ASTM D-3999 & D-5311 Standards


## Specifications

| | 100 | 200 | 300 |
|---|---|---|---|
| Load Capacity | 25 kN | 50 kN | 100 kN |
| Stroke | 50 mm | 100 mm | 100 mm |
| Max. Specimen Diam. | 70 mm | 100 mm | 150 mm |
| Max. Specimen Length | 175 mm | 250 mm | 375 mm |

## Accessories

1. Ultrasonic sensor for P- and S-wave velocity measurement
2. Unsaturated soil testing package
3. Resilient Modulus upgrade

For more accessories, please contact GCTS.

## Description

The GCTS Cyclic/Stress-Path Soil Triaxial System (STX-100/200/300) is intended for performing dynamic tests for liquefaction, resilient modulus, cyclic strength, complex modulus, synchronized cyclic axial, confining stress loading and other dynamic triaxial tests. This system also provides the necessary versatility to automatically perform conventional triaxial tests as well as more advanced procedures, such as stress or strain path.

The standard STX system includes all the necessary hardware and software to automatically perform all triaxial stages, including saturation and consolidation, and easily create cyclic and static customized test procedures. It allows creation of an unlimited variety of waveforms, including user-generated profiles, such as a digitized earthquake record. The system software provides advice for the user as to how to perform testing tasks and helps the user select the proper test parameters to automatically execute the desired test. This enables laboratory personnel to perform more complex testing procedures at a substantially lower operating cost with minimal operator error.

Standard systems are available for testing specimens with a diameter of 70 mm, 100 mm, and 150 mm. Large-scale systems are also available.

# Large-Scale Cyclic/Stress-Path Soil Triaxial System

## STX-600

- Electro-Hydraulic digital servo control
- Dynamic and static triaxial tests
- Frequencies up to 20 Hz
- 300 mm specimen diameter
- Axial loads up to 1,000 kN
- Cell pressure up to 2,000 kPa
- Direct servo control of stress, strain (axial, radial, volumetric) or any other calculated variable


## Specifications

| | |
|---|---|
| Load Capacity | 300 kN |
| Stroke | 150 mm |
| Max. Specimen Diameter | 300 mm |
| Max. Specimen Length | 700 mm |

## Accessories

1. Device for small strain measurement (DEF-1600)
2. Accessories for smaller specimen sizes
3. Dynamic confining pressure for synchronized dynamic biaxial tests

For more accessories, please contact GCTS.

## Description

The GCTS Large-Scale Cyclic Soil Triaxial System (STX-600) is intended for performing dynamic tests on soils with large particle sizes, such as gravely soils and railway ballasts. The triaxial cell accepts 300 mm diameter samples with heights up to 700 mm. This system is typically used to perform tests for liquefaction, resilient modulus, cyclic strength, complex modulus, synchronized cyclic axial, confining stress loading and other dynamic triaxial tests.

The STX-600 also provides the necessary versatility to automatically perform conventional triaxial tests as well as more advanced procedures, such as stress or strain path.

The standard STX-600 system includes all the necessary hardware and software to automatically perform all triaxial stages, including saturation and consolidation. The user is able to program custom waveforms for testing and can be easily programmed to perform customized testing procedures. The system software advises the user on important testing tasks and is very easy to learn, allowing training time to be minimized while maximizing productivity.

# Extra Large-Scale Soil Triaxial System

## STX-2000

- Electro-Hydraulic digital servo control
- 1,000 mm Specimen Diameter
- Axial loads up to 3,000 kN
- Cell Pressures up to 3,000 kPa
- Direct servo control of stress, strain (axial, radial, volumetric) or any other calculated variable
- Dynamic compaction frame with 200 kN load capacity and frequencies from 0 to 100 Hz


## Specifications

| | |
|---|---|
| Load Capacity | 3,000 kN |
| Stroke | 500 mm |
| Max. Specimen Diameter | 1,000 mm |
| Max. Specimen Length | 2,000 mm |

## Accessories

1. Compaction split mold/jacket stretcher for different size specimens.
2. Test accessories for custom-sized specimen.

For more accessories, please contact GCTS.

## Description

The GCTS Extra Large-Scale Soil Triaxial System (STX-2000) is intended for performing tests on soils with large particle sizes, such as rock backfills and gravely soils. The triaxial cell accepts 1,000 mm diameter samples with heights up to 2,000 mm. This system also provides the necessary versatility to automatically perform conventional triaxial tests as well as more advanced procedures, such as stress or strain path. In addition, the STX-2000 has the capability of performing dynamic triaxial tests.

The STX-2000 includes all hardware needed to create and load a large specimen into the testing chamber without the need of a forklift. It includes a dynamic compaction frame, which can create the specimen using a 200 kN axial load at frequencies up to 100 Hz.

This system uses an innovative cost-saving and space-saving design with many automation features. This includes an automatic triaxial cell assembly that hydraulically locks the triaxial cell without requiring any tightening of nuts or bolts.

The standard STX-2000 system includes all the necessary hardware and software to automatically perform all triaxial stages, including saturation and consolidation. Custom testing procedures can be easily programmed by the user, and an unlimited variety of waveforms can be executed by the system as defined by the user. The program alerts the user to important testing steps that must be performed, minimizing training time while increasing productivity.

The triaxial cell included with the STX-2000 system is constructed of stainless steel. The standard unit features a composite, see-through Plexiglas cell wall reinforced with anodized aluminum rings. All the standard GCTS triaxial cells can accommodate smaller diameter specimens using the optional platens and provide the necessary information required to automatically execute the desired test.

# Frozen Soil Triaxial System

## FSTX-200

- 200 kN (44 kips) axial load and 30 MPa (4,350 psi) cell pressure capacity
- 30 Hz maximum loading frequency
- Computer temperature control from -20 °C (-35 °C with $LN_2$) to +150 °C
- Electro-hydraulic closed-loop digital servo control
- Software modules for the performance of UU, CU, and CD static tests with stress path control and dynamic tests such as liquefaction, modulus/damping measurement, and resilient modulus
- Optional internal axial & circumferential deformation measurement system
- Optional platens with ultrasonic transducers for P-and S-wave velocity measurements


## Specifications

| | |
|---|---|
| Load Capacity | 200 kN |
| Pressure Capacity | 30 MPa |
| Stroke | 100 mm |
| Max. Specimen Diameter | 75 mm |
| Max. Specimen Length | 150 mm |

## Accessories

1. Submersible instrumentation to measure axial and radial strains.
2. Ultrasonic velocity measurement system.
3. Optional hollow cylinder platens and torque actuator for resonant column / torsional shear tests.

For more accessories, please contact GCTS.

## Description

The GCTS Frozen Soil Triaxial System (FSTX-200) was designed to study the formation of gas hydrates within soil samples and to characterize the geomechanical properties and response of hydrate -laden soils and rocks found mainly within ocean sediments on the continental margins and embedded in regions of permafrost.

This equipment is capable of performing isotropic and anisotropic consolidation, UU, CD, and CU triaxial tests with volume change or pore pressure measurements, stress/strain path tests, $K_0$ consolidation, cyclic loading (including cyclic stress paths) and other tests. This system is also capable of performing flexible-wall permeability tests. The FSTX system complies with ASTM D3999 and D5311 specifications.

The GCTS FSTX-200 uses a computer-controlled metering valve and internal copper vaporization coil for the precise control of test temperatures. It includes a pump for circulation of bath fluid that circulates inside the triaxial cell and one RTD that can be mounted on the top of the triaxial cell. Also included is an efficient cooling/heating device that allows for temperature control between –20°C and +150°C (optional cooling unit for –30°C) without requiring external Liquid Nitrogen ($LN_2$). GCTS provides other necessary components, such as the gas delivery system, gas/water mixing tank, flow meters, and volume change devices, making the FSTX-200 a true turn-key system.

# Unsaturated Soil Triaxial System

## USTX-2000

- Fully integrated system with multi-directional automatic valves, volume change and diffused air flushing devices, de-airing tank, and vacuum pump
- Direct control and measurement of pore-air pressure ($u_a$) at the top of the test specimen
- Performs static and dynamic tests (Saturated and Unsaturated Triaxial Shear with stress/ strain path, Hydraulic Conductivity Measurements with suction control, Resilient Modulus, Cyclic Strength, etc.)
- Closed-loop digital servo control
- Double cell wall construction for accurate volume change measurements


## Specifications

| | |
|---|---|
| Load Capacity | 10 kN |
| Stroke | 50 mm |
| Max. Specimen Diameter | 70 mm |
| Max. Specimen Length | 185 mm |

## Accessories

1. Electro-hydraulic actuator with 50 kN load capacity and 30 Hz maximum frequency
2. Internal submersible instrumentation to measure both axial and radial strains
3. Ultrasonic velocity and bender element sensors
4. Upgrade for resilient modulus testing

For more accessories, please contact GCTS.

## Description

The GCTS Unsaturated Soil Triaxial System (USTX-2000) is an electro-pneumatic system with closed-loop digital servo control. An 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 unsaturated soil specimens.

The adoption of double cell walls essentially eliminates the compliance errors associated with a single cell when measuring overall specimen volume changes. This innovative system performs unsaturated soil testing with a degree of automation not presently found in any other commercially-available system.

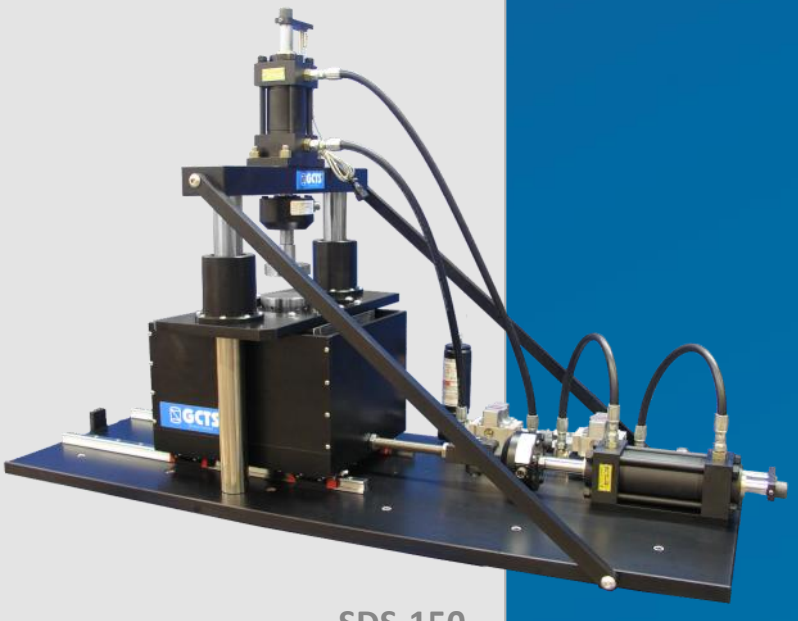
The USTX-2000 includes motorized ball valves to automatically recharge the pressure volume controllers, flush air bubbles diffused through the ceramic stone, and reverse the direction of the volume change device, which allows for an infinite range of volume measurement as required by the on-going test. This system also includes components, such as a de-airing water reservoir and vacuum pump, to perform saturated and unsaturated soil triaxial tests.

The system software provides over twenty parameters for real-time display and control, including stresses, strains, suction, and more.

# Direct Shear Testing System for Soils

## SDS-100/150

- Closed-loop servo control of double-acting normal and shear load actuators
- Shear load capacity up to 50 kN (5 ton) with up to 100 mm stroke
- Normal load capacity up to 50 kN (5 ton) with up to 50 mm stroke
- Normal load reaction support mounted on sliding bearings to minimize horizontal friction
- Systems for both cylindrical specimens of up to 100 mm (4 in.) and cubical specimens of up to 150 mm (6 in.) sides
- Software for automatic performance of direct shear tests with constant normal stress or normal stiffness
- Real-time graphical display of the test progress



SDS-150

## Specifications

| | SDS-100 | SDS-150 |
|---|---|---|
| Load Capacity | 20 kN | 50 kN |
| Stroke (Normal) | 25 mm | 50 mm |
| Stroke (Shear) | 50 mm | 100 mm |
| Max. Specimen Dimensions | 100 mm | 150 mm |

SDS-100

## Description

The GCTS Direct Shear Testing Systems (SDS-100/150) feature electro-hydraulic closed-loop digital servo control of the shear and normal loads to automatically perform conventional direct shear tests, as well as more advanced tests. These systems can be easily programmed to perform tests where the normal load is a function of a prescribed stiffness to simulate actual compressibility of a ground shear plane.

