Electromechanical Dynamic Cyclic Simple Shear (EMDCSS)

The GDS Electromechanical Dynamic Cyclic Simple Shear Device (EMDCSS) is the premier device for simple shear testing. It is capable of carrying out dynamic cyclic tests ranging from small strain (0.005% shear strain amplitude) to large strain (10% shear strain amplitude), as well as a large range of extremely accurate quasi-static testing. This is the ultimate choice for a no-compromise simple shear machine with the greatest range of testing capabilities. This is the number 1 choice for advanced commercial testing or academic research.

Key Features:	Benefits to the User:
Active height control:	Constant volume conditions are enforced i.e simple shear. No manual intervention is required between stages. Little or no effects of vertical compliance due to the extremely stiff system design, critical for high quality DSS testing.
GDS Shear Loadcell:	Designed so that shear force is measured in front of the linear guides, as such the shear force measurement does not include frictional errors.
Teflon coated low friction retaining rings:	A cylindrical soil specimen is laterally confined by teflon coated low friction retaining rings, ensuring a constant cross sectional area (K-zero condition).
Electro-mechanical actuators that give superior performance, reduce space and provide cost savings:	Electro-mechanical actuators can carry out tests up to 1mm at 5Hz, with greater accuracies than comparable pneumatic actuators. Mains powered means no external noisy power pack is required and as opposed to pneumatic/hydraulic systems, electro-mechanical systems draw only the power that is required.
Axial & Shear linear guidance provided by super-stiff crossed-roller bearings:	200mm bearing length not only provides stability while ensuring minimal rotation of the topcap during shearing, allowing testing to be simple shear rather than rotational motion (an important aspect for testing to international standards), but also provides high load capacity with low friction with accurate linear guidance.

Technical Specification:

Dimensions:	1200mm (H) x 500mm (L) X 770mm
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).
Displacement Resolution:	24 bit (i.e. +/- 20mm = <0.6µm, +/- 15mm = +/- <0.5µm, +/- 2.5mm = <0.1µm)
Load Range (kN):	5, 10
Operating Frequency (Hz):	5
Power:	240V or 110V 50/60Hz 1 ph
Sample Sizes:	50, 63.5, 66, 70, 100 and 150mm
Weight Approx (kg):	220

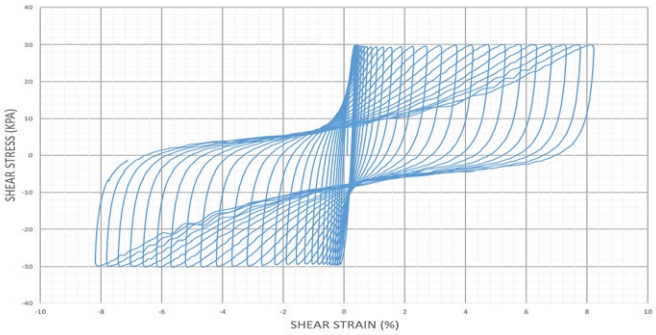
Optional Extras:

Vertical Bender Elements:	50, 63.5, 66, 70, 100, 150mm
Local Horizontal LVDT Displacement Measurement	Available
Local Vertical LVDT Displacement Measurement	Available
Load Calibration Jig and Load Cell (5, 10kN)	Available
Direct Shear Sample	60mm Square, 63.5mm Round
Water Reservoir to Aid Sample Saturation	Available

How does it work?

A cylindrical soil specimen is laterally confined by Teflon coated low friction retaining rings, ensuring a constant cross sectional area. Vertical displacement is kept constant by using dynamic active height control, whilst shear force loading is applied, therefore constant volume conditions are enforced.

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.



