Optional frequency ranges

Static to 0.5Hz ✓
Static to 5Hz ✓

Testing Options

Simple shear testing ✓
Direct shear testing ✓

Load capacity options

5kN ✓ 10kN ✓

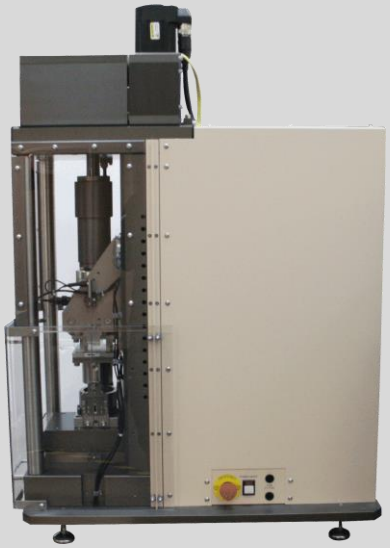
Available specimen diameter

50mm ✓ 70mm ✓
custom ✓

Specimen height

20mm (25mm max) ✓

Electromechanical Dynamic Cyclic Simple Shear (EMDCSS)



What is it?

A cylindrical soil specimen is laterally confined by Teflon coated low friction retaining rings, ensuring a constant cross sectional area. Vertical displacement may be prevented whilst shear force loading is applied (Fig. 1), therefore constant volume conditions are enforced, i.e Simple Shear.

The GDS Electromechanical Dynamic Cyclic Simple Shear (EMDCSS) apparatus is a preferred device for research into dynamic soil behaviour because of its simplicity for the user and its ability to model many types of field loading conditions that are difficult to achieve with other laboratory equipment. The EMDCSS apparatus allows for a smooth and continuous rotation through 90 degrees of the principal stress directions. The ability to simulate principle stress rotation is common to many geotechnical problems, including earthquake loading. The simple shear device allows direct investigation of the shear stress v. shear strain in drained and undrained situations (see graph Fig. 1). The simple shear test is used for routine work for undersea structures, landslips and earthquake performance studies. In addition, the dynamic cyclic capability allows investigation of damping ratio and liquefaction, also under the conditions of simple shear.

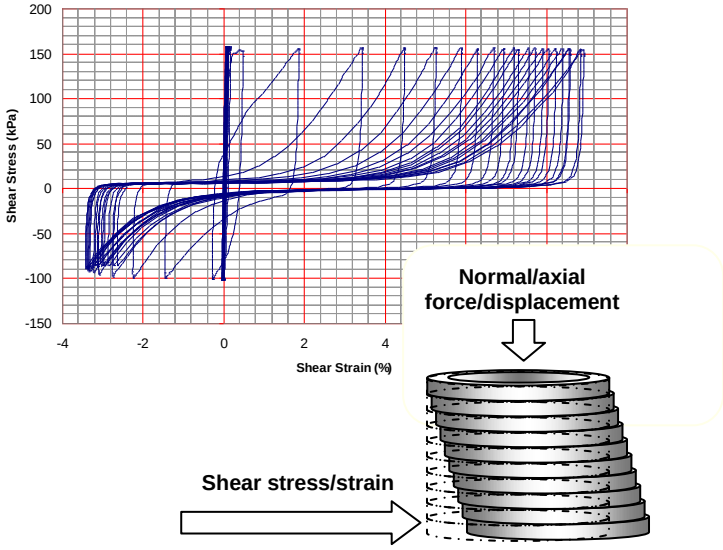


Fig. 1 Typical Graph shear stress (kPa) v shear Strain (%) and sample schematic during simple shear

Technical specification

- *Overall dimensions and weight = 1200mm (H) x 500mm (L) X 770mm (W), Weight = 160kg*
- *Electrical specification = 240V or 110V 50/60Hz 1 ph*
- *Data acquisition = integrated with control module with 8 (+/- 10V range) input channels, 16 bit A/D converters.*
- *Control module = closed-loop control feedback system integrated with data acquisition module. Twin feedback 16bit control channels, dedicated USB communication interface.*
- *Displacement range: axial = +/- 25mm, shear = +/- 15mm: Accuracy = <0.1% FSO (In practice, axial range is +/-50mm to aid sample placement, however measured stroke is +/- 25mm).*
- *Measured Displacement for test (low range LVDT's): axial = +/- 2.5mm, shear = +/- 2.5mm: Accuracy = <0.1% FSO*
- *Displacement resolution = 16 bit (i.e. +/- 20mm = 0.6µm, +/- 15mm = +/- 0.5µm, +/- 2.5mm = <0.1µm)*
- *Force accuracy = <0.1% of load cell range on both axial and shear (i.e. 5N for 5kN load cell, 10N for 10kN load cell)*
- *Force resolution = 16 bit (i.e. <0.2N for 5kN load cell, <0.4N for 10kN load cell)*
- *Control data points per cycle = 5,000@1Hz, 1,000@5Hz*