The top shear box can be horizontally translated and the bottom shear box is mounted on pre-loaded sliding bearings to minimize horizontal friction. Set screws with nylon tips are used to adjust the shear gap and the top shear box is suspended on springs that balance its own weight. This allows for different shear gap settings, more precise measurement, and control of the normal stress.

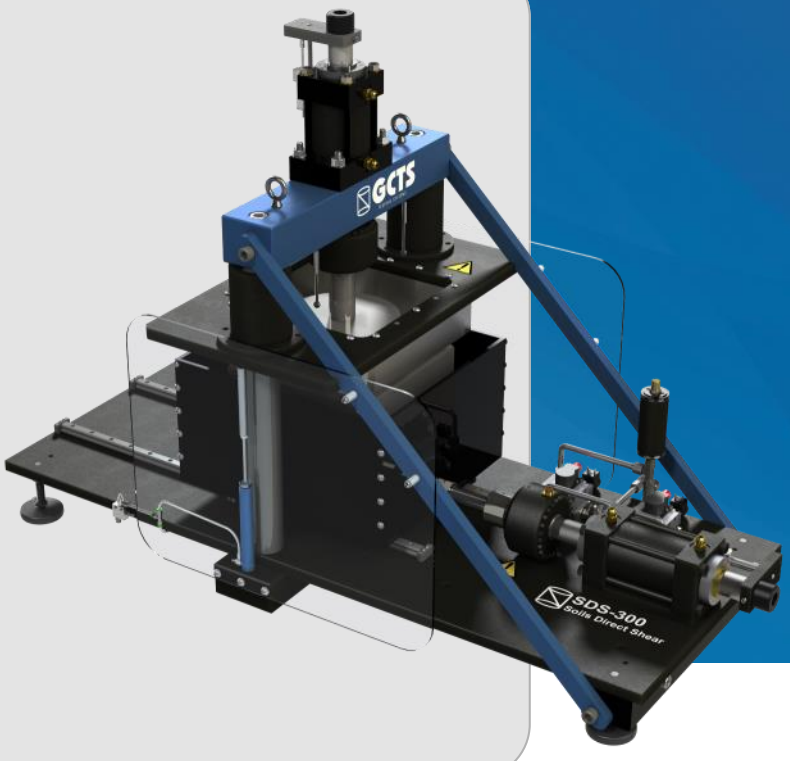
Included with these systems are loading plates with a square grid of retractable pins, which help grab different types of samples, such as soils, asphalt and other materials. A water reservoir is also included to submerge specimens during testing.

The SDS systems are especially well-suited to test coarse, granular materials and to simulate interface materials because of their high load capacity, ability to accommodate large specimens, and elimination of vibrations that can disturb or compact granular specimens.

# Direct Shear Testing System for Soils and Asphalts

## SDS-300

- Closed-loop servo control of double-acting 100 kN (10 ton) shear load actuator with 100 mm stroke and 100 kN (10 ton) normal load capacity with 50 mm stroke
- Normal load reaction support mounted on sliding bearings to minimize horizontal friction
- Accepts 300 mm (12 in.) square specimens
- Software for automatic performance of direct shear tests with constant normal stress or normal stiffness
- Available interface platens to test soils, asphalt and geo-membranes
- Other load capacities and specimen size dimensions are available, including large-scale test systems for shear loads of up to 1,000 kN (100 ton)




## Specifications

| | |
|---|---|
| Shear Load Capacity | 100 kN |
| Normal Load Capacity | 100 kN |
| Shear Stroke | 100 mm |
| Normal Stroke | 50 mm |
| Max. Specimen Dimensions | 300 mm by 300 mm |
| Max. Specimen Height | 300 mm |

## Description

The GCTS Direct Shear Testing System for Soils and Asphalts (SDS-300) features electro-hydraulic closed-loop digital servo control of the shear and normal loads for test automation. Loads or deformations for both the shear and normal actuators can be prescribed for automatic performance of conventional direct shear tests as well as more advanced tests. This system can be easily programmed to perform tests such as the constant normal stiffness test, where the normal load is a function of a prescribed stiffness for simulating actual compressibility of a ground shear plane (e.g. soil-pile interaction).

The SDS-300 is especially well-suited to test coarse, granular materials and simulate interface materials because of its high load capacity, ability to accommodate large specimens, and elimination of vibrations that can disturb or compact granular specimens.

Included with this system are loading plates with a square grid of retractable pins, which help grab different types of samples, such as soils, asphalt and other materials. Also included is a water reservoir to submerge specimens during testing.

The top shear box can be horizontally translated and the bottom shear box is mounted on sliding bearings to minimize friction. Set screws with nylon tips are used to adjust the shear gap. The top shear box is suspended on springs to balance its weight, causing normal load readings to be extremely accurate. The shear boxes also ensure that shear transfer is done through the top of the shear boxes rather than the sides, making this system the most accurate large-scale direct shear testing system on the market.


Top Shear Box with Balancing Springs

# Simple Shear Testing System

## SSH-25

- Dynamic and static simple shear apparatus capable of applying cyclic loads up to 10 Hz (30 mm./sec max. velocity)
- Closed-loop servo-control of double acting (push/pull) normal and shear load actuators
- 18 kN normal and shear load capacity
- ± 25 mm shear stroke and 50 mm normal stroke
- 100 mm. (4") diameter standard specimen size
- Normal load reaction support mounted on sliding bearings to minimize horizontal friction
- Software for automatic performance of simple shear tests with real time graphical display of test progress
- Load frame, signal conditioning unit, and hydraulic pump mounted to a moveable cart
- Optional accessories and software to perform direct shear tests


## Specifications

| | |
|---|---|
| Shear and Normal Load Capacity | 18 kN |
| Shear Stroke | ± 25 mm |
| Normal Stroke | 50 mm |
| Max. Specimen Diameter | 100 mm |
| Max. Specimen Height (Simple Shear) | 40 mm |

## Accessories

1. 70 mm diameter specimen rings (other sizes available upon request)
2. Ultrasonic (compressional and bender element) sensors and electronics
3. Direct shear upgrade

For more accessories, please contact GCTS.

## Description

This system features a closed-loop digital servo-control of the shear and normal loads for test automation. Stresses or strains for both the shear and normal actuators can be prescribed to automatically perform conventional simple shear tests as well as cycle dynamic tests, such as liquefaction or cyclic strength.

A high-precision vertical deformation sensor is included to perform liquefaction tests on dry sands by specifying a zero-vertical deformation during cyclic shear loads. The electro-hydraulic loading system for both the normal and shear load actuators can apply or maintain the prescribed loads or deformations with a very small compliance.

The system includes a stiff lateral support of the top cap to minimize rotation compliance while allowing it to move freely in the vertical direction. The sliding base is mounted on pre-loaded linear bearings to keep both caps parallel to each other during simple shear tests.

The SSH-25 is mounted on a convenient cart with casters that not only supports the apparatus, but also houses the hydraulics inside. The wireless interface and standard power allows the user to place this system anywhere where there is a power source.

# Static/Dynamic Simple Shear Testing System

## SSH-100

- Dynamic and static simple shear apparatus capable of applying cyclic loads up to 30 Hz
- Digital servo control of shear and normal loads or displacements
- Servo control of the confining pressure
- Acrylic cell capable of 1,000 kPa (150 psi) lateral confining pressure (2,000 kPa option available)
- 25 kN normal and shear load capacity
- Includes platens for static and cyclic triaxial tests
- Lateral support of top cap to minimize rotation compliance and sliding base mounted on preloaded linear bearings
- Software for automatic performance of simple shear and triaxial tests (static and dynamic) with real-time graphical display of test progress
- Automatic tilt mechanism for fast and easy specimen installation
- Optional HAEV Platens for unsaturated soil testing


## Specifications

| | |
|---|---|
| Shear and Normal Load Capacity | 25 kN |
| Shear Stroke | ± 25 mm |
| Normal Stroke | 50 mm |
| Max. Specimen Diameter | 100 mm |
| Max. Specimen Height (Simple Shear) | 30 mm |
| Max. Specimen Height (Triaxial) | 250 mm |

## Accessories

1. Platens with HAEV disks for unsaturated testing
2. Ultrasonic (compressional and bender element) sensors and electronics
3. Internal instrumentation for very small strain measurements
4. Resonant column upgrade
5. 2,000 kPa confining pressure cell available

For more accessories, please contact GCTS.

## Description

The design of the GCTS Simple Shear Testing System (SSH-100) is based on our external cell wall triaxial system. The apparatus has a fixed top and a sliding bottom base mounted on special linear bearings to help with specimen loading and unloading. The system also has a stiff internal support to minimize lateral compliance of the top cap.

One of the main advantages of the GCTS Simple Shear Testing System is the apparatus does not require a reinforced membrane, as lateral support is provided via the confining pressure, which can be servo-controlled. This means that consolidation can be done at K values other than $K_0$. However, this device also includes Teflon-coated thin rings to externally reinforce the standard latex membranes to ensure $K_0$ consolidation.

The SSH-100 is capable of testing 100 mm (4 in.) and 71 mm (2.8 in.) diameter specimens. Because the internal lateral support is provided by the confining pressure, specimen of different heights can be tested. This means that the system can be used to test either simple shear or triaxial test specimens with heights up to 2.5 times their diameter.

# Dynamic Hollow Cylinder Testing System

## HCA-100/150

- Closed-loop synchronized digital servo control
- Complete turn-key system
- Capable of ± 225 N-m torsional loads & ± 100 kN axial loads at up to 30 Hz
- Confining, back, pore, and internal pressure servo control up to 2,000 kPa
- Angular displacement sensor with a deflection range of ±25˚to measure large shear strains (±40˚range optional)
- Non-contacting deformation sensors with a ± 2.5 mm range to detect small shear strains
- Software for advanced hollow cylinder and triaxial test procedures
- Standard systems to test 150 mm OD and 75 mm ID
- Large-scale testing systems also available
- Optional unsaturated soils testing system package also available
- Optional internal high-speed torque motor for resonant column testing, ultrasonic platens, and temperature controller also available


## Specifications

| | HCA-100 | HCA-150 |
|---|---|---|
| Load Capacity (Axial) | 100 kN | 100 kN |
| Load Capacity (Torsional) | 225 N-m | 225 N-m |
| Stroke | 75 mm | 75 mm |
| Max. Specimen OD | 100 mm | 150 mm |
| Max. Specimen Height | 220 mm | 330 mm |

## Accessories

1. Platens with HAEV disks for unsaturated testing
2. Ultrasonic (compressional and bender element) sensors and electronics
3. Internal instrumentation for very small strain measurements
4. Resonant column upgrade

For more accessories, please contact GCTS.

## Description

By providing digital servo control of axial load, torque, confining pressure, internal pressure, and back pressure, the GCTS Dynamic Hollow Cylinder Testing System (HCA-100/150) is capable of subjecting the soil specimen to any stress state and follow any stress/strain path.

The HCA-100/150 is capable of simulating most field stress/strain path tests (static or dynamic), including plane strain, simple shear, and small shear strains. Other possible tests include: measurement of dynamic shear strength and deformation, liquefaction potential, shear modulus and damping ratio. The system is versatile in allowing the user to design custom procedures with operating frequencies of up to 30 Hz.

The included software automatically calculates up to 28 HCA test parameters in real-time that can be used as control feedback to prescribe an infinite number of stress/strain paths. This includes the principal stress angle (α), allowing the system to easily prescribe the rate and magnitude of the $\sigma_1$ rotation.

The system manages all the instrumentation and continuously monitors sensor outputs to accurately account for uplift pressures acting on the loading piston, area changes, deformation and volume change sensor setup, re-positioning, and more. It also advises the user on how to perform testing tasks and reminds the user of important steps in the test, which help minimize the learning time and ensure laboratory personnel can conduct tests with minimal error.

# Large-Scale Dynamic Hollow Cylinder System

## HCA-600

- Complete turn-key system
- Dynamic and Static Hollow Cylinder Apparatus capable of applying synchronized loading at frequencies up to 10 Hz or single axis loading at frequencies up to 25 Hz
- 1,000 N-m torque and ± 300 kN axial load capacity
- Confining, internal, and back pressure servo control up to 2,000 kPa
- Angular displacement sensor with a deflection range of ±25° to measure large shear strains (±40° sensor optional)
- Realistically imitates all stress path conditions encountered in the field
- Easily duplicate and control static or dynamic changes in the magnitude and direction of the principal stresses
- Study inherent or induced soil anisotropy


## Specifications

| | |
|---|---|
| Axial Load Capacity | 300 kN |
| Torsional Capacity | 1,000 N-m |
| Stroke | 100 mm |
| Max. Specimen Diameter | 300 mm OD |
| Max. Specimen Height | 600 mm |

## Accessories

1. Platens with HAEV disks for unsaturated testing
2. Ultrasonic (compressional and bender element) sensors and electronics
3. Internal instrumentation for very small strain measurements

For more accessories, please contact GCTS.