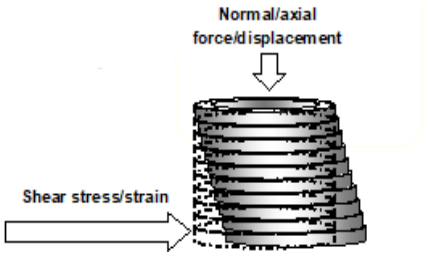
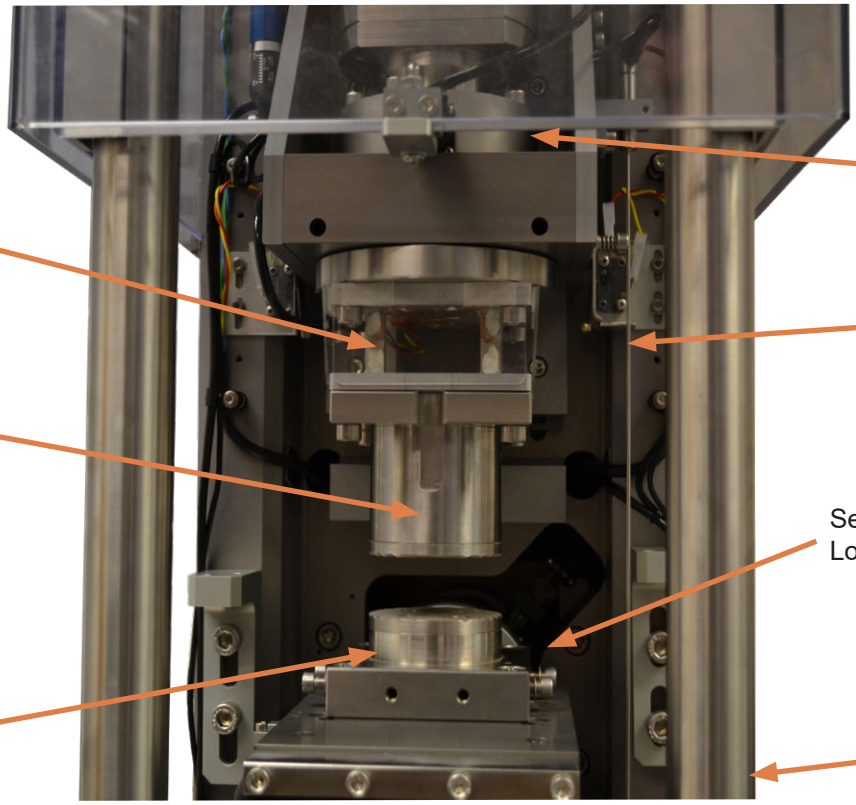
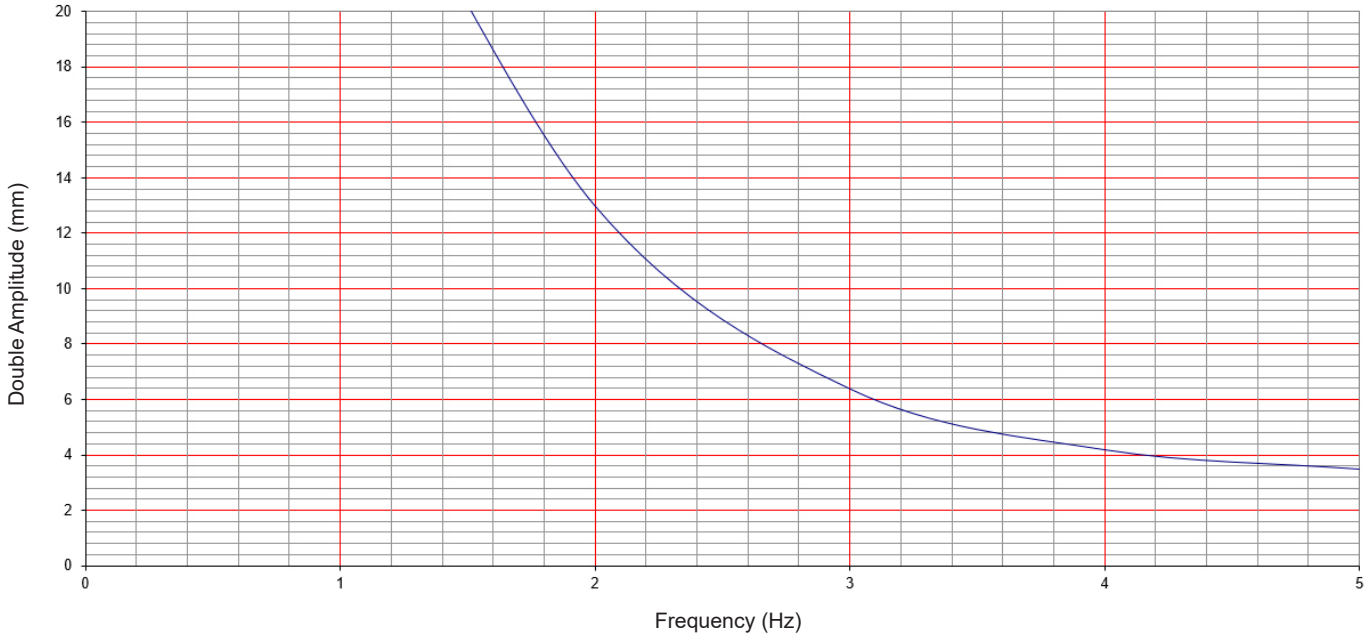


Fig. 1 Typical Graph shear stress (kPa) v shear strain (%) and sample schematic during sample shear

Key System Features



Typical system performance, showing frequency and amplitude (shear axis)



Frequency (Hz)	with zero kN force datum	
	Amplitude (mm)	Double Amplitude (mm)
0.1	15	30
0.2	15	30
0.5	15	30
1	14	28
2	6.5	13
3	3.2	6.4
4	2.1	4.2
5	1.75	3.5

Example Test Results

Typical results from a dynamic simple shear tests are shown below. The test on a remoulded clay sample was performed at 1Hz while maintaining constant volume condition using active height control. The pore pressure build up can be clearly seen in Fig.2 (as calculated from the normal stress drop-off), with failure occurring around the 20th cycle when the double amplitude of horizontal strain reached over 10%. The machine was able to maintain the stress targets to significant strain levels beyond the failure as can be seen on Fig. 3 & 4. Finally, the measured drop-off in vertical stress during cyclic test in constant volume can be seen in Fig. 5.