System overview

The GDS EMDCSS apparatus uses a cylindrical test specimen. The specimen is supported laterally by a stack of low friction constraining rings – this arrangement enforces K-zero conditions. The top of the test specimen is connected to an actuator which is free to move vertically but is rigidly fixed in the horizontal direction by means of high quality linear guides. The base of the test specimen is connected to an actuator that is free to move horizontally but is rigidly fixed in the vertical direction by high quality pre-loaded linear guides.

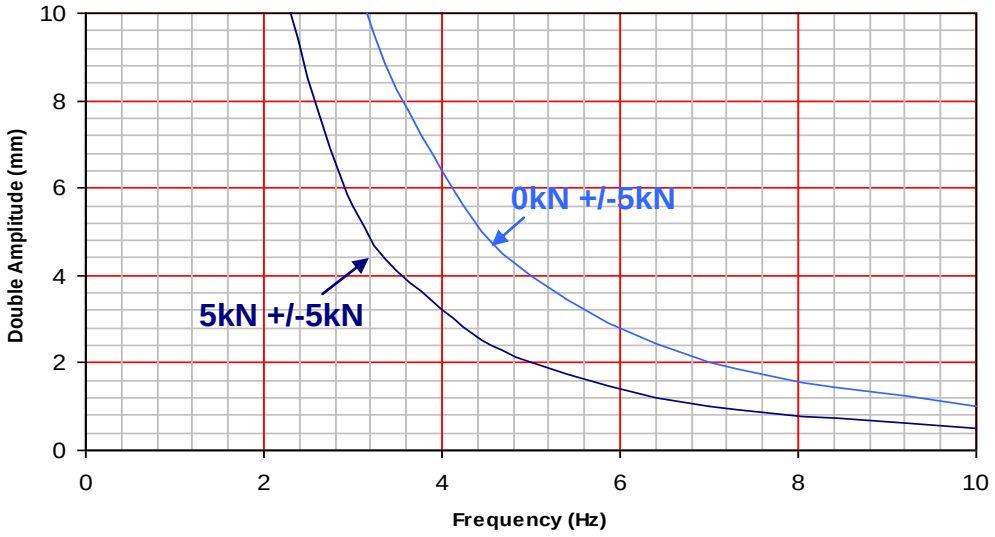
Constant volume conditions may be maintained by the system controlling the height of the sample via feedback from the localised axial transducer. This is called Active Height Control. This ensures system compliance is removed which would exist if the axial ram was simply 'locked off'.

Both horizontal and vertical actuators are 5kN or 10kN electromechanical brushless DC servo motors with closed-loop control of force and displacement by means of the GDS Digital Control System, or DCS. The DCS unit is used in all GDS dynamic systems. In addition, a special high resolution displacement transducer is used for feedback when accurate control of the height of the test specimen is required, for example, during simple shear testing and also for high resolution shear strain control.

A high-quality, high-speed PC is used for overall system control, results acquisition and presentation. Communications use a high speed USB connection to the GDS DCS. Acquired data is stored locally on the GDS DCS and passed to the controlling computer at maximum USB speeds by a separate communications process.

The complete system is controlled by GDSLAB software, a well developed system used by more than 300 customers for generalised control of all geotechnical laboratory equipment. GDSLAB is currently used for triaxial (static, dynamic and unsaturated), consolidation testing (traditional hanging weight, hydraulic consolidometer and constant rate of strain equipment), hollow cylinder (static and dynamic), direct shear and simple shear (monotonic and dynamic).

Typical system performance, showing frequency and amplitude



Frequency (Hz)	with 5kN force datum		with zero kN force datum	
	Amplitude (mm)	Double Amplitude (mm)	Amplitude (mm)	Double Amplitude (mm)
0.1	50	100	50	100
0.2	50	100	50	100
0.5	26.5	53	26.5	53
1	13.3	26.6	13.3	26.6
2	6	12	6	12
3	2.8	5.6	4.4	8.8
4	1.6	3.2	3.2	6.4
5	1	2	2	4
7	0.5	1	1	2
10	0.25	0.5	0.5	1

Features overview

- Teflon coated, low friction constraining rings used to maintain k-zero conditions
- High quality, low friction linear guides used to ensure strength and alignment in normal and shear directions.
- Static/monotonic tests with no minimum rate
- Dynamic cyclic tests with waveform chosen from GDS waveform database (sine, square, triangular, haversine etc.) or by user defined 1000 point waveform.
- The EMDCSS can be upgraded in the field to monotonic/cyclic direct shear system by ordering the optional shear box attachment (changes pedestals and platen arrangement).
- Complies to ASTM D6528 and in accordance with NGI testing procedures.
- P and S wave measurements with Bender Element system (optional).

