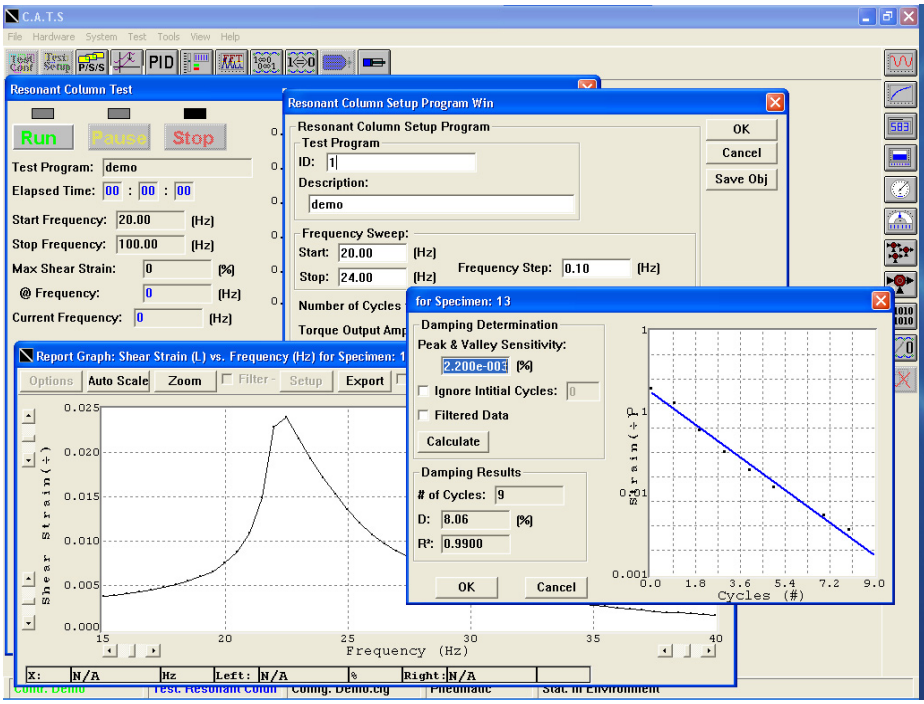
GCTS is committed to designing accurate testing systems by integrating innovative software engineering with advanced hardware. GCTS systems perform at the highest levels of reliability, providing efficient systems that satisfy customer needs and expectations.

GCTS TESTING SYSTEMS

TSH-100 and CATS-RC/TSH
Resonant Column/Torsional Shear Testing System and CATS Module



- **Automatic determination of resonant frequency and damping ratio from frequency sweep and free vibrations data**
- **Capable of performing modulus/damping resonant column and torsional tests on soils and asphalts (solid and hollow specimens)**
- **Floating drive and measurement system to allow for large angular & axial specimen deformations**
- **1,000 kPa (150 psi) maximum confining pressure - higher confining pressures available with stainless steel cell wall**
- **Platens with ultrasonic transducers for P- and S-wave velocity measurements and HAEV discs for unsaturated soil testing available.**
- **Standard systems for 71-mm and 100-mm diameter specimens available. Other platens sizes are also available**
- **Does not require complicated electronics such as an oscilloscope or function generator**
- **Available upgrades of most resonant column systems to a computer-controlled system**

DESCRIPTION

The GCTS TSH-100 Resonant Column/Torsional Shear Testing system combines the features of both resonant column and torsional shear devices into one system so that the effects of soil parameters such as void ratio, confining pressure, strain amplitude, and number of load cycles on shear modulus and material damping can be evaluated. In fact, 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 frequencies up to 250 Hz in first-mode resonance while the bottom is fixed. Non-contacting rotational sensor and a torque transducer attached to the top platen monitor the torsional motion and torque directly. The non-contacting sensor is located on extended arms to amplify the rotational deformation providing a shear strain resolution of 10-6. An optional accelerometer can also be installed to measure large shear strains.