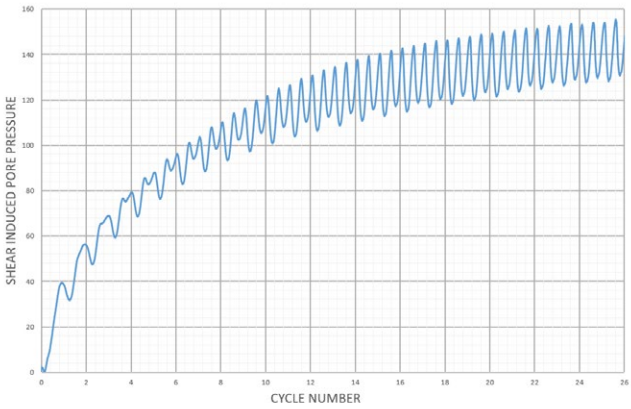


Fig. 2 Equivalent pore water pressure build up

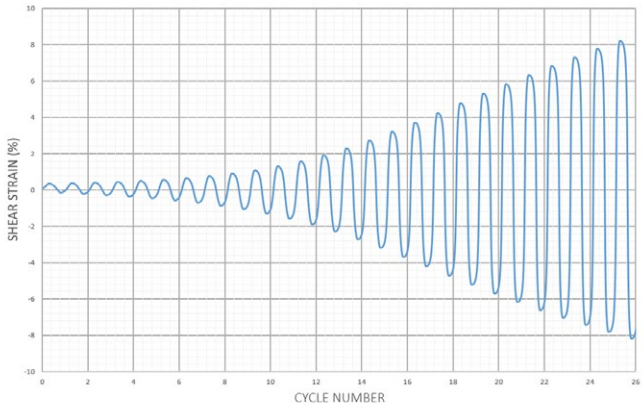


Fig. 3 Shear strain build up to failure

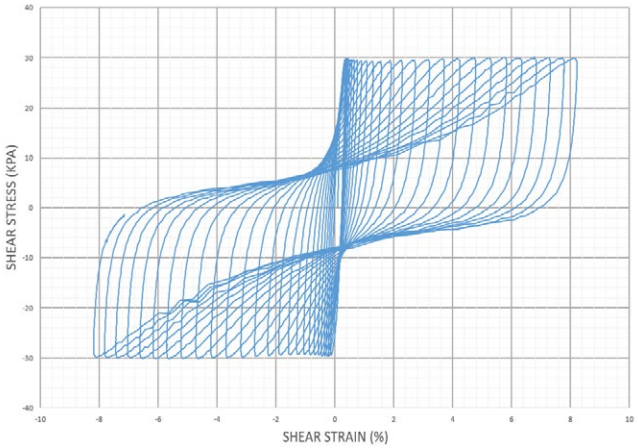


Fig. 4 Shear stress vs shear strain

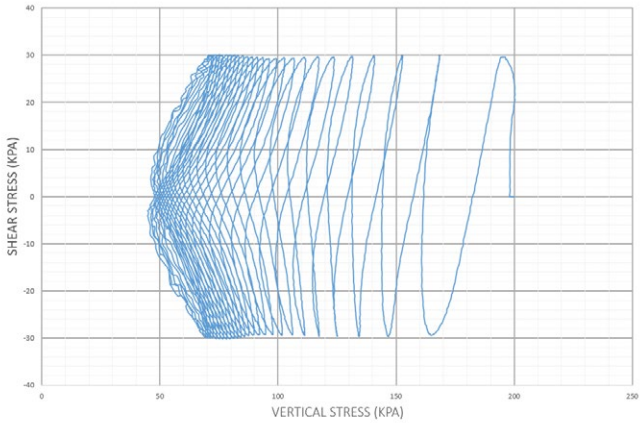


Fig. 5 Shear stress vs vertical stress

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. 6). Located between the topcap and the vertical actuator, the shear force load cell eliminates errors due to friction and system, which could otherwise be recorded in the results of the test.