## Description

The GCTS Large-Scale Dynamic Hollow Cylinder System (HCA-600) is an advanced testing apparatus used for the development of constitutive models and the determination of strength parameters of isotropic and anisotropic soils. It is capable of performing stress path tests with controlled rotation of the principal stress directions. Granular soils with large particles can be tested using this system, as the variation of the radial strain over the wall thickness is negligible for large diameter specimens.

The HCA-600 provides independent control of axial load, torque, confining pressure, inside pressure, and back pressure. All five axes can be controlled using feedback from any direct or calculated input, including more than twenty test parameters that are automatically computed by the GCTS software in real-time.

The Hollow Cylinder Apparatus is the only device capable of imposing three-dimensional stress states and control the rotation of the principal stress direction. With the included software, the varied stress path conditions encountered in the field are able to be realistically imitated in the laboratory with ease.

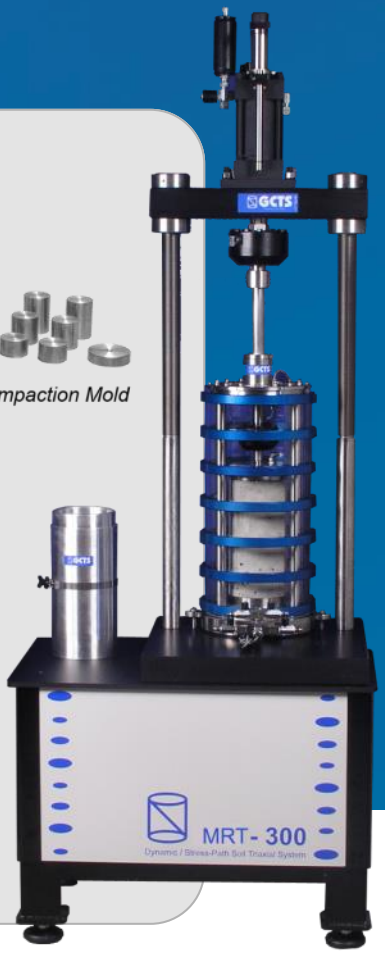
The GCTS program continuously monitors all sensor outputs and calculates all variables during the test, allowing it to accurately account for uplift pressures, dimensional changes, and more. The HCA-600 includes automated valves and controls to automatically perform all test stages, including saturation, consolidation, and shear. Test programs are effortlessly created through a graphical interface that provides advice on how certain tasks should be performed, minimizing learning time and user errors.

# Resilient Modulus Testing System

## MRT-050/100/200/300

- Electro-Hydraulic (Electro-Pneumatic for MRT-050) Digital Servo Control
- Complete turn-key system
- Easy to use software for automatic test performance
- Meets AASHTO, SHRP and ASTM standards
- Triaxial cells for specimens from 70 mm (2.8 in.) to 150 mm (6 in.) diameter
- Available indirect tension fixtures to perform ASTM D4123 and SHRP P-7

*AASTO T-2 Material Compaction Mold*




## Specifications

| MRT- | 050 | 100 | 200 | 300 |
|---|---|---|---|---|
| Load Capacity | 10 kN | 22 kN | 45 kN | 100 kN |
| Stroke | 50 mm | 50 mm | 100 mm | 100 mm |
| Max. Diameter | 70 mm | 70 mm | 100 mm | 150 mm |
| Max. Height | 190 mm | 190 mm | 250 mm | 375 mm |

## Accessories

1. NCHRP 1-28 specified LVDT CLAMPS
2. Calibration Hardware
3. Additional platens & required sensors for smaller specimens to meet AASHTO T-307 specifications
4. Unsaturated option for suction controlled tests

For more accessories, please contact GCTS.

## Description

The GCTS Resilient Modulus Testing Systems (MRT Series) boast a modular design which allows the system to be configured to test soil in a variety of modes. This system is based on the GCTS SCON Digital Signal Conditioning and Controller and can be supplied with a pneumatic or hydraulic loader.

The GCTS Resilient Modulus software features built in AASTHO, SHRP, and NCHRP test sequences and the capability to specify user-defined sequences. Contact stress is automatically adjusted according to each procedure as selected. Available waveforms include haversine, sine, square and triangular, along with a user-defined waveform selection. Optional peak and valley compensation ensures proper and quick matching of the load parameters. Real-time displays of the prescribed versus actual dynamic load and the dynamic deformation measurements by each sensor are always present.

The deformation ratio of the two sensors, $R_v$ (to ensure that the two deformation sensors are in agreement), and resilient modulus, $M_r$, are also calculated in real-time. During export, curve fitting is done to match the results to models that predict $M_r$ as a function of $\sigma_m$, $\sigma_d$, and cell pressure (CP). Four different functions are calculated automatically, as required by AASHTO and NCHRP procedures.

The MRT-300 can test specimens with a 70 mm, 100 mm, or 150 mm diameter, although it is recommended to use a smaller system for 70 mm diameter specimens, such as the GCTS Electro-Pneumatic Resilient Modulus System (MRT-50). All standard systems include the required dual external deformation sensors with supports and internal/external load cell.

# Poly-Axial Testing System

## SPAX-2000

- Tests rectangular specimens with 75 mm sides and 150 mm height
- Capable of applying 5 MPa and 2 MPa as the maximum major and minor stresses, respectively
- Independent stress or strain closed-loop digital servo control of each of the three axes
- Front and back hinged doors swing open for easy specimen access
- Internal load cells are rigidly attached to upper and side loading platens
- Especially well-suited for $K_0$ and plane strain testing
- Complete turn-key system
- Systems manufactured to customer specifications
- Can perform true triaxial test on unsaturated soils


## Specifications

| | |
|---|---|
| Max. Major Stress | 5 MPa |
| Max. Minor Stress | 2 MPa |
| Specimen Side Dimensions | 75 mm by 75 mm |
| Specimen Height | 150 mm |

## Accessories

1. Set of non-contracting deformation sensors for measurement of normal displacements.
2. Ultrasonic velocity measurement system.
3. Special ultrasound platens made to customer specifications.
4. PCP-2000 Unsaturated testing upgrade

For more accessories, please contact GCTS.

## Description

The GCTS Poly-Axial Testing System (SPAX-2000) includes four hydraulic load rams, each equipped with LVDTs for independent computer control of each platen. Stress or strain can be used as the feedback control. With this configuration, the specimen can remain centered, minimizing end platen friction. This is accomplished by controlling the deformation rate of one LVDT on each plane and forcing the opposing LVDT on each plane to mimic the deformation rate of the controlled LVDT.

Each of the horizontal loading rams has an internal load cell due to the possibility of end platen friction at the top and bottom porous stones, which is more likely if the specimen exhibits significant non-homogeneity. The load cell on the bottom vertical loading is omitted because the side platens are smooth and can be lubricated, making end platen friction a small issue for this direction. Pore pressure is measured at the top and bottom specimen ends.

Stresses and strains in the third direction are applied through chamber fluid pressure. A volume change device is used to measure and control the strains in this direction. Optional proximity sensors can also be used to measure deformations in this direction.

# Residual Ring Shear Testing System for Soils

## SRS-150

- Harmonic Drive motor technology for computer-controlled, zero backlash, continuous rotational speed range from 0.001 to 360 degrees per minute
- 300 N-m continuous torque capacity
- 10 kN axial load capacity
- 1,000 kPa maximum normal stress
- 1,300 kPa maximum shear stress
- Infinite rotational stroke
- Compact design: loading frame and motor fit inside the rolling cart for easy specimen preparation
- Suction control panel to perform unsaturated tests
- Accepts 150 mm (6 in.) OD & 100 mm (4 in.) ID annular specimens (98 $cm^2$ effective simple area)

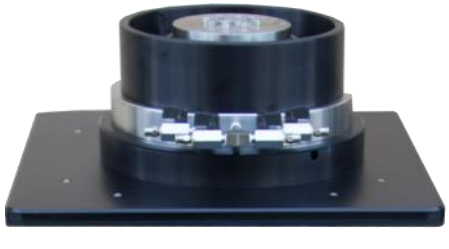

## Specifications

| | |
|---|---|
| Axial Load Capacity | 10 kN |
| Torque Capacity | 300 N-m |
| Stroke | 100 mm |
| Max. Specimen Outside Diameter | 150 mm |
| Max. Specimen Inside Diameter | 100 mm |
| Max. Specimen Height | 30 mm |

## Accessories

1. Pressure cell for SRS-150 ring shear apparatus
2. Top and bottom 150 mm OD & 100 mm ID loading platens for unsaturated soil testing
3. Pressure control panel and pressure chamber for unsaturated soil testing at suctions up to 1,500 kPa
4. Upgrade with optional bender element transducers available

For more accessories, please contact GCTS.



## Description

The GCTS Residual Ring Shear Testing System for Soils (SRS-150) is a fully automatic electro-pneumatic and servo-controlled testing system used for determining the drained residual strength of continuously sheared soils. The SRS-150 ring shear apparatus was developed using the Harmonic Drive™ motor technology for a true continuous shearing rate without inherent backlash found in gear assemblies of other ring shear devices.

The Harmonic Drive™ shearing actuator allows for a large range of shearing rates at very high resolutions and a large torque capacity. The SRS-150 is capable of applying shearing rates ranging from 0.001 to 360 degrees per minute continuously without backlash for replication of true in-situ strain rates during failure. It is fitted with an electrical slip ring, which allows for unlimited continuous specimen shearing through multiple full rotations to measure the full residual strength.

The SRS-150 is capable of performing “multi-stage” tests where a sample is consolidated at a given pressure, sheared to its residual strength, then consolidated to a new pressure and sheared again. This procedure allows for determination of the failure envelope using a single specimen.

The device accepts 150 mm OD and 100 mm ID samples for testing granular materials. The system components are conveniently placed inside the rolling cart for mobility and ease of specimen preparation.

# Soil-Water Characteristic Cell

## SWC-150

- Simulates vertical in-situ pressure state
- Tracks volume changes
- Tracks water content
- Applied suctions up to 1,500 kPa
- Both drying (de-adsorption) and wetting (adsorption) curves
- Dual pressure gauges and regulators for precise pressure control
- Stainless steel construction with hand-operated knobs for fast setup
- Pressure compensator on the loading ram
- Flushing ability and measurement of diffused air
- Optional hanging column for applying suctions below 5 kPa
- Optional heater for preventing vapor condensation inside the cell
- Optional null-type initial suction measurements on undisturbed specimens available


## Specifications

| | |
|---|---|
| Applied Suction | 1,500 kPa |
| Max. Specimen Diameter | 75 mm |

## Accessories

1. Top and bottom SWC platens with bender element sensors for measuring shear wave velocity in soil
2. Ultrasonic velocity measurement system
3. Deformation gauge
4. Convection heater
5. Pressure booster

For more accessories, please contact GCTS.

## Description

The Fredlund SWCC Device (SWC-150) is a simple and flexible unsaturated soil testing apparatus to measure the soil water characteristic curve while applying various stress states.

The SWC-150 can be used to obtain the complete soil-water characteristic curve (SWCC) for a soil sample. The Fredlund SWCC device allows the operator to control matric suctions from near zero values up to 1,500 kPa (215 psi), and is capable of applying one-dimensional loading, $K_o$, to a specimen with a diameter up to 75 mm. The device is economically priced and is a complete turn-key system.

The cell is constructed from stainless steel and includes the necessary plumbing and valves for periodic flushing and measuring of diffused air. Several different high air-entry-value (HAEV) ceramic stones can be easily interchanged. Dead weights can be used to apply normal stresses. An optional pneumatic load frame loader is available to apply larger stresses.

Through its convenient design, the apparatus allows the use of a single soil specimen to obtain the entire SWCC with any number of data points.

# Soil Axial Strain Measurement Device

## DEF-6100-AXC

- Standard available sizes include: 70 mm, 100 mm, and 150 mm diameter specimens (other sizes optionally available)
- Horizontally guided to prevent rotation
- Made of acrylic with lightening holes for minimum mass
- Can be used for Uniaxial or Triaxial testing
- Measures axial strains directly on specimen
- Very easy to setup and use
- Meets NCHRP requirements

DEF-6100 device shown with optional DEF-SRCP*

## Specifications

| Part No. | Specimen Diameter |
|---|---|
| DEF-6100-AXC-070: | 70 mm |
| DEF-6100-AXC-100: | 100 mm |
| DEF-6100-AXC-150: | 150 mm |

## Description

The GCTS Soil Deformation Device (DEF-6100-AXC) measures axial strain directly on a specimen, providing very accurate results. The device consists of upper and lower support rings that have a low weight but high strength. The GCTS Soil Deformation Device is available in both standard and custom sizes.