Test Results

Typical results from a dynamic simple shear test are shown below. The test was performed at 1Hz on a well graded sand. The pore pressure build up can be clearly seen in Fig.2, with failure occurring around the 10th cycle. At this point the shear strain immediately starts to ramp up to significant strains with no increase in the peak shear stress, also signifying that failure has occurred (Fig. 3). Fig. 4 shows the rapid movement of the shear strain whilst the shear stress remains the consistent controlling function. Finally, the corresponding build up of vertical stress from the constant volume system is seen in Fig. 5.

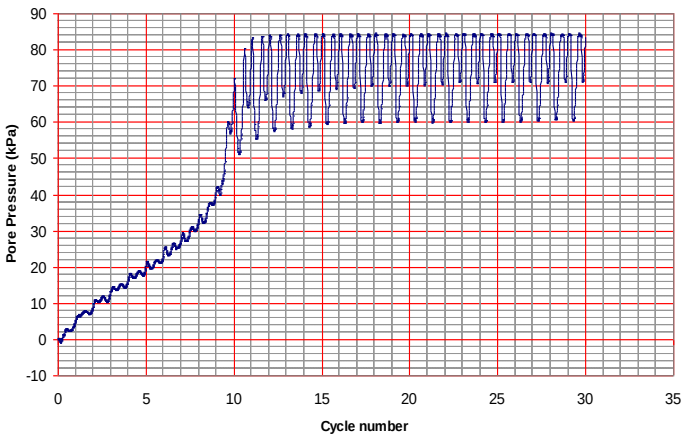


Fig. 2 Pore water pressure build up to failure

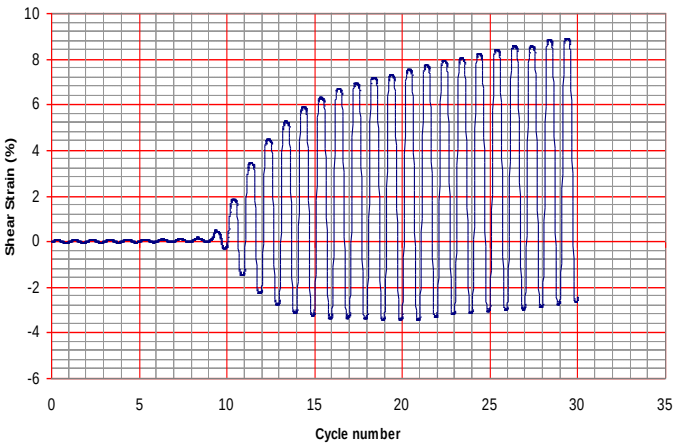


Fig. 3 Shear strain build up to failure

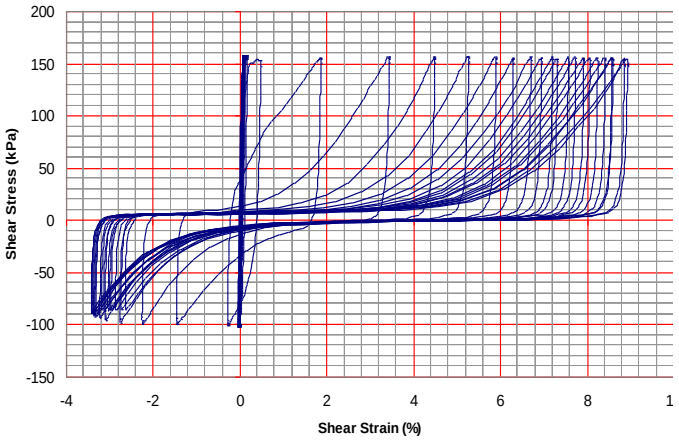


Fig. 4 Shear stress v shear strain

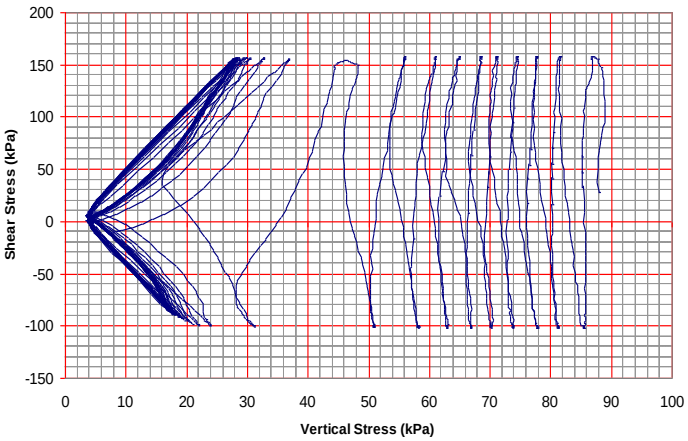


Fig. 5 Shear stress v vertical stress

GDS DCS – Digital Control System

GDS dynamic systems are all based around the GDS DCS high speed digital control system with closed loop feedback of displacement and load.

With 16 bit data acquisition (A/D) and 16 bit control output (D/A) in single channel control, the GDS DCS can run at a control frequency of 10kHz over the 2 channels. This means that when running at 10Hz the system uses 500 control points per cycle. When running at 1Hz, it uses 5,000 control points per cycle

The advantage of the GDS DCS system is that no matter which dynamic system is purchased, they all use the same high speed control system. This ensures that the system has the highest level of functionality and reliability because all GDS dynamic systems, across the range, use the same high specification control system. A result of this is the accuracy and resolution of the test is only a function of the actuator used, whether it be a low-cost pneumatic actuator, high-accuracy electromechanical actuator or high-capacity hydraulic actuator.