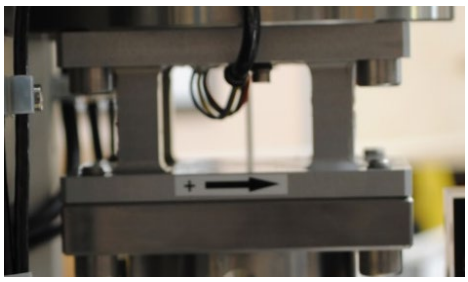


Fig. 6 Shear load cell located directly above sample

Testing in Constant Normal Stiffness (Upgrades Available On Systems Built Prior to 2021)

Testing in Constant Normal Stiffness (CNS) conditions have been widely used to better represent the effects of soil contraction/dilatation on the normal stress at the interface between the soil and the piles. A new (2021) upgrade to the control system and the firmware of GDS' EMDCSS allows the apparatus to perform both static and dynamic simple shear tests in CNS conditions. The upgrade allows the customer to choose the value of the constant normal stiffness required for the test in kPa/mm or kN/mm. Systems made prior to 2021 can also be upgraded to perform CNS testing, it does not require any hardware modifications of the existing equipment and can be done remotely.

Please contact GDS for the upgrade options of EMDCSS' shipped before 2021.

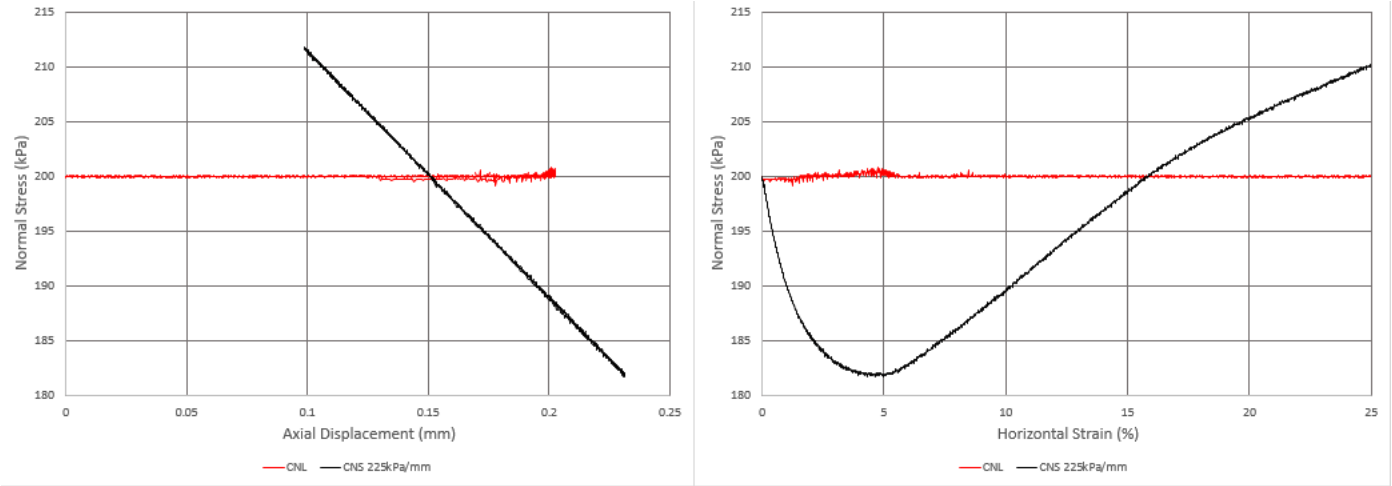


Fig. 7 Static simple shear results showing the difference between the constant normal load and constant normal stiffness conditions.