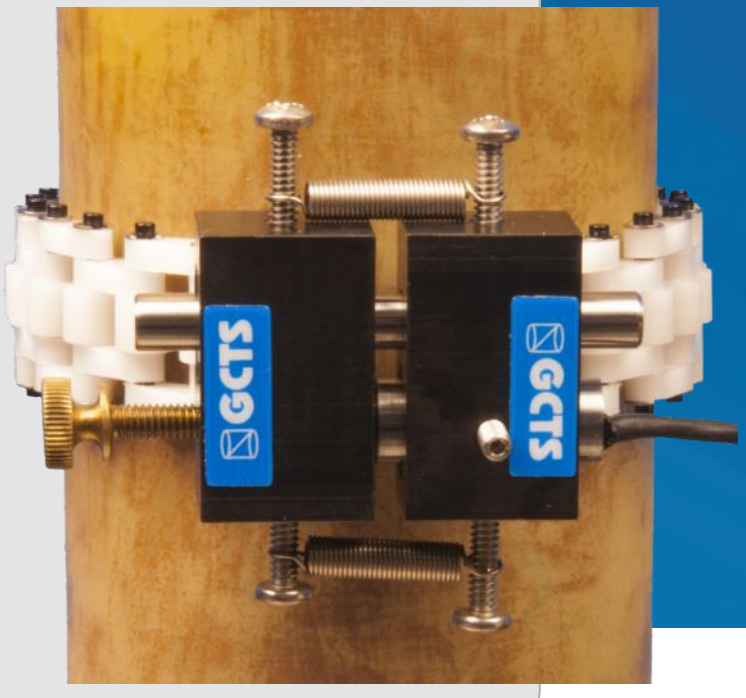
The DEF-6100-AXC Internal Axial Measurement Device includes two soft-tipped axial LVDT holder rings and can be used with submersible or standard LVDTs (used with non-conductive media only).

The Transducer supports are split in two halves, clamped using rubber bands and guided in order to prevent rotation or “folding” while allowing for lateral expansion. For soft specimens, the clamps can be set onto the top and bottom platen to prevent damage to the specimen.

# Soil Circumferential Strain Measurement Device

## DEF-SRCP

- Measures average radial strains
- 2,000 kPa water service
- Accommodates specimens with an initial diameter from 35 mm to 75 mm
- Made of lightweight materials for minimum mass
- Can be used for uniaxial or triaxial testing
- Includes non-contacting sensor
- Very easy to setup and use




## Specifications

| | |
|---|---|
| Resolution | 0.2 µm |
| Deformation range | 5 mm |
| Maximum pressure | 2,000 kPa |
| Media | Water/Oil |
| Excitation | 5 VDC |
| Output | 0-5 VDC |

## Description

The GCTS Soil Circumferential Deformation Device (DEF-SRCP) measures the average change in circumference directly on the specimen, providing accurate radial strain measurements. The device consists of a circumferential roller assembly made with anodized aluminum links and Teflon rollers to ensure smooth displacements.

This material combination has a small mass and high stiffness to minimize device compliance. The DEF-SRCP includes an integrated submersible proximity sensor with 5 mm range. The standard DEF-SRCP can be configured to accommodate specimens with an initial diameter from 35 mm to 75 mm by adding or removing assembly links.

Additional links can be purchased to accommodate specimens with up to 150 mm in diameter. For larger specimens, we recommend using the GCTS Large-Scale Deformation Device (DEF-S1600).

# Large-Scale Deformation Device

## DEF-S1600

- Measures average axial and radial strains on 300 mm diameter specimens
- Waterproof to 2,000 kPa
- Available devices for cylindrical specimens with diameters from 200 mm to more than 1,000 mm
- Can be used for testing soils, asphalt and other materials
- User configurable
- Small strain measurements on large-scale specimens
- Range selection for small, medium, and large radial strains

## Specifications

| | |
|---|---|
| Range | 25 mm |
| Sensor Repeatability | 0.001 mm |
| Excitation | 5 Volt RMS @ 3 kHz AC |

## Description

The GCTS Large-Scale Deformation Device (DEF-S1600) is a device used to measure the circumferential and axial changes on a cylindrical specimen inside a triaxial cell in order to calculate the radial and axial strain in the specimen.

The DEF-S1600 deformation device is composed of two, three, or four DEF-S1610 Axial Deformation Gauges and one or two DEF-SRCP-600 circumferential deformation gauges. Each DEF-S1610 includes one LVDT holder with a 150 mm radius, one road extension holder with the same radius, and one rod extension for measuring the axial strains.

This device measures the axial strains within the middle half of the specimen height to avoid platen end effects. The two holders are attached to the specimen using tension springs and are guided by a precision bearing and light shaft to maintain parallelism. Different size extension rods are available from GCTS to measure axial deformation over different gauge lengths.

Several DEF-S1610 devices can be installed in one specimen to measure the average axial deformation. A minimum of two DEF-S1610 located at 180 degrees from each other should be used.

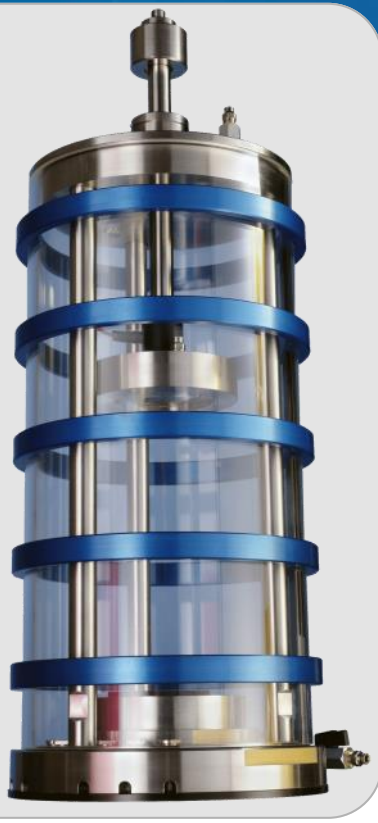
The standard DEF-SRCP-600 device includes a 10 mm (0.4 inch) range water-submersible LVDT. This LVDT can be positioned in three different locations on the device to provide three different deformation ranges. These three different mechanical ranges translate roughly to 10%, 2.5% and 1% radial strain ranges on a 300 mm diameter specimen.

The DEF-SRCP-600 and the DEF-S1610 devices can each be purchased separately if only radial or axial measurements are required for large-scale specimens. Additional units can be easily added at any point if additional measurements are required.

# Soil Triaxial Cells

## TRX-100/200/300

- Stainless steel construction
- 1,000 kPa (150 psi) capacity
- External cell wall with internal tie rods
- Top and bottom drainage
- Stiff, low-friction loading piston and graphite seal
- External or internal load cells and LVDTs
- Three standard triaxial cells for 70 mm, 100 mm, and 150 mm specimen diameters
- Optional large-scale triaxial cells for testing specimens up to 1,000 mm (40 in.) diameter available
- Optional cell with 2,000 kPa capacity available



## Specifications

| | 100 | 200 | 300 |
|---|---|---|---|
| Max. Axial Load | 25 kN | 50 kN | 100 kN |
| Max. Specimen Diam. | 70 mm | 100 mm | 150 mm |
| Max. Specimen Length | 175 mm | 250 mm | 375 mm |

## Description

The GCTS Soil Triaxial Cell (TRX-100/200/300) is constructed of stainless steel and includes a see-through Plexiglas external cell wall. After a specimen is loaded for testing, the external cell wall is lowered over the cell and fastened into place, resulting in minimum disturbances to the specimen. All the standard triaxial cells can accommodate smaller diameter specimens using optional platens. These triaxial cells accept specimens with a length of approximately 2.5 times the diameter.

Standard units come with a set of top and bottom stainless steel or anodized platens, porous stones, all necessary O-rings, and reinforced metal rings. The ductility of metal rings offers an additional safety factor in case the acrylic cell wall is accidentally damaged. At the bottom of the cell are valves and quick disconnect fittings for top drainage and pore pressure, bottom drainage and pore pressure and chamber filling and emptying. Five bleed ports located at the high points are also provided to completely remove any remaining air bubbles while filling the cell with water.

The loading piston diameter for the 70 mm cell is a 15.9 mm (5/8 in.) stainless steel shaft and 25.4 mm (1 in.) for the 100 mm and 150 mm cells. A stainless steel, extra-precision ball bearing guides the loading shaft. Both swivel loading buttons and rigid threaded connectors are provided with these cells. The swivel buttons allow the top cap to rotate during loading.

The threaded adaptor is used for a rigid connection, which forces the axial deformation to be uniform. Stress reversal is easily applied with this adaptor.

Up to eight feedthrough ports to connect internal instrumentation can be added as an option. Other optional devices are available upon request.

# Large-Scale Soil Triaxial Cell

## TRX-600

- Accepts specimen with a 300 mm diameter and 700 mm height
- 2,000 kPa (300 psi) pressure capacity
- Stainless steel construction
- Light-weight reinforced acrylic cell wall
- Top and bottom specimen drainage
- Low-friction graphite seal
- Hardened stainless steel loading piston and extra-precision ball bushing guide
- Rigid loading connection for stress reversal
- External or internal load cells and LVDTs
- Feedthrough connectors for GCTS axial and radial strain measurement devices and other transducers
- Complete testing systems are available from GCTS


## Specifications

| | |
|---|---|
| Pressure Capacity | 2,000 kPa |
| Max. Specimen Diameter | 300 mm |
| Max. Specimen Height | 700 mm |
| Overall Cell Height | 1,400 mm |
| Overall Cell Diameter | 660 mm |

## Accessories

1. Large-scale circumferential measurement device.
2. Submersible instrumentation for 300 mm diameter specimens to measure axial strains.
3. Signal conditioning unit for three LVDTs with ± 10 VDC output.

For more accessories, please contact GCTS.

## Description

The stainless steel-constructed Large-Scale Soil Triaxial Cell (TRX-600) is ideal for static or dynamic testing of soils with coarse particles. It is also well suited for testing ballast material composed of crushed gravels and other sharp particles.

The TRX-600 accepts specimens with diameters up to 300 mm and length of 700 mm. The standard unit features a light-weight, see-through Plexiglas cell wall reinforced with anodized aluminum rings. The ductility of metal rings offers an additional safety factor in case the acrylic cell wall is accidentally damaged.

The TRX-600 includes a stainless steel, extra-precision ball bearing to guide the loading shaft. Both swivel loading buttons and rigid threaded connectors are provided with this cell. The swivel buttons allow the top cap to rotate during loading. The threaded adaptor is used for a rigid connection, imposing a different boundary condition by forcing the axial deformation to be uniform. Stress reversal is easily applied with this adaptor. A split compaction mold is also included with this cell.

Available options include the GCTS DEF-S1600 Submersible internal instrument to measure axial and radial strains. This device can be provided with two or three axial gauges and one or two circumferential gauges. Also available are pneumatic vibratory compactors with adjustable frequencies. Complete testing systems, including dynamic load frames, pressure panels, and servo control, can be provided by GCTS. GCTS can also provide reinforced sample membranes that minimize punctures and membrane penetration while offering a low stretch resistance.

# Double-Walled Unsaturated Soil Triaxial Cell

## TRX-2C

- Stainless steel construction
- 2,000 kPa (300 psi) capacity
- Double external cell wall (internal tie rods)
- Top pore-air, bottom pore-water, bottom flushing, and independent internal and external cell pressure/drainage ports
- Sealed electrical feedthrough connectors for internal instrumentation including deformation device, ultrasonic velocity, mid-plane pore pressure, and other sensors
- Specimen platens with easily interchangeable HAEV ceramic discs
- Stiff, low-friction loading piston and graphite seal
- High-ductility metallic reinforcement rings

## Specifications

| | |
|---|---|
| Pressure Capacity | 2,000 kPa |
| Max. Specimen Diameter | 75 mm |
| Max. Specimen Height | 185 mm |

## Accessories

1. Set of 70 mm diameter specimen end platens upgradable with bender elements.
2. Ceramic stone mounted on stainless steel ring for quick installation/removal.

For more accessories, please contact GCTS.

## Description

The GCTS Unsaturated Soils Triaxial Double Wall Cell (TRX-2C) is designed with two cell walls to prevent differential pressure changes for the inner wall while changing the confining pressure, thus eliminating volume change errors due to cell expansion typically associated with single cell units. This also limits the amount of disturbance caused in the specimen, as the outer cell wall is lowered around the specimen after it is prepared.