The GCTS System can also perform closed-loop

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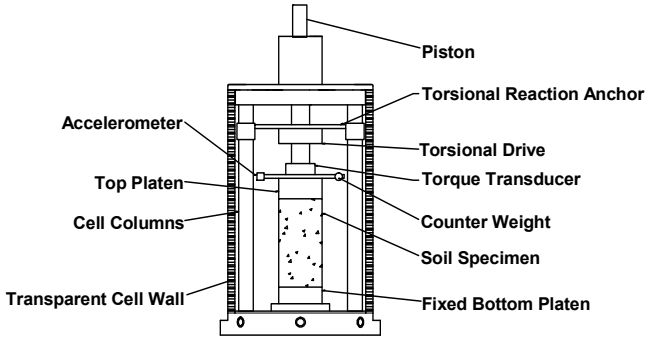
torsional shear tests (stress or strain controlled) on the same soil specimen, either statically or dynamically at up to 50 Hz.



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 allowing large vertical specimen deformations throughout the complete test. Its unique configuration also allows for very large shear deformations of up to ±20°.

GCTS offers two different Resonant Column cells: the TSH-100 and the TSH-200. The TSH-100 accepts specimens with diameters from 38 mm to 70 mm and with lengths of 2 times the diameter. The TSH-200 accepts specimens with diameters from 50 mm to 100 mm.

The motor assembly is floating to accommodate large axial deformations and is supported by the specimen. The standard motor (TSH-MOT-2) for both, the TSH-100 and TSH-200 systems, has a 2.3 N-m torque capacity and weighs 1.8 kg. In addition, GCTS offers a smaller motor for testing soft soils. The TSH-MOT-1 weighs only 0.5 kg and has a 1.2 Nm torque capacity.

The GCTS CATS Resonant Column/Torsional Shear module is part of our 32-bit Windows© software, CATS (Computer Aided Testing System), which is the most advanced geotechnical software available today. This software test module has greatly simplified the operation of instruments and conduction of the resonant column test by allowing the user to directly program test calculated parameters in the units of interest (such as strain) based on the specimen dimensions. These parameters are calculated in real time and are available for display, and/or graphing. Use of calculated test parameters directly eliminates complex and lengthy pre-calculations required in designing test programs. This allows the user to concentrate on the material behavior rather than on the electronics and equipment operation.

The resonant column test module has the ability to automatically calculate these specimen results for each tested specimen:

- Resonant Frequency (Hz)
- Maximum Shear Strain
- Shear Velocity (m/sec)
- Shear Modulus (MPa)
- Damping Ratio – Free Vibration Decay (%)
- Damping Ratio – Half Power Bandwidth (%)
- Predominant Frequency from Free Vibration Data FFT Analysis (Hz)
- Natural Frequency - from Resonant Frequency and Phase Shift (Hz)
- Natural Frequency - from Resonant Frequency and Free Vibration Decay (Hz)
- Natural Frequency - from FFT Frequency and Free Vibration Decay (Hz)

The module requires, at a minimum, that the accelerometer or proximitor(s) that is used for the shear deformation be measured electronically. The torque input for the software can either come from a torque sensor, or it can be a function of the output to the driving motor.

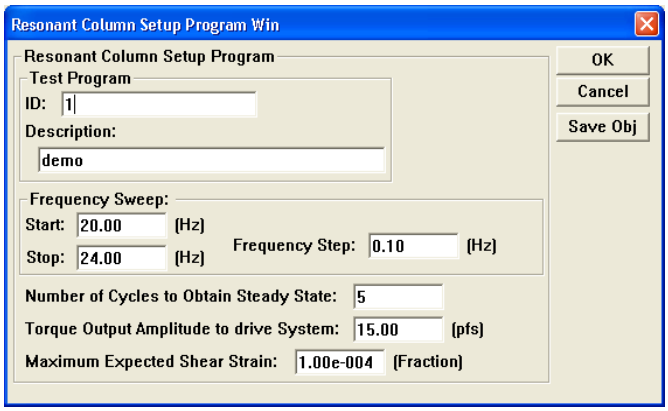
The resonant column test module contains three test inputs, which are calculated in real time, and they are as follows:

Table 1. Standard Calculated Inputs

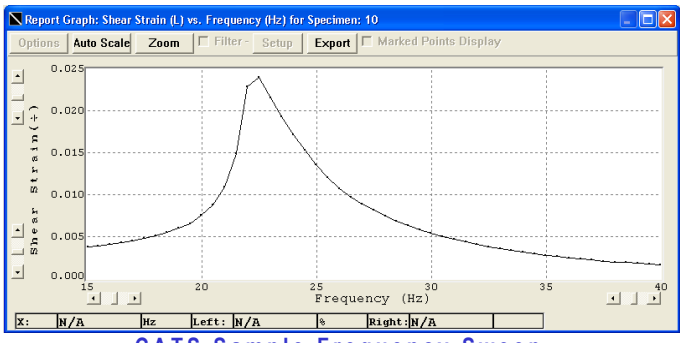
1	t	Torque
2	γ	Shear Strain
3	τ	Shear Stress

The shear strain, γ, is a real-time calculation using the curve fitted results of either the accelerometer or proximitor(s) inputs.

The resonant column module test program is easy to setup, where the user enters the starting frequency, the stop frequency, the frequency step, and few other parameters, and the software will conduct the test automatically without user intervention. This minimizes the number of cycles at each frequency preventing premature specimen degradation.



CATS Software Screen for RC Test Setup



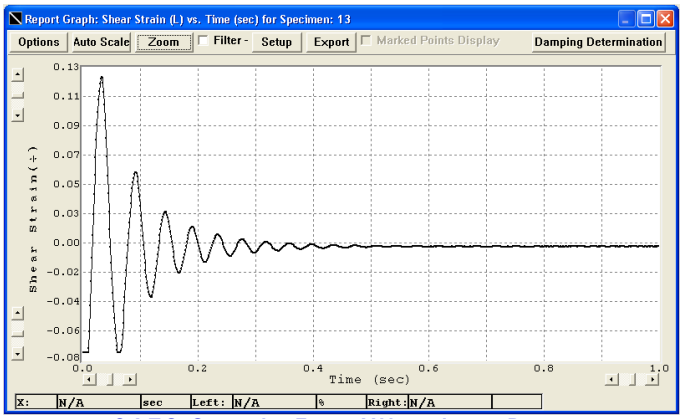
CATS Sample Frequency Sweep

At the end of the test, the software calculates the specimen results and the user can see the frequency sweep on how the resonant frequency was determined.

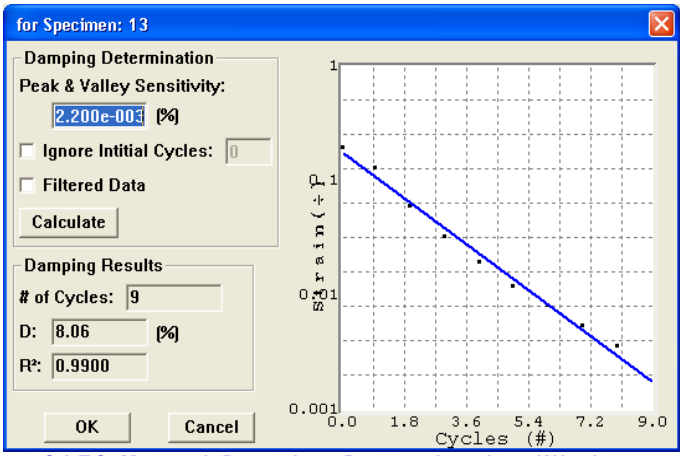
The user can also see the forced vibrations data of the specimen (at the resonant frequency), as well as the free vibrations data, from which one of the damping ratios is determined

Free Vibrations Damping Ratio Determination

If the user is not satisfied with how the Free Vibration Decay Damping Ratio was determined, the user can manually determine it using the damping Free Vibration Decay Damping Ratio Determination Window.