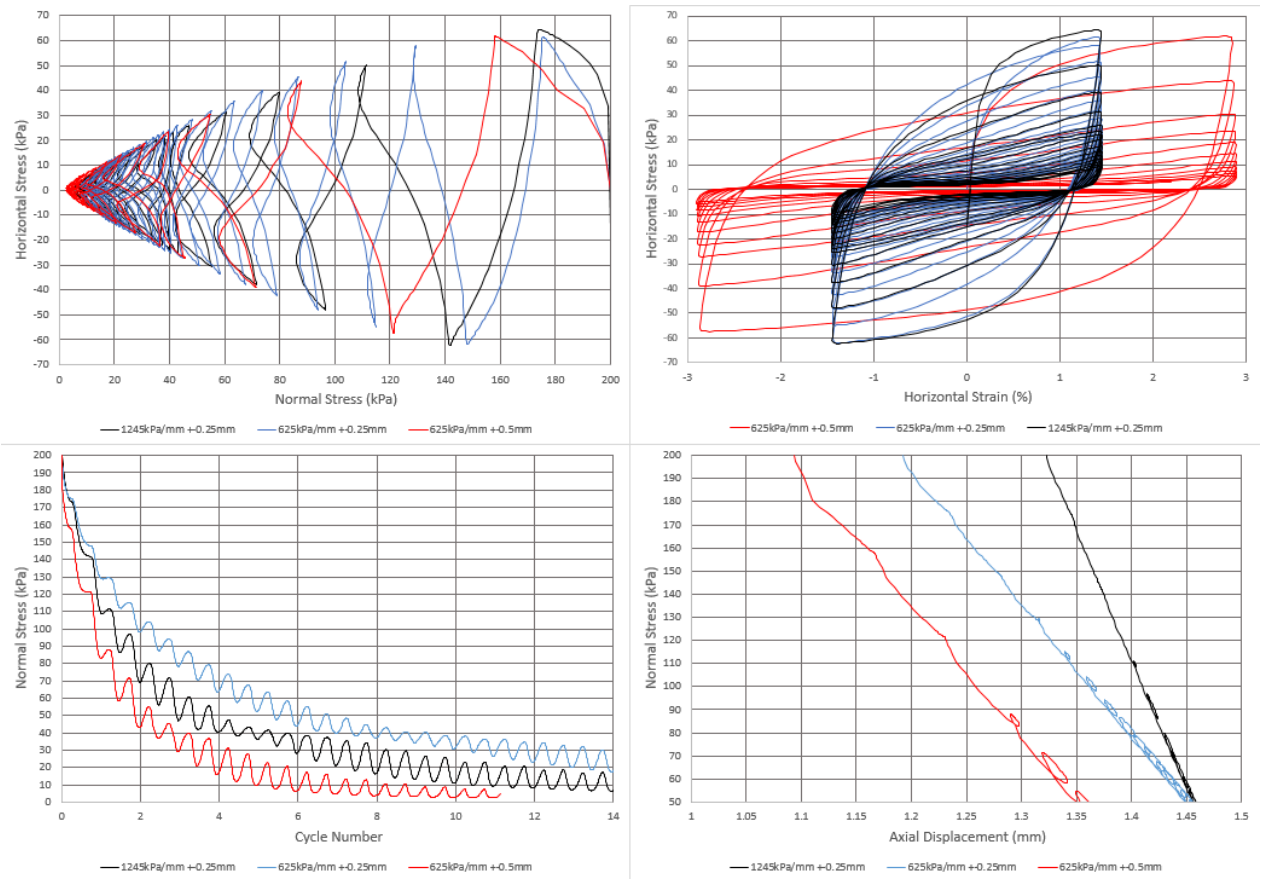


Fig. 8 Results from the dynamic CNS simple shear tests with varying constant normal stiffness and horizontal strain amplitude.

Super-stiff frame construction:

The GDS EMDCSS system has been designed to yield the ultimate in performance for simple shear tests and to remove compromises that exist in other simple shear systems.

The EMDCSS has been designed to be as stiff as possible. This is an important feature for a simple shear system; the quality is governed by the topcap and pedestal guidance. Even if the pedestal guidance system is near perfect, if the system compliance is too high, the results will be compromised as the topcap movement will affect the result of the test.

The EMDCSS achieves the high degree of stiffness by utilising a deep support beam to mount the linear guides and two stainless steel pillars at the front of the machine to further brace the system. The linear guides that are used are heavily over rated for the loads the system will be subjected to. Again, this increases the stiffness of the system.

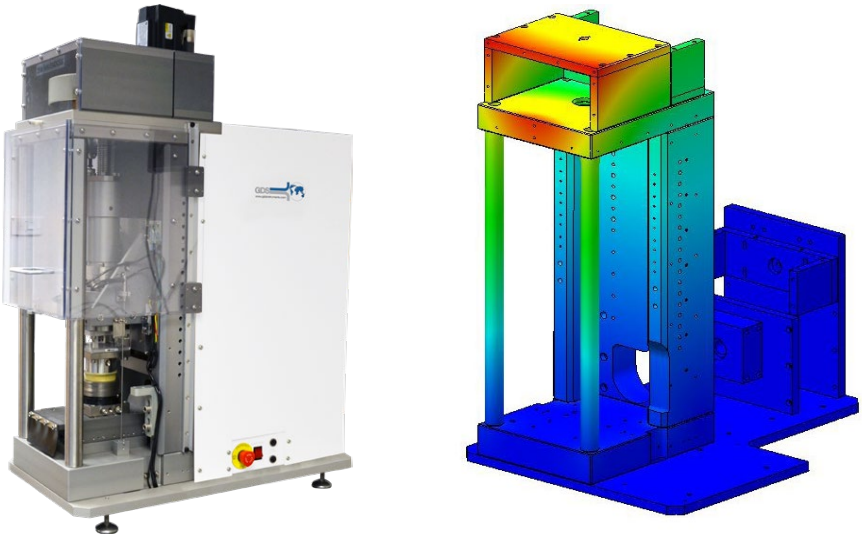


Fig. 9 Finite Element verified for maximum machine stiffness where it matters

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. 10).
- The complete unit is then installed into the main machine, where the side arms may be removed.