The triaxial cell is constructed of stainless steel and accommodates cylindrical specimens up to 70 mm in diameter with a length to diameter ratio between 2 and 2.5. The system features a see-through, acrylic, external double cell wall and a stiff loading piston with a low friction graphite seal.

At the bottom of the cell are ball valves and quick disconnect fittings for top drainage and pore water pressure, bottom drainage and pore water pressure, bottom flushing, internal confining fluid pressure and external confining fluid pressure. A bleeding port is also provided at the top of the cell. Included are an internal spherical seat loading connection set and a rigid loading connection for stress reversal.

The standard unit also includes four sealed electrical feedthrough connectors to accommodate different type of sensors, like load cells, LVDTs, ultrasonic transducers, etc. The unit also includes four plugs for sealing the feedthrough connectors while not in use.

# Pressure Control Panel

## PCP-200

- Complete pressure control for the GCTS triaxial system
- Single pressure gauge to measure accurate pressure differences with 2.5 kPa (0.5 psi) resolution
- Includes venturi vacuum pump
- 1,000 kPa maximum pressure
- 150 cc volume capacity with a resolution of 0.01 cc
- Graded water level sight tubes for electronic and manual readings
- Mounting platform for pressure transducers and necessary plumbing


## Specifications

| | |
|---|---|
| Pressure Capacity | 1,000 kPa |
| Volume Capacity | 150 cc |
| Resolution | 0.01 cc |

## Description

The GCTS Pressure Control Panel (PCP-200) provides complete pressure control for triaxial systems. The volume change device can be used for both triaxial tests and permeability tests. The system meets ASTM D3999-91 and D5311-92 pore-water pressure measurement compliance requirements and has a pressure capacity of 1,000 kPa.

## Accessories

1. Computer control of confining pressure.
2. Computer control of back pressure.
3. Computer control of pore-air pressure.
4. Digital servo controller and acquisition system.

For more accessories, please contact GCTS.

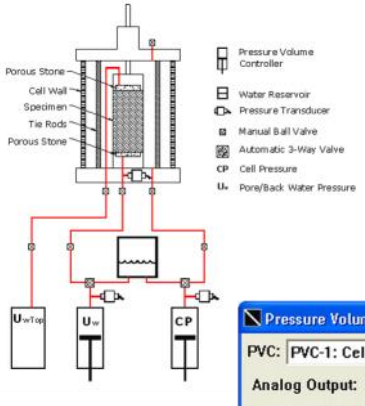
# Pressure Panel & Pressure-Volume Controller

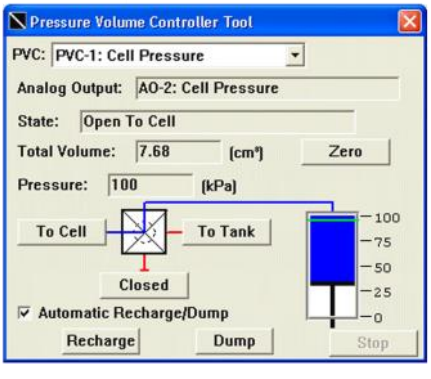
## PCP-2000

- 0.25% pressure and 0.1% volume precision
- Static or pulsating pressure application at up to 10 Hz
- Flow velocities from 0 to 2,000 cc/min
- 300 cc to 3,000 cc capacities
- Select from available models ranging from 1 to 3.5 MPa
- Stainless steel construction mounted on steel cabinets complete with calibration gauge, water reservoir, vacuum pump, and necessary plumbing
- Stiff construction for very low compliance
- Turn-key pressure panel with de-airing tank, vacuum pump, precision gauge, and more
- Electro-actuated ball valves for automatic operation


## Specifications

| | |
|---|---|
| Pressure Capacity | Up to 3,500 kPa |
| Volume Capacity | Up to 3,000 cc |
| Pressure Transducer Precision | 0.25% |
| Volume Transducer Precision | 0.1% |




## Description

The GCTS Pressure Panel & Pressure-Volume Controller (PCP-2000) has been designed to provide accurate system pressure and volume control. The system uses hydraulic or pneumatic digital servo control to maintain the necessary test conditions.

The durability of hydraulic and pneumatic control avoids vibrations, achieves higher pressures, and is more durable and responsive than conventional stepper motor devices. A pressure transducer or external LVDT provides a direct feedback response used in the control process.

The PCP-2000 Pressure Panel includes all the necessary components required for testing soils. System operation is integrated with the easy-to-use GCTS software, which has the flexibility to follow simple or complex test conditions. The system can be used to control confining, internal, or back (pore) pressure.

Check with GCTS to determine material compatibility. Using multiple Pressure-Volume Controllers enables the user to perform complete back-pressure saturation, consolidation, and triaxial loading procedures automatically without user intervention. Other test procedures can also be fully automated using the included electro-actuated ball valves.

# Standalone Pressure/Volume Controllers

## ePVC Series

Mobile Control Application

Small, Medium, and Large Volume Models

## Description

The ePVC Series of Standalone Pressure / Volume Controllers provide independent control of pressure or flow for a variety of applications. These controllers are electro-mechanical and only require standard 100-240 VAC, 50/60 Hz power for operation - no hydraulic power is needed!

The ePVCs feature closed-loop servo-control of the pressure or volume. They include large volume capacities and strokes with direct, integrated transducers for precise volume measurements. This prevents gear backlash and control errors caused by motor encoders commonly found in other systems.

These controllers are ideal for the control of confining pressure in triaxial tests, head pressure in permeability tests, fluid flow or pressure in hydro-fracture tests, or even the axial load in long-term creep tests. They can also be used for any industrial process where precise programming of pressure or flow rate is required. They can also be used to measure flow in permeability tests or measure volume change in triaxial tests while applying the prescribed pressure.

GCTS also offers continuous-flow models for use when a pause to recharge the intensifier is unacceptable. With no pause at the end of each intensifier's stroke, true continuous flow is provided.

A front panel keypad is provided to easily set any desired pressure or flow rate manually. The ePVCs also include interface programs for PC and mobile devices (iOS, Android and Windows) to remotely set pressures or flow rates. Multiple units can be linked through our CATS software for simultaneous control as required by triaxial, hydro-fracturing, creep, and other testing applications.

The ePVCs also include six analog input channels with data acquisition that can be programmed to record data from external sensors (signal conditioning sold separately).

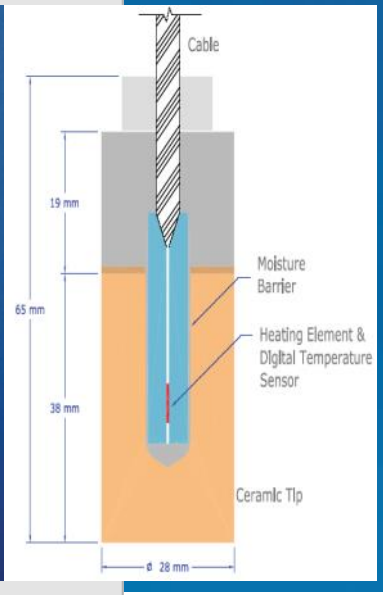
### Small Volume Series

| Stainless Steel Model | Nominal Pressure (MPa) | Nominal Volume (CC) | Resolution (cc) | *Max. Flow Rate (cc/min) |
|---|---|---|---|---|
| ePVC-5S | 5.0 | 180 | 0.001 | 271 |
| ePVC-3S | 3.5 | 260 | 0.001 | 391 |
| ePVC-2S | 2.0 | 463 | 0.002 | 695 |
| ePVC-1S | 1.0 | 823 | 0.003 | 1,236 |

# Fredlund Thermal Conductivity Sensor

## FTC-100

- Digital design
- Transmission of data over 100 m without affecting signal quality
- 1 to 1,000 kPa range
- 5% accuracy
- Accurate for all soil types
- Measurements are unaffected by soil water salinity
- Moisture barrier protects electronics from unfavorable moisture infiltrations
- Special burial cable permits long-term installation in moist environments
- 16–channel multiplexer accepts four or more types of sensors including suction sensors
- 12V battery pack and a solar panel can be provided as power supply


## Specifications

| | |
|---|---|
| Range | 1 to 1,000 kPa |
| Cable Length | 10 m per sensor |
| Controller | 16 channels |
| Power | 12 VDC |

## Accessories

1. 12-volt rechargeable battery for supplying power for the sensor operation
2. Calibration cell for a single FTC-100 sensor made of anodize aluminum. Includes 5 bar ceramic stones, seals, and fitting for 1/4 inch OD tubing

For more accessories, please contact GCTS.

## Description

The Fredlund Thermal Conductivity Sensor (FTC-100) is an unsaturated soil sensor for measuring soil suction and temperature in the field. The system consists of ceramic-tipped sensors, a suction sensor controller (data logger), and a power supply. Typically, 16 sensors are included with 10 m (30 ft.) of cable for each sensor. The data logger consists of a 16-channel multiplexer that can be connected to a laptop or PC. Power is supplied with a 12-Volt battery pack.

The sensor tip has a miniature heating element and a temperature sensor embedded in the center. The heating curve of the sensor is obtained by sending a controlled current to the heating element. The temperature rise in the sensor after heating depends on the water content of the sensor, which is a function of the surrounding soil suction. Calibration curves developed in the laboratory are provided to obtain the suction corresponding to field measured change in temperature.

# Ultrasonic Velocity Measurement System

## ULT-200

- 40 MHz sampling rate with 16-bit resolution
- Smart software features for accurate measurement of wave velocities
- Ultrasonic velocity measurements of compression and shear waves in asphalt, soil, rock, & concrete specimens
- Digitally controlled pulser and receiver including a switch to automatically select P– or S-wave transducers
- Hardware and software to accommodate P, S1, S2 inputs
- State-of-the-art software for data acquisition, analysis, storage, plotting, & reporting
- Available transducer platens for use inside soil and rock triaxial cells


## Specifications

| | |
|---|---|
| Sampling Rate | 156 Hz—40 MHz |
| Resolution | 16 bit |
| Inputs | P, S1, S2 |
| Wave Pulse Output | Unipolar 45-100 V |
| | Bipolar 90-200V |
| Max. Input Voltage | ± 500 mV |
| Input Impedance | 5,000-10,000 Ω |
| Output Impedance | 50 Ω |
| Max. Power per Pulse | 10 mJ |

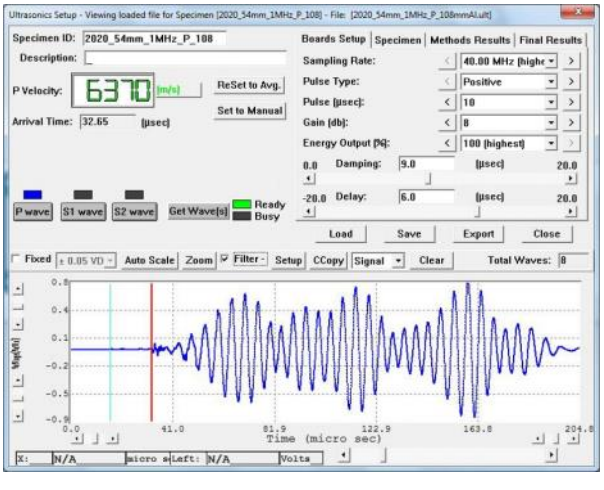
## Description

The ULT-200 Ultrasonic Velocity Test System is a turnkey system and includes everything required to perform Ultrasonic Velocity measurements on laboratory specimens. The new hardware and software utilize the latest technology to allow for precise determination of wave velocities.

With the ULT-200 the user also has the ability to control the pulse signal polarity and number of pulses to stack, this is important in helping to eliminate the influence of the compression wave signals on the relatively weaker Shear wave signals. The ULT-200 system uses a fast-acting pulser that provides excitation to the ultrasonic sensor and an ultra high speed Analog-to-digital converter for storing the resulting waveforms signals. The sampling rate can be selected from 40 MHz to a sampling rate as low as 156 Hz allowing the user to capture a wide range of ultrasonic signals.

Within the CATS Ultrasonic software the user is able to digitally control the receiver and pulser, ensuring an easy setup and high degree of repeatability. This software also allows for automatic measurement while performing triaxial or unconfined shear loading. The ultrasonic data can be collected at any specified interval, such as time, stress, strain or any other test parameter.