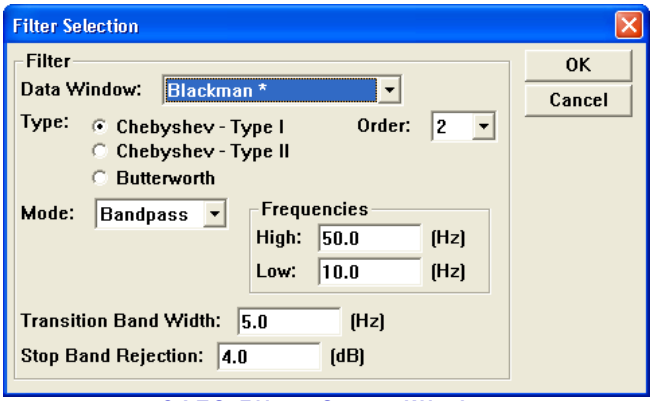
CATS Sample Free Vibrations Data



CATS Manual Damping Determination Window

Filtering

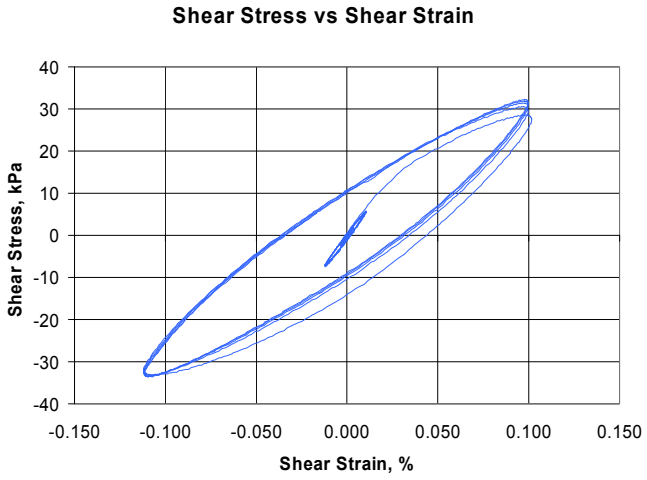
The user can also filter the free vibrations data in case some external noise of a certain frequency (such as AC power) proves to provide too much of an influence on the results. The user can view the FFT (Fast Fourier Transform) of the free vibration results, and then optionally employ a filter in order to reduce the effects of this unwanted signal.



CATS Filter Setup Window

The resonant column module of the GCTS CATS software simplifies the usage of the resonant column/torsional shear apparatus by providing a convenient way to calculate the needed test parameters (shear strain, shear stress, etc.) just by entering in the specimen dimensions and system configuration. It also features an easy to setup test program which reduces the amount of time required for test setup. After a short period a testing the software automatically calculates the specimen results, which makes this software module an invaluable tool in resonant column/torsional shear testing.

Torsional Shear



SPECIFICATIONS

1) TSH-100 RESONANT COLUMN/TORSIONAL SHEAR SYSTEM
Closed-loop digital control of shear torque or angular deformation with floating torsional drive and measurement system to allow for large vertical specimen deformations. Easy-to-use software for the performance and data reduction of resonant column tests with automatic calculation of shear modulus, shear strain, and damping at strain levels from 10% to 10-4%. Allows for application of axial loads for anisotropic consolidation or triaxial testing (requires a loading frame). Complete "turn-key" system.

1.1) TSH-100-CELL
Four column stainless steel construction with external reinforced acrylic plastic cell wall. 1,000 kPa lateral confining pressure capacity. Includes feed-trough connectors for internal angular displacement/velocity, torque, and axial deformation transducers. Also includes lines for top and bottom specimen drainage, stainless steel loading piston, ball bushing guide, and graphite seal. Accepts samples with diameters from 35 mm to 70 mm and with a length of 2.0 to 2.5 times the diameter. Supplied with valves and fittings.

1.2) TSH-MOT-2
Electrical servo motor actuator for the application of torsional loads. 2.33 N-m (peak) and 0.78 N-m (continuous) capacity. +/-25 degrees stroke and up to 250 Hz frequencies. Mounted on internal floating frame to allow for large vertical specimen deformations. 1.8 kg (4.0 lbs) weight.