Fig. 10 Specimen top cap held above sample

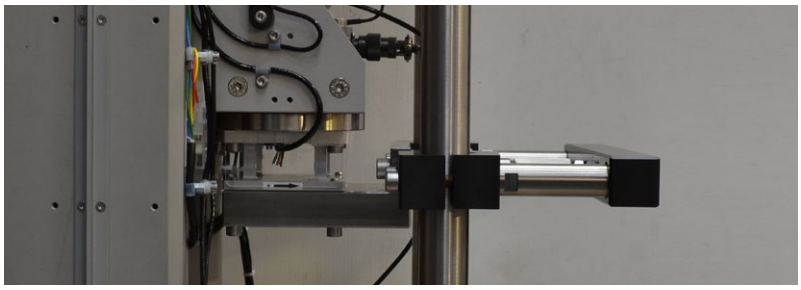
Vacuum Sample Prep Kits as standard

The sample former offered by GDS allows set up of non-cohesive samples with ease. The mould fits around the confining rings, and using a vacuum pump, pulls the membrane tight against the rings, allowing for the sample to be easily and correctly prepared. The mould is available in all sample sizes for the EMDCSS.

Fig. 11 Non-cohesive sample prepared in the Vacuum Sample Prep Kit

EMDCSS Load Calibration Kit Option

The EMDCSS Calibration Jig is used to calibrate the vertical, horizontal and shear load cells in situ. It has multiple configurations to ensure all load cells can be calibrated effectively. The reference load cell is connected to a spare channel on the EMDCSS data acquisition unit (DCS) and is read through the GDSLAB software. The calibration jig is available for both the 5kN and 10kN EMDCSS versions.



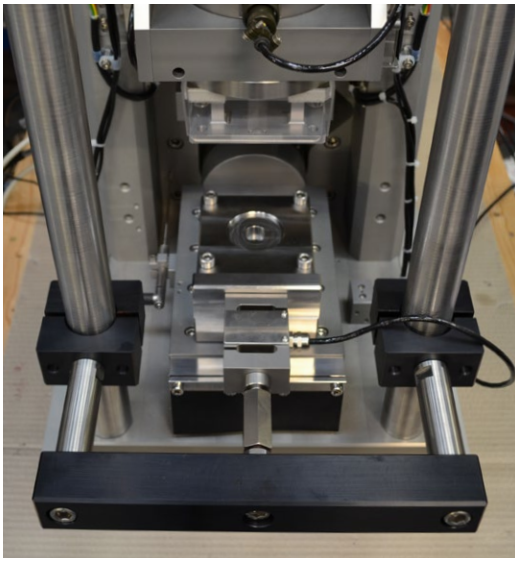


Fig. 12 EMDCSS with calibration option fitted

Direct Shear Option

With the addition of a water bath and a new sample set, the EMDCSS is able to perform direct shear tests on square samples. Neither the load, displacement capabilities or frequency, are altered by this upgrade for the system.

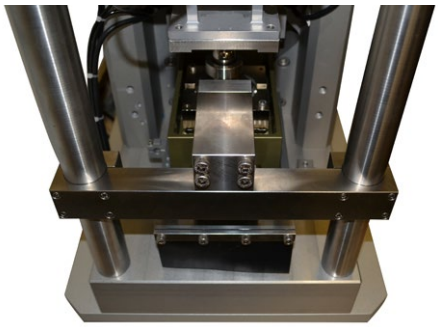


Fig. 13 EMDCSS with direct shear bath fitted

Bender Element Option

Bender elements can be implemented in all sizes of pedestal and top-cap within the EMDCSS range. Due to the short sample height (20mm), a high data acquisition rate is required because the travel time is extremely short. If we assume the velocity of the soil is 400m/s (for example) and the soil is 20mm high, the travel time over the 20mm would be 0.00005 seconds or 0.05 milliseconds. The GDS bender element system acquires data simultaneously at 2 Mega samples/second which gives a read interval resolution of 0.0005ms, therefore 100 samples would be acquired over the total travel time which is adequate for the velocity to be determined. Acquisition speeds any slower than 2 Mega samples/second would start introducing resolution errors.