GDSLAB control software

The GDSLAB control and acquisition software is a highly developed, yet extremely flexible software platform. Starting with the Kernel module and the ability to perform data acquisition only, additional modules may be chosen for your testing requirements. Some currently available modules are as follows:

- Simple Shear (Static and Dynamic)
- Dynamic Triaxial Tests
- SATCON (saturation and consolidation)
- Standard triaxial
- Stress path testing (p, q and s, t)
- Advanced loading tests
- Unsaturated testing
- K0 consolidation
- Permeability

GDSLAB has the ability to be configured to your hardware of choice, no matter how unique the arrangement. A text file (*.ini) or initialisation file is created that describes the hardware connectivity to the PC. The hardware layout is available in graphical format via the GDSLAB 'object display'. This makes setting up the devices and checking the connectivity extremely simple (see Fig. 6).

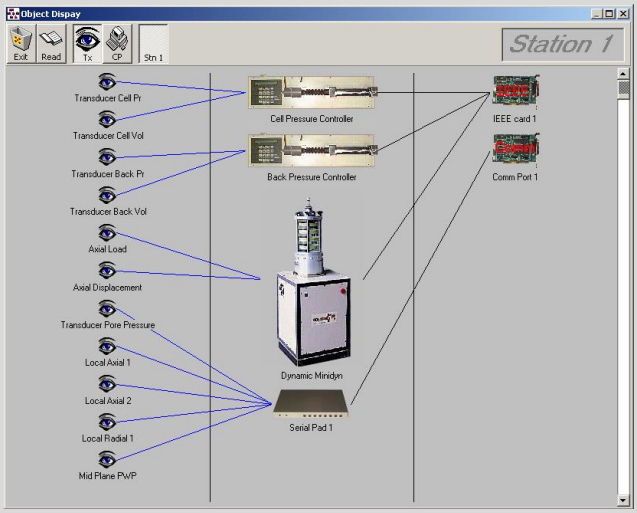


Fig.6 GDSLAB object display showing a GDS Advanced Triaxial Testing System (DYNTTS) setup

For further information on GDSLAB, please refer to the dedicated GDSLAB datasheet.

GDSLAB dynamic simple shear test module

- Is a simple-to-use user interface for running dynamic cyclic loading and simple shear tests
- Provides sinusoidal cyclic control of axial displacement or axial force and shear displacement or shear force
- Allows a complete cycle of data to be saved every N cycles where the value of N is defined by the user
- Controls data displayed in real-time
- Saves up to 1000 points per cycle
- Has built-in standard waveforms: sinusoidal, triangular, square, havesine.
- Has user defined waveforms using 1000 point ASCII file.

Fig. 7 shows a GDSLAB dynamic test in progress.