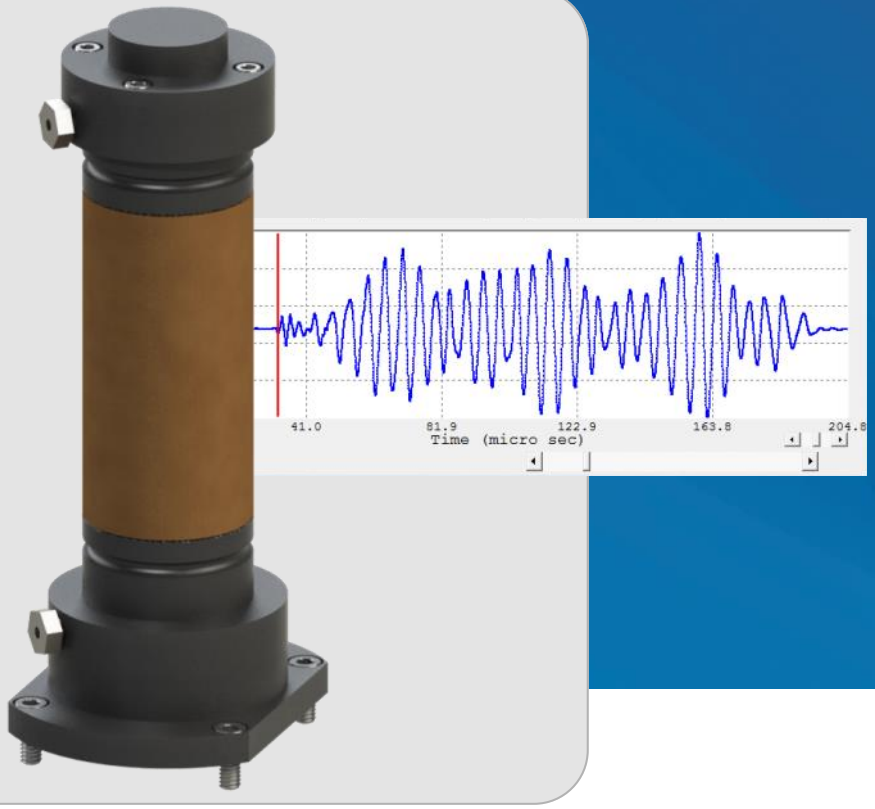
Included with this system is a set of combination platens designed for both P and S wave velocity measurements. Available platens include models for benchtop testing, unconfined loading, soil triaxial loading, and rock (high pressure) triaxial loading.



# Ultrasonic Velocity Sensors

## ULT Platens

- Fully-submersible aluminum construction
- Measures P- and S-wave velocities in soil sample
- All platens have optional bender element for unsaturated soil testing
- Standard platen diameters from 35 mm to 100 mm, with custom sizes available upon request
- Pressure capacity of 2 MPa in water
- Compatible with any ultrasonic measurement device, such as the GCTS ULT-200 system
- Platens available for triaxial, simple shear, torsional shear, hollow cylinder, and unconfined compression tests




### ULT-TRX

### ULT-TSH

### ULT-HCA

## Description

Platens for solid, cylindrical soil specimens with embedded P- and S -wave crystals. Bender element can be added with an additional cartridge that plugs into the platen, making it easy to replace bender elements.

These platens must be used with a compatible ultrasonic velocity measurement device, such as the GCTS ULT-200.

Both saturated and unsaturated tests can be performed using these platens, as HAEV disks may be used. All platens can be fully submerged in water and have a pressure rating of 2 MPa.

Platens are available to perform tests on hollow cylindrical soil specimens.

Platens range from 35 mm to 100 mm in diameter, although special platens can be made to meet customer specifications.

Platens are available for triaxial, simple shear, hollow cylinder, torsional shear, polyaxial, unconfined compression, and resonant column tests.

# Soil Testing Accessories

## ACC-CM Specimen Compaction Mold

ACC-CM Compaction split mold/jacket stretcher for cylindrical specimens with a height of 2.0 times the diameter. Anodized aluminum construction with vacuum port and precision machined spiral grooving for even membrane expansion. Split compaction molds are available for up to 300 mm diameter specimens.

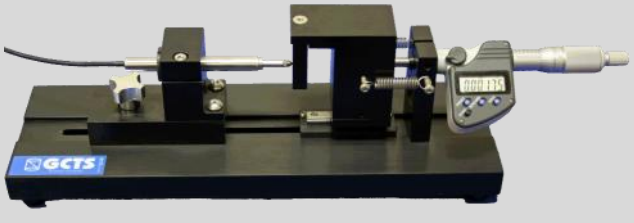
## TRXM Specimen Latex Membranes

Impermeable latex membranes for up to 300 mm (12 in.) diameter specimens. The length of the membranes is sufficient to accommodate tall specimens up to 2.5 times the diameter with overlap for the top and bottom loading platens for O-ring sealing. Membranes are available in 0.3 mm or 0.6 mm thickness (for diameters above 150 mm, membranes are 2 mm thick). Membranes come in a pack of one dozen (12).

Membranes for larger diameter specimens are also available. Please contact GCTS for more information.

## DCD-25 LVDT Calibration Device

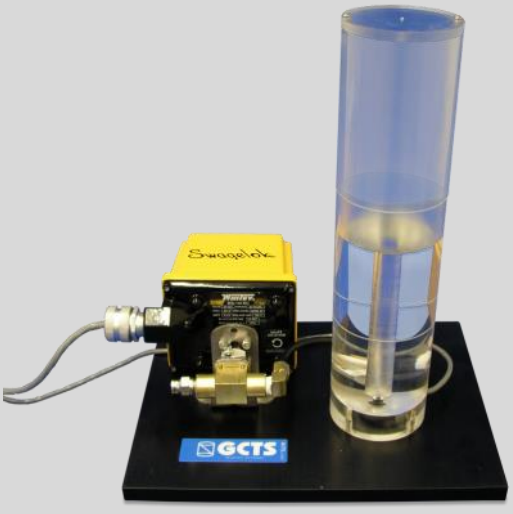
The GCTS LVDT Calibration Device provides a very simple and easy-to-use technique to accurately calibrate a wide variety of LVDTs. The DCD-25 features spring loaded linear displacement to prevent system compliance when reversing directions. The readout is available in both SI and English units. The device has an adjustable mounting bracket that can accommodate LVDTs of most sizes. It provides a calibration range of 25 mm (1 inch) with 0.001 mm (0.00005 inch) resolution.



# Soil Testing Accessories

## DAF-200 Diffused Air Flushing Device

The GCTS Diffused Air Flushing Device is an accessory designed to eliminate diffused air bubbles formed beneath ceramic plates during unsaturated soil testing. The GCTS Diffused-Air Flushing device is connected to the bottom of the ceramic stone via a computer-controlled ball valve. A water level sensor is attached to the bottom of the device. Air flushing is performed by opening the ball valve and moving a sufficient amount of water. The water level is then brought back to the original level by the pressure/volume controller.




## VCD-400 Volume Change Device

The GCTS Volume Change Device (VCD-400) is equipped with a frictionless rolling diaphragm and an internal LVDT guided by a ball bearing, which enables volume change measurements with no pressure differential.

| | |
|---|---|
| Resolution | 0.01 cc |
| Stroke volume capacity | 400 cc |
| Pressure capacity | 2,000 kPa |
| Excitation | 5 VAC @ 3 kHz |
| Output | 2.6 V/V (approximately) |
| Automatic 4-way directional valve control | 24 VDC |
| Operation | **VCD-400A**—Automatic<br>**VCD-400M**—Manual |


## Installation & Training

GCTS has a highly knowledgeable and professional staff who are capable of training your system operators regardless of the operator's level of familiarity with the systems.

Our training staff has decades of experience ranging from commercial to high-level research. They will guide your operators step by step to ensure they are fully comfortable with the entire testing process. Our team is also available to help with system installation and maintenance. Short courses are also periodically offered at GCTS facilities. Please contact GCTS to schedule an appointment.

# Digital Signal Conditioning and Control Units

## SCON-1400/3000

- 16 or 24 bit A/D resolution and 100 kHz conversion rate with track-and-hold
- Adaptive digital servo control with Windows™ interface software
- Accepts Universal Digital Signal Conditioning modules for load cells, LVDTs (AC and DC), pressure sensors, or other analog input signals
- Internal and external temperature monitoring


| Specifications | SCON-1400 | SCON-3000 |
|---|---|---|
| Resolution | 16 bit | 24 bit |
| Max. Analog Inputs | 4 AC, 4 DC/SG | 23 Universal* |
| Max. Analog Outputs | 4 (max. 2 servo outputs) | 23 Universal* |
| Microprocessor | 800 MHz | 3.4 GHz |
| Maximum Control Loop Rate | 4,000 Hz | 10,000 Hz |
| Max. Power | 0.4 kW | 1.0 kW |
| Interface | Wi-Fi, USB, TCP/IP | Wi-Fi, USB, TCP/IP |

* Inputs and Outputs are interchangeable. The total number of inputs and outputs must be less than or equal to 23.

## Description

The GCTS SCON units are complete and self-contained modules that feature integrated microprocessor-based digital servo controllers, a built-in function generator, data acquisition, and digital I/O unit.

By utilizing state-of-the-art Universal Signal Conditioning boards, these systems can accept load cells, pressure transducers, LVDTs, thermocouples, or other analog input signals. Each channel features digital offset and gain and an anti-alias filter. This system also includes “track-and-hold,” which ensures the converted values from all attached sensors represent a single instant in time, eliminating any data skew from delays in the A/D converter.

The signal conditioning electronics are fully digital with settings directly manipulated by the software. Different equipment configurations are saved, which makes it very easy to change any sensor. The digital settings are also protected, eliminating the chance of accidental modifications to sensor calibrations and amplifications. In addition, the systems incorporate automatic sensor recognition that will automatically load the correct sensor setup upon connecting or changing of a transducer. This system also allows for easy creation of virtual sensors based on existing ones with a smaller calibrated range.

Included with these systems is the GCTS CATS Standard Software that is compatible with all versions of Windows™. The standard systems also include calculated inputs from one or several analog channels that can be directly servo controlled or monitored in real time. Any system sensor can then be used to provide advanced servo control with on-the-fly, bumpless transfer, switching between any connected transducer or calculated inputs.

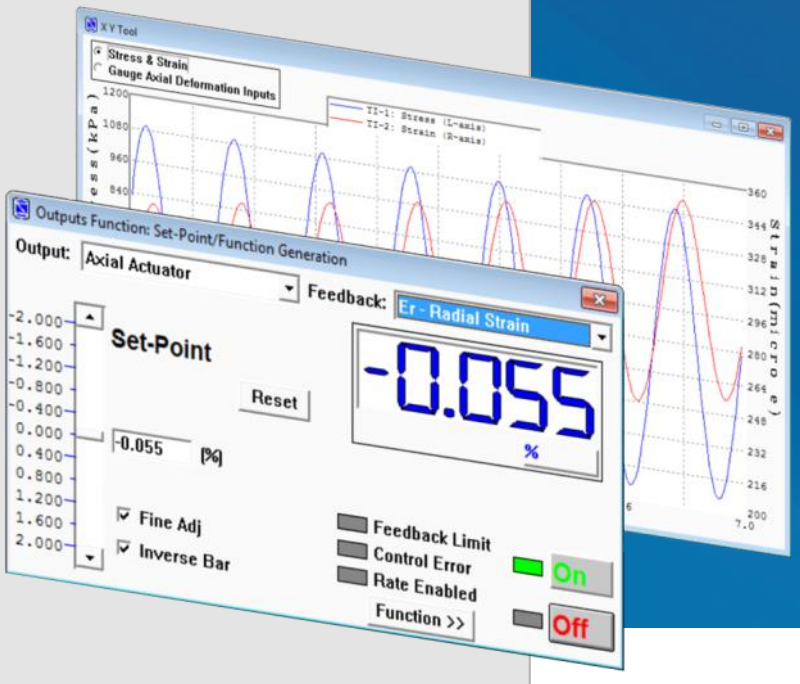
The newest SCON system, the SCON-3000, can wirelessly communicate with the controlling computer, allowing a user with a laptop computer to freely move around the laboratory while remaining in control of the testing system.