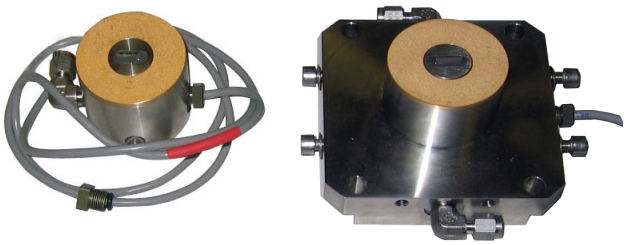


Fig. 14 Bender Element shown in pedestal and topcap

Shear Local Strain LVDT Option

The EMDCSS topcap can be modified to allow a local LVDT to be used with the system, adding an additional shear strain measurement to the system. The LVDT is mounted on a bracket connected directly to the pedestal. This then measures a flattened surface off the topcap. The transducer connects into the data acquisition unit of the EMDCSS (DCS). The LVDT upgrade is available for all sample sizes.

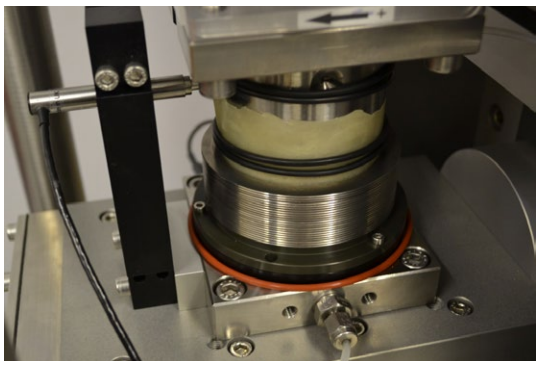


Fig. 15 Local shear LVDT location on topcap

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. 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'.

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.

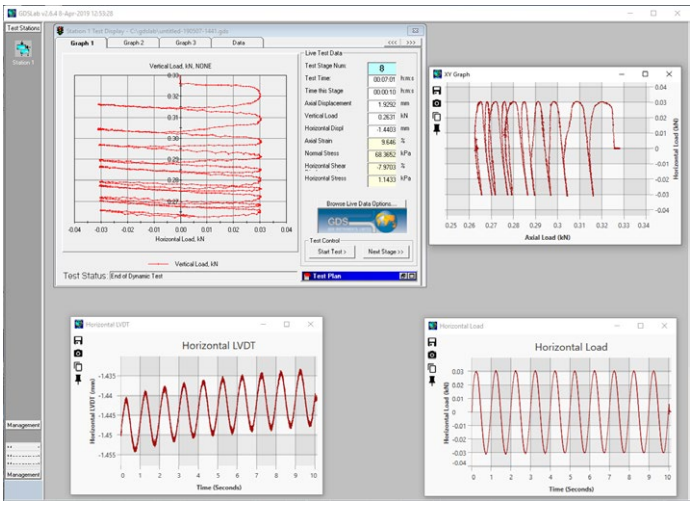


Fig. 16 shows GDS simple shear test module using the new ADVDCS V2 control systems.

DSS Water Reservoir

A common upgrade on the DSS system is a water reservoir. The reservoir provides free access to water at atmospheric pressure for the topcap and pedestal as per ASTM D6528-17 clause 6.12 Water Access System. The water reservoir allows up to 3 hydraulic connections and fits to the EMDCSS case mounting screws behind sliding cover.

Adaptive Control - As Standard

Adaptive Control is a cutting edge technology that significantly improves the dynamic load control performance of an apparatus, leading to increased testing precision.

The GDS Adaptive Control firmware algorithm automatically adjusts the control gain values based on the observed specimen stiffness, removing the need for the user to enter a specimen stiffness value prior to the test. This has the additional advantage of ensuring specimen stiffness changes during a test are also dealt with correctly. When testing using an apparatus running GDS Adaptive Control, the firmware automatically optimises the control gains' values based on variations in soil stiffness as a cyclic test stage progresses, enabling a consistent loading amplitude to be applied to the test specimen. This marks a significant improvement over traditional PID closed-loop systems which, especially when testing multiple specimens of varying stiffness, require the user to re-tune the system before each dynamic cyclic test as well as risk under-performance when specimen stiffness changes during loading.

ADVDCS v2 Acquisition Pad Used with EMDCSS

Overview: The ADVDCS v2 is a modern high speed digital control and acquisition system developed especially for geotechnical testing, and is the premier device in the GDS range, typically supplied with our most advanced dynamic test and control systems. The ADVDCS v2 has been fully designed and developed by GDS' in-house engineering team.

The ADVDCS v2 is based around a modern, high speed, 32 bit processing core and has eight simultaneous sampling 24 bit universal analogue input channels, enabling any transducer in the GDS range to be connected. High speed digital bus technology allows real-time streaming of transducer data making it ideal for high speed data acquisition. The ADVDCS v2 supports full digital control of servo motor and hydraulic actuators allowing accurate, precise and noise free control of actuators.