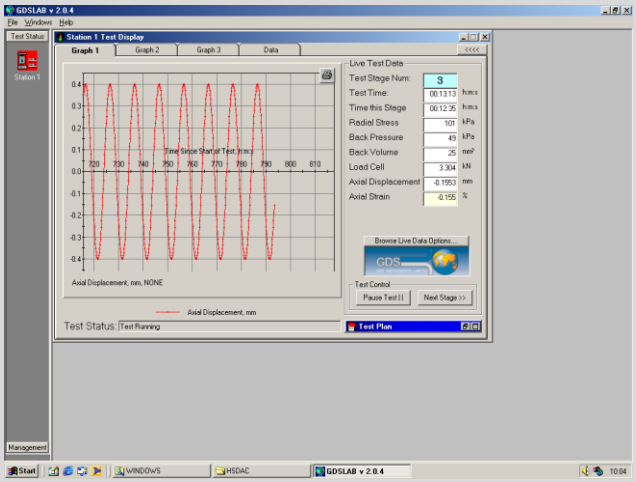


Fig.7 Test display showing a dynamic test in progress

Transducers

- Normal force: +/-5kN load cell, accuracy better than 0.1% FRO, resolution 0.2N
- Normal stroke: 50mm displacement transducer, accuracy 0.1% FRO, resolution 1μm
- Shear force: NEW +/-5kN load cell, accuracy better than 0.1% FRO, resolution 0.2N. The new GDS shear force load cell provides a direct measurement of sample shear force (see below)
- Shear stroke: 50mm displacement transducer, accuracy 0.1% FRO, resolution 1 micrometre
- Vertical displacement: +/- 2.5 mm LVDT displacement transducer, accuracy 0.1% FRO, resolution 0.1 micrometre.
- Shear displacement: +/- 2.5 mm LVDT displacement transducer, accuracy 0.1% FRO, resolution 0.1 micrometre.
- Pore pressure transducer: 1000kPa, accuracy 0.1% FRO, resolution 0.05kPa
- Feedback transducer for normal force actuator can be normal force load cell, normal stroke transducer or specimen displacement transducer. The software automatically selects which transducer to use for feedback depending on the test stage. The specimen displacement transducer is used when simple-shear operation is required as this gives the best resolution to maintain zero change in height – the requirement for simple shear
- Feedback transducer for shear force actuator can be shear force load cell, shear stroke transducer or shear strain LVDT. The software automatically selects which transducer to use for feedback depending on the test stage.

GDS shear force load cell

The GDS shear force load cell is designed specifically for the direct measurement of shear forces being applied to the specimen (see Fig. 8). Located between the specimen base pedestal and the horizontal actuator at the base of the system, the shear force load cell eliminates errors due to friction and system compliance.

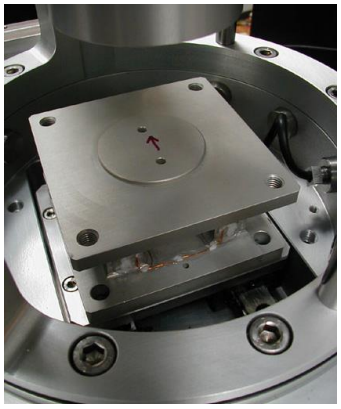


Fig. 8 GDS shear force load cell

Sample preparation

- Sample preparation has been designed by GDS specifically for preparing simple shear specimens.
- Detachable side arms are clamped to the base pedestals which, in turn, independently hold the specimen top-cap above the sample to decrease sample disturbance (see Fig. 9).
- The complete unit is then installed into the main machine, where the side arms may be removed.

Fig. 9 GDS simple shear sample preparation equipment

Why buy GDS EMDCSS?

- Unique system with ability to do simple shear in both static and dynamic modes
- Dedicated shear force load cell designed to reduce errors due to friction
- Includes dedicated sample preparation equipment available for each sample size
- Well developed GDSLAB software provides a consistent interface across all of your geotechnical laboratory testing, with the flexibility to setup your system exactly as you require with the knowledge that future expansion is not only possible, but simple.
- Excellent GDS user support (see testimonials at www.gdsinstruments.com)
- DCSS upgradeable to the following tests:
  - Direct shear system
  - Bender element test system (P and S-wave)

***Latest Developments:* Small strain combined with large strain testing unique to the GDS system**

With the addition of a +/- 2.5mm shear displacement LVDT and a 'times 10' gain module on the shear force load cell it has been shown to be possible to carry out very small strain simple shear tests alongside the larger strain dynamic tests, thus allowing the user to connect the 's-shaped' stiffness v. strain curve between G_{zero} and $G_{operational}$. At frequencies below 1Hz the system has been used to run dynamic tests at peak tp peak displacements of 10μm (a shear strain of +/-0.025%).

Due to continued development, specifications may change without notice.