1.3) TSH-AMP
Motor Controller for closed-loop control of torsional load or angular deformation. PWM servo amplifier for TSH-MOT-2 electrical motor with 2.5 kHz bandwidth. 125 Watt peak power capability designed for use with highly dynamic resonant column motor. Uses a +/-10 volt command input and includes TTL Enable Input to disable the power stage and perform free vibration tests with a minimum of back EMF. 110 or 220 VAC operation (please specify voltage when ordering).

1.4) TSH100-ACC-S70
Test Specimen Accessories for 70 mm Diameter Solid Specimens
Set of test specimen accessories for TSH-100 and end platens with bottom pore water pressure port including the following:
(1) Set of Top/Bottom end platens for 70 mm.
(1) Set of O-rings for sealing membranes to platens for 70 mm specimens.
(1) dozen latex membranes

1.5) TSH-CAL-AL
Resonant column calibration specimen. Anodize aluminum construction. Includes removable added mass.

1.6) SR-DF-FO-250
Fiber Optics Deformation Sensor with Dual Range Output. +/- 0.1 mm low range and +/-6.0 mm high range with 0-15 kHz flat frequency response.

1.7) SR-DF-C375-250
Deformation sensor ±6 mm with 0.25% linearity.

1.8) SCON-1500 DIGITAL SERVO CONTROLLER AND ACQUISITION SYSTEM
Microprocessor based digital servo controller, function generator, data acquisition, and digital I/O unit. Advanced servo control from any system sensor with "on-the-fly bump-less" transfer switching between any connected transducer or calculated input. Configured to read 4 transducers or inputs (8 maximum with additional DSB-111 boards) and 1 control output (4 maximum with additional DSB-121 boards).

1.9) WIN-CATS-STD
32-bit Windows 98/2000/NT/XP software for advanced digital servo control from any system sensor or calculated channel with "on-the-fly" bump-less transfer. Includes calculated channels with user defined equations and Universal test module to perform static and dynamic user defined procedures.

1.10) WIN-TSH
Resonant Column test module to automatically perform conventional resonant column tests. Includes automated frequency sweep for forced vibration procedures, least squares calculation of free vibration damping, Power Ratio damping, and graphing and report generation of test results.

OPTIONS

2) Windows Computer
Windows XP computer for graphical user interface.

3) SR-TQ-2N
Torque sensor +/- 2.0 N-m range.

4) TSH-ANG
Angular deformation sensor with +/-20 degree range for low frequency torsional shear tests. Mounts on torque motor shaft and includes motion amplification wheels. 0 to 1 Hz frequency response.

5) TSH100-ACC-S38
Test Specimen Accessories for 38 mm Diameter Solid Specimens.

6) TSH100-ACC-S50
Test Specimen Accessories for 50 mm Diameter Solid Specimens.

7) TSH100-ACC-H70
Test Specimen Accessories for 70 mm Outside Diameter and 35 mm Inside Diameter Hollow Specimens.

8) TSH-MOT1+AMP
Electrical servo motor actuator for the application of torsional loads. 1.2 N-m (peak) and 0.12 N-m (continuous) capacity. +/-25 degree stroke and up to 250 Hz frequencies. Mounted on internal floating frame to allow for large vertical specimen deformations. 0.5 kg (1.1 lbs) weight. Includes linear servo amplifier for closed-loop control of torsional load or angular deformation. 0-24 VDC output and 500 Hz bandwidth. 40 Watt peak power capability designed for use with highly dynamic.

9) TSH-200-CELL
Four column stainless steel construction with external reinforced acrylic plastic cell wall. 1,000 kPa lateral confining pressure capacity. Includes feed-trough connectors for internal angular displacement/velocity, torque, and axial deformation transducers. Also includes lines for top and bottom specimen drainage, stainless steel loading piston, ball bushing guide, and graphite seal. Accepts samples with diameters from 50 mm to 100 mm and with a length of 2.0 to 2.5 times the diameter. Supplied with valves and fittings.

10) PCP-200 PRESSURE CONTROL PANEL & VOLUME CHANGE DEVICE

11) FRM-10-P LOAD FRAME.

WARRANTY

One (1) year parts and labor.

SHIPPING

Standard shipping volume:	1.2m x 1.0m x 1.0m
Standard shipping weight:	230 kg