The ADVDCS v2 is the direct result of GDS research into high accuracy dynamic control, and contains machine learning algorithms that adapt in real-time to dynamic changes in sample compliance thereby delivering excellent control over the full machine performance envelope.

Technical Specification:

Connection to PC:	USB
Acquisition Channels:	8 Analogue + 1 Quadrature Decoder
Control Channels:	2 (Analogue or digital)
Multi Box Capability:	x4
Max Number of Channels:	Up to 32 analogue + 4 quadrature channels with synchronised data acquisition
Sample Rate:	5kHz
Resolution:	24 bit, 16,777,216
Gain Ranges:	8 (User defined in software)
Description:	Advanced level solution for the highest performance of dynamic acquisition & control
Voltage Resolution:	~ 0.000001 mVolts (1 nanovolt)
Voltage Input Type:	Fully Differential, Balanced Precision Inputs with Integrated Signal Conditioning
Transducer Excitation Voltage:	Differential, Fixed Precision +/-5V, Independent (not Ganged), Ratiometric Excitation
Number of Input Ranges:	8 Independently Selectable Ranges Per Channel from (-10...+10mV) to (-10...+10V)
Excitation Current Sense:	Yes - can monitor transducer currents - alerts user of disconnected transducers
Excitation/Transducer Fault Detection:	Overvoltage, Overcurrent, Absent Transducer
Excitation Fault Tolerance:	Independent Per Channel, if any channel is shorted the other channels will continue to operate normally
Current Input Mode:	Yes - Via resistor fitted in cable termination (different ranges possible)
Differential Measurement Range:	-10mV...+10mV up to -10V...+10V for balanced differential signals
Transducer Calibration:	Linear, polynomial and custom transducer calibration
Virtual Transducers:	Up to 32 virtual transducers (e.g. strain, compliance, calculated values)
Data Acquisition Options:	Digital filtering for noise reduction
Digital Control:	1 kHz 32-bit floating point control loop
Analogue Control:	Control of both digital and analogue motor drives possible
Compliance Estimation:	Real time specimen compliance estimation
Adaptive Control:	Adaptive load and stress control
Custom Waveforms:	Custom waveform control with a maximum of 16000 points per waveform
Sample Docking:	Automatic sample docking
Display and Monitoring:	Data acquisition in GDSLab via USB interface, High resolution real time graphs
Software:	GDSLAB
System Characteristics:	200 MHz dual core ARM Cortex-M4 CPU, 32-bit architecture, On-board flash memory, 480 Mbit/s USB connection
Minimum System Requirements:	OS: Windows 7 or later, CPU: 1.5 GHz or higher, Memory: 2 GB, USB 2.0

Why Buy GDS?

GDS have supplied equipment to over 86% of the world's top 50 Universities:

GDS have supplied equipment to over 86% of the world's top 50 Universities who specialise in Civil & Structural Engineering, according to the "QS World University Ranking 2020" report.

GDS also work with many commercial laboratories including BGC Canada, Fugro, GEO, Geolabs, Geoteko, Golder Associates, Inpijn Blokpoel, Klohn Crippen, MEG Consulting, Multiconsult, Statens Vegvesen, NGI, Ramboll, Russell Geotechnical Innovations Ltd, SA Geolabs, SGS, Wiertsema and Partners to name a few.

TOP 50

Would you recommend GDS equipment to your colleague, friend or associate?

100% of our customers answered "YES"

Results from our post-delivery survey asked customers for feedback on their delivery, installation (if applicable), supporting documentation, apparatus and overall satisfaction with GDS. The survey ran for two years.

Made in the UK:

All GDS products are designed, manufactured and assembled in the UK at our offices in Hook. All products are quality assured before they are dispatched.

GDS are an ISO9001:2015 accredited company. The scope of this certificate applies to the approved quality administration systems relating to the "Manufacture of Laboratory and Field Testing Equipment".

40 YEARS OF BRITISH INNOVATION

Extended Warranties:

All GDS apparatus are covered by a 12 month manufacturers warranty. In addition to the standard warranty, GDS offer comprehensive extended warranties for 12, 24 and 36 months, for peace of mind against any repairs in the future. The extended warranties can be purchased at any time during the first 12 months of ownership.

2 YEAR EXTENDED WARRANTY
1 YEAR EXTENDED WARRANTY
3 YEAR EXTENDED WARRANTY

GDS Training & Installation:

All installations & training are carried out by qualified engineers. A GDS engineer is assigned to each order throughout the sales process. They will quality assure the apparatus prior to shipping, if installation has been purchased, install the apparatus on the customers site & provide the training.

Technical Support:

GDS understand the need for ongoing after sales support, so much so that they have their own dedicated customer support centre. Alongside their support centre GDS use a variety of additional support methods including remote PC support, product helpsheets, video tutorials, email and telephone support.