SCON-3000

# Advanced Computer Aided Testing Software

## WIN-CATS-ADV

- Advanced servo control from any system sensor or calculated variable
- On-the-fly, bumpless transfer and adaptive compensation
- Advanced digital temperature control
- Automatic frequency sweeps
- Independent and synchronized control of up to 10 outputs
- Complete units library including SI, Metric, English and user-defined units
- Real-time graphics of input channels
- Remote monitoring of test through networks
- Application programs include Direct Shear, Simple Shear, Triaxial, Resilient Modulus, Resonant Column, Hollow Cylinder, and more



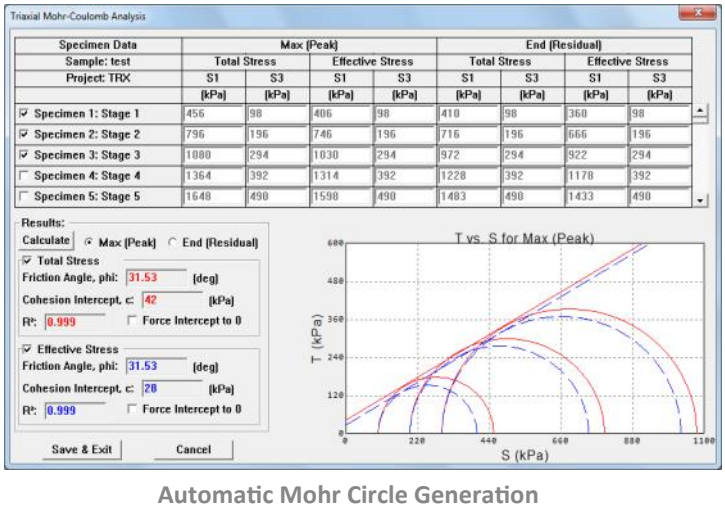

## Description

The GCTS Advanced Windows™ compatible software, coupled with SCON electronics, is the most advanced Geotechnical testing software available today. This software has simplified the operation of our instruments, allowing the user to directly program test-calculated parameters in the units of interest based on the specimen's dimensions. These parameters are calculated in real-time and are available for display, graph and control. Since GCTS signal conditioning electronics are fully digital, optimization and calibration settings are software controlled. Alternate equipment configurations can be easily saved within the software so that the software can quickly recognize when a sensor has been changed and update with the new settings. All the offset and gain settings are managed by our computer software, reducing the possibility of accidentally changing the sensor calibration. The CATS software includes a digital filter on the sensor inputs to assist in eliminating any noise from the digital signal.

All of our testing systems have been designed to take full advantage of our software and electronics so that all test stages can be automatically performed with minimal user intervention.

The Universal test module of the CATS Advanced software is a very versatile and powerful module that allows the user to establish any test procedure that they wish. It allows the user to simultaneously control up to 10 outputs (synchronous or asynchronous) in any phase, and allows the user to run unlimited phases or test programs.

GCTS offers many application software modules to perform specific test procedures (Triaxial, Direct Shear, Resonant Column, and more), and each module includes the Universal Module to program user-defined tests.

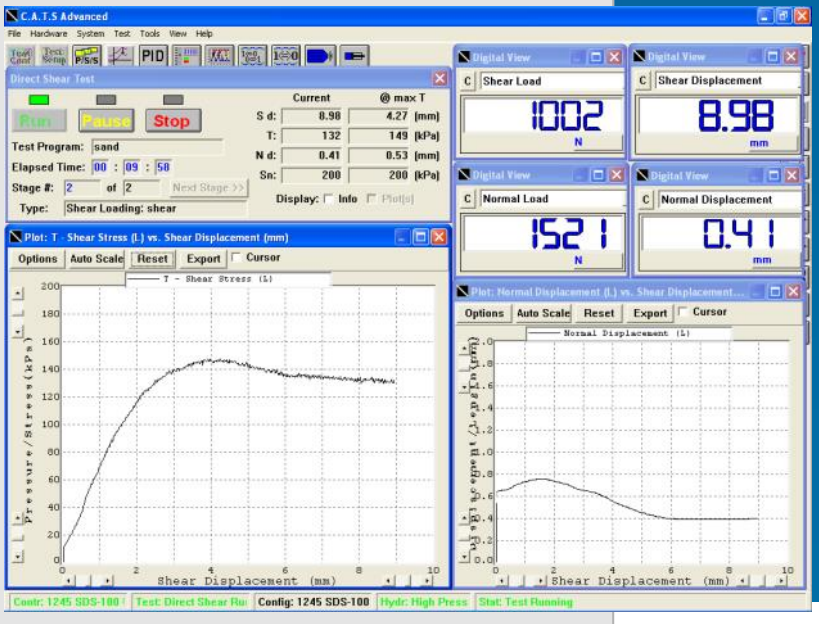



Automatic Mohr Circle Generation

# Application Software Modules

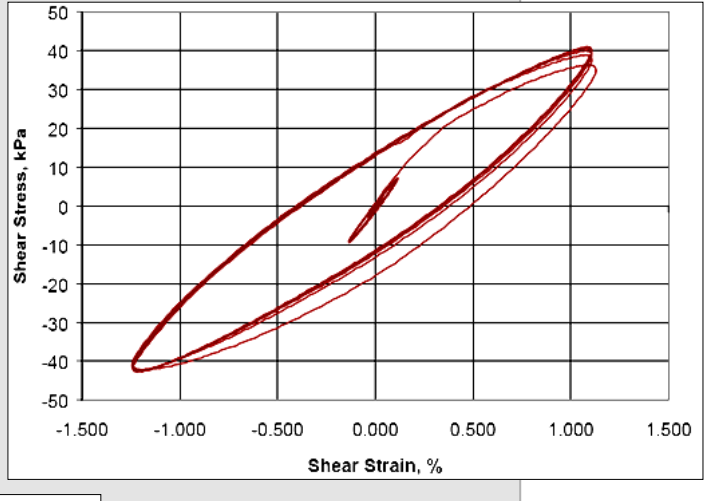
## CATS-DSH

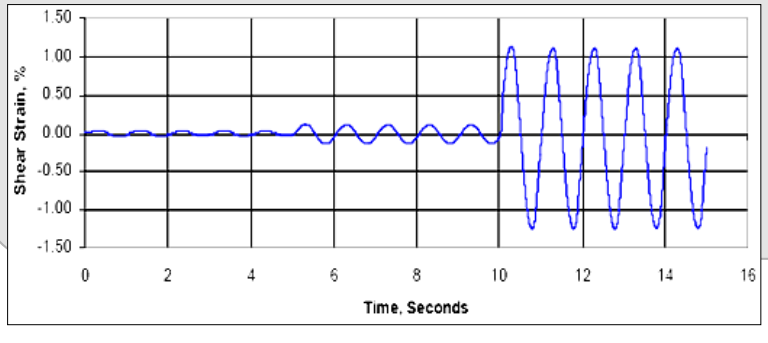
The GCTS Direct Shear Software allows for the complete automation of direct shear tests. This software automatically controls all stages of testing, including consolidation and shearing, and calculates tests parameters in real-time for observation. The user can also easily program custom testing procedures. After testing, the system will automatically calculate the friction angle and cohesion intercept for the sample.




## CATS-SSH

The GCTS Simple Shear Software is used for automatic performance of simple shear tests. All stages of testing, including saturation, consolidation, and shearing, can be completely computer-controlled, so minimal user intervention is needed during testing. The software is very intuitive and easy to use, which reduces training time and minimizes user error. The results, such as cyclic shear modulus and damping ratio, are automatically calculated and plotted.

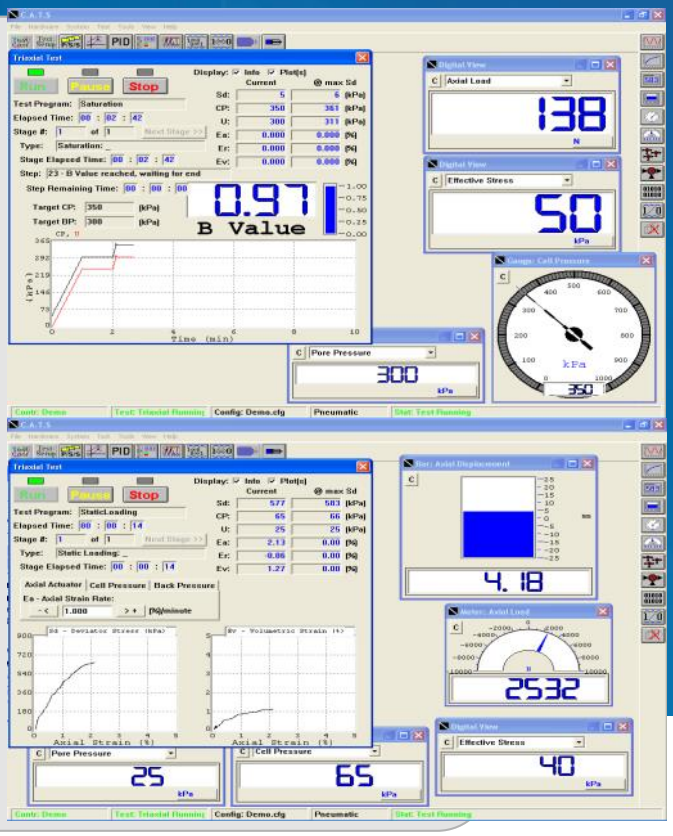


# Application Software Modules

## CATS-TRX-SOIL

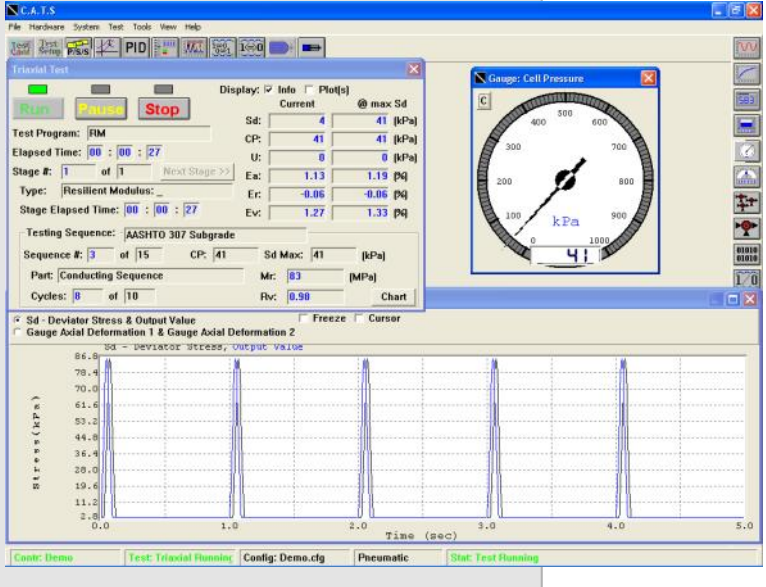
The GCTS Soil Triaxial Software allows for the automatic test execution of soil triaxial tests under static or dynamic loading conditions. This software enables automatic control of all test stages, including saturation, consolidation, and shearing. B values are automatically calculated for saturation, and consolidation can be performed under both isotropic and anisotropic conditions. Dynamic loading conditions can be used to test for liquefaction, resilient modulus, cyclic strength and more. Multi-stage testing can also be performed using this software. The software will automatically create a Mohr-Coulomb model after testing so results can be analyzed quickly.




## CATS-TRX-MRT

The GCTS Resilient Modulus Software automatically performs resilient modulus tests. This software can control all stages of testing, including user-defined, custom stages. The user can also select different waveforms for testing, including sine, haversine, and triangular.

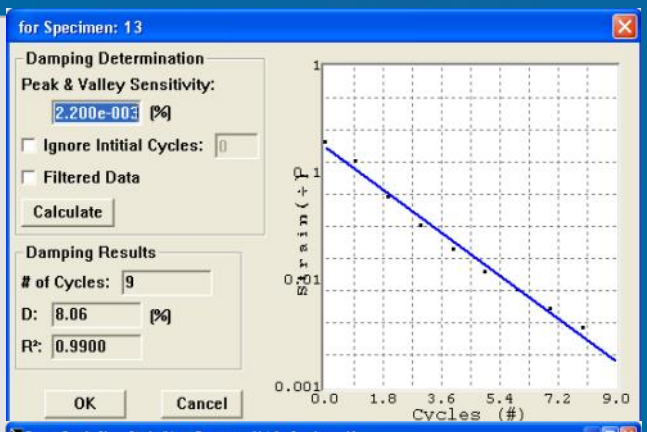
During testing, there is on-the-fly measurement of $R_V$ (to ensure that the two deformation sensors are in agreement) and $M_r$. During export, curve fitting is done to fit the results to models that predict $M_r$ as a function of $\sigma_m$, $\sigma_d$, and cell pressure.

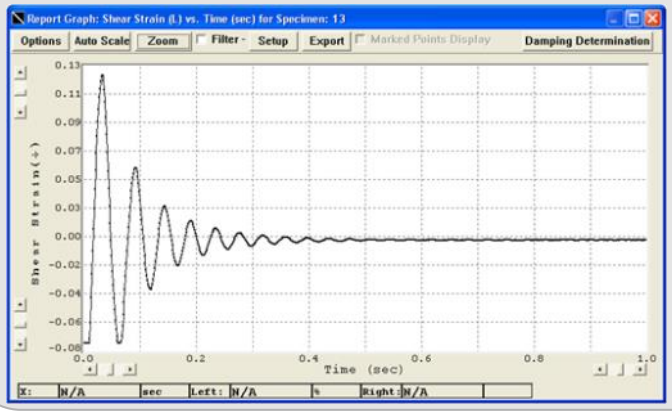


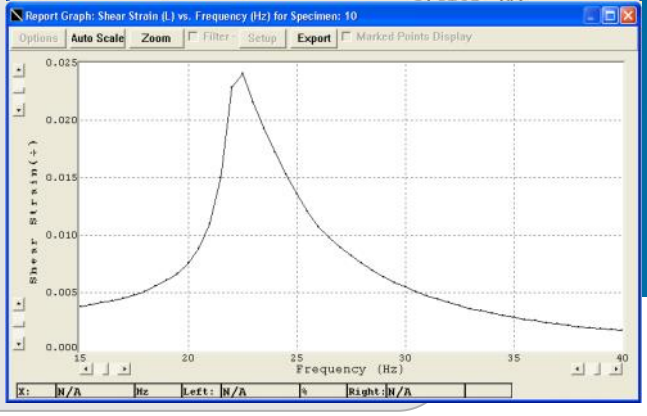
# Application Software Modules

## CATS-RC/TSH

The GCTS Resonant Column and Torsional Shear Software permits the automatic test execution of resonant column and torsional shear tests. The software can automatically determine the resonant frequency and damping ratio and plot the hysteresis plot for the shear stress versus shear strain. The shear modulus and damping ratio properties are automatically calculated. The damping ratio is calculated using several methods, such as “free vibration decay”, “half power ratio”, and “phase angle”.

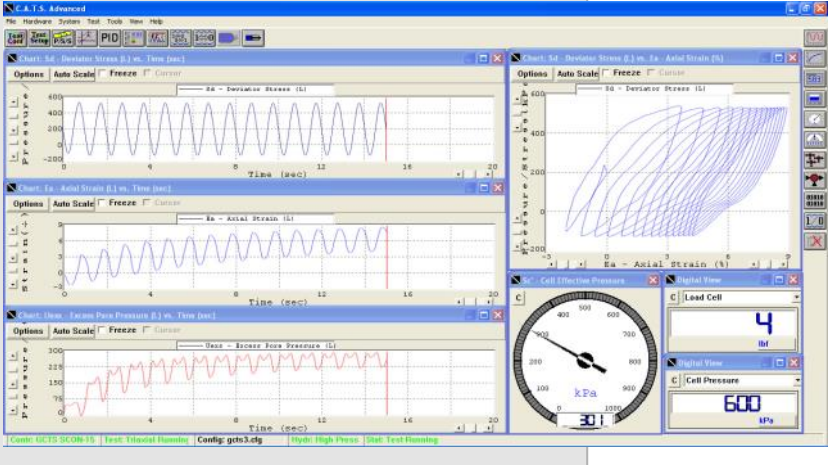


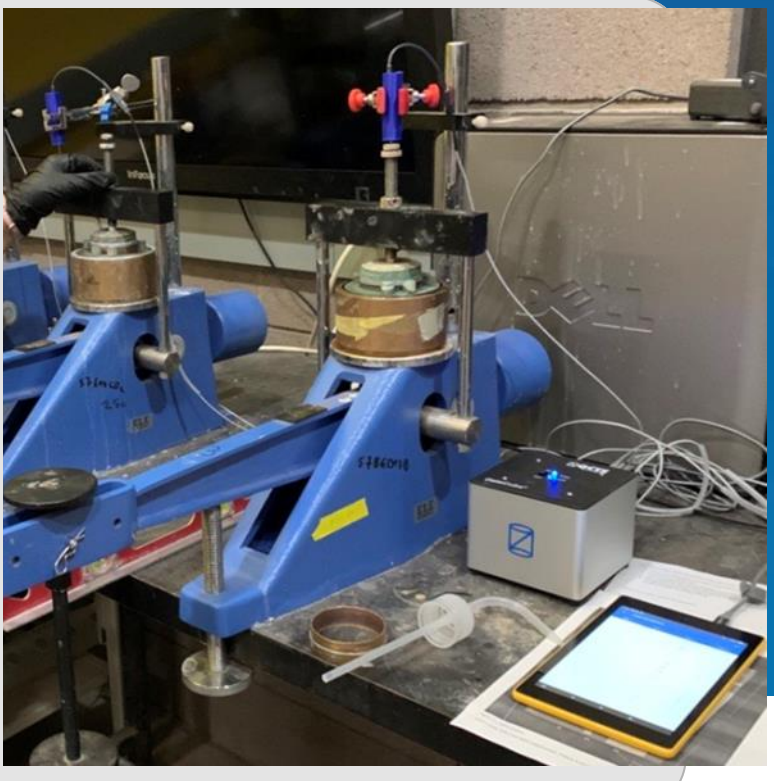

## CATS-HCA

The GCTS Hollow Cylinder Software enables the automatic performance of hollow cylinder tests. The software completely automates the testing system, allowing it to perform all stages of testing, including saturation, consolidation, and loading with minimal user intervention. The software can compute and control the test with a variety of parameters. This includes the principal stress angle (α), allowing it to easily prescribe the rate and magnitude of the $\sigma_1$ rotation. The software can be used to conduct dynamic stress/strain path, plane strain simple shear, liquefaction potential, shear modulus and damping ratio tests, along with many others.



# Consolidation Application


Mobile Application



Laboratory Setup

## Description

The soil consolidation apparatus (consolidometer) used to perform the oedometer test is a quintessential laboratory device for any geotechnical testing laboratory and has largely stayed unchanged since its introduction. GCTS has developed a simple data acquisition unit with an app to bring the consolidometer apparatus into the digital age. The DataCube unit with a deformation sensor can monitor and record the specimen deformation after the load has been applied, eliminating the need for the manual recording. The consolidation app saves and plots the data which can be emailed with a touch of a button.

The analog dial gage on the consolidometer is replaced by a DC type deformation sensor which is then connected to the DataCube unit. One DataCube can accommodate up to four (4) deformation sensors, so a single unit can upgrade up to four (4) consolidometers. The consolidation app on a wireless device (Android, iOS, or Windows) is connected to the DataCube via Bluetooth™ to begin recording the data. After each load increment is applied the app records and processes the data. The sample test results file is shown on the following page.


DataCube

# Remote Monitoring App for iPhone & iPad

## gTest

- Remote monitoring of test status in real-time
- Facilitates transducer and test setup
- Improves productivity and time efficiency
- Alerts if test system reaches warning/abort limits
- Secure encrypted data transmission
- Interface screens for triaxial, direct shear, creep and other GCTS CATS test modules


## Description

GCTS has developed gTest, a remote monitoring application used to display test status in real-time. Current test information can be displayed digitally or graphically from any location. Sensor outputs, hydraulic power supply status, cycle count, and other general test progress can be accessed through a local wireless network or through the internet at remote locations.

The gTest app can be used to facilitate transducer setup where a view of the computer screen might be obstructed, as the test specimen may be placed inside an environmental chamber or some other hard-to-reach place. This application also allows the user to move freely around the testing system and check every one of the test sensors to ensure they are properly working and set at their right position. gTest improves productivity and eliminates requirement for a second person to set up and start a test.

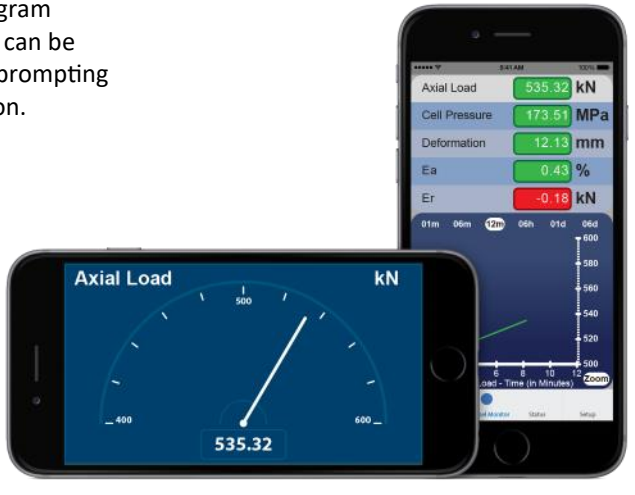
The gTest app can be run from remote locations via the Internet, allowing the user to monitor test status without having to physically be in front of the test system.

This convenient application gives the user the freedom to go back to their office (or home) and be able to continuously monitor the test system performance. Test program sequencing mistakes and glitches in the hydraulic or pneumatic pressure supplies can be detected at their onset, allowing for timely corrective action. With this app, one person can manage multiple test systems even if they are located in different rooms.

This application is also a great tool for university labs. While inexperienced students are performing their own experiments, the lab instructor can easily monitor their progress. Test program errors and abnormal test results can be quickly noticed by a supervisor, prompting the student for appropriate action.

Transmitted data is securely encrypted, providing access to only pre-authorized personnel. If desired, the user can give access to GCTS support engineers allowing for remote service and real-time system optimization.

The gTest application software includes all of the different test mode interface screens offered by GCTS CATS test software modules. Each one offers an automatic screen setup to monitor and graph relevant test data for each particular test mode.



# Notes

# Useful Conversions

### LENGTH

- 1 in = 2.54 cm
- 1 in = 0.0254 m
- 1 ft = 0.3048 m
- 1 ft = 30.48 cm
- 1 cm = 0.3937 in
- 1 m = 3.281 ft
- 1 km = 0.62137 mi

### AREA

- 1 $in^2$ = 6.4516 $cm^2$
- 1 $in^2$ = .00064516 $m^2$
- 1 $ft^2$ = 0.09290 $m^2$
- 1 $ft^2$ = 929.03 $cm^2$
- 1 $ft^2$ = 144 $in^2$
- 1 $cm^2$ = 0.155 $in^2$
- 1 $m^2$ = 10.7638 $ft^2$
- 1 $m^2$ = 1550 $in^2$

### VOLUME

- 1 $in^3$ = 16.387 $cm^3$
- 1 $in^3$ = 16.387x$10^{-6}$ $m^3$
- 1 $ft^3$ = 0.028317 $m^3$
- 1 $ft^3$ = 28316.8 $cm^3$
- 1 $ft^3$ = 1728 $in^3$
- 1 $cm^3$ = 0.06102 $in^3$
- 1 $m^3$ = 35.315 $ft^3$
- 1 $m^3$ = 61023 $in^3$

### FORCE / MASS

- 1 kg = 9.807 N = 0.009807 kN
- 1 kg = 2.205 lb
- 1 lb = 4.448 N = 0.004448 kN
- 1 kN = 224.82 lb
- 1 kN = 101.98 kg
- 1 ton (USCS) = 2000 lb = 8.896 kN
- 1 ton (SI) = 1000 kg = 2205 lb
- Note: g = 9.807 $m/sec^2$ = 32.2 $ft/sec^2$

### PRESSURE

- 1 $kg/cm^2$ = 98.07 kPa
- 1 psi = 6.895 kPa
- 1 psf = 0.04788 kPa
- 1 tsf (USCS) = 95.76 kPa
- 1 $ton/m^2$ (SI) = 9.807 kPa
- 1 $kN/m^2$ = 1 kPa
- 1 atm = 101.33 kPa
- 1 atm = 33.93 ft of $H_2O$

### UNIT WEIGHT

- 1 $kN/m^3$ = 6.366 $lb/ft^3$
- 1 $kN/m^3$ = 0.102 $Mg/m^3$
- 1 $lb/ft^3$ = 0.1571 $kN/m^3$
- 1 $Mg/m^3$ = 9.807 $kN/m^3$
- 1 $ton/m^3$ (SI) = 9.870 $kN/m^3$
- 1 $kN/m^3$ = 0.102 $ton/m^3$ (SI)
- 1 $kN/m^3$ = 0.003183 $ton/ft^3$ (USCS)

### METRIC PREFIXES

- micro (μ) - $10^{-6}$
- milli (m) - $10^{-3}$
- centi (c) - $10^{-2}$
- deci (d) - $10^{-1}$
- hecto (h) - $10^{2}$
- kilo (k) - $10^{3}$
- Mega (M) - $10^{6}$
- Giga (G) - $10^{9}$

### COMMON EQUIVALENTS

- 1 $ft^3$ of water = 62.4 lbf
- 1 gal of water = 8.34 lbf
- 1 $m^3$ of water = 1000 kg
- 1 $m^3$ of water = 9.81 kN
- $\gamma_{concrete} \approx 150\ lb/ft^3$
- 1 kPa = 10.2 cm of water
- 1 gal (USCS) = 231 $in^3$

### TEMPERATURE

- °F = 1.8 (°C) + 32
- °C = (°F - 32) / 1.8
- °R = °C + 459.69
- K = °C + 273.15

# Contact Information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TESTING SYSTEMS