Company Profile of GDS Instruments
A division of Global Digital Systems Ltd

Summary

GDS Instruments, a division of Global Digital Systems Ltd, is a world leader in the manufacture of laboratory and field testing equipment for use by geotechnical engineers and geologists. We are specialists in software based triaxial testing systems for soils and soft rocks, consolidation testing systems, and in-situ testing systems for the evaluation of shear modulus v. depth profiles. GDS is an ISO9001:2000 certified company.

History

GDS Instruments was founded in England in 1979, then known as "Geotechnical Digital Systems". The company's first product was the computer controlled triaxial testing system based on the "Bishop & Wesley'' stress path cell. The cell was linked to the computer via microprocessor controlled screw pumps driven by stepping motors.

The screw pump or "digital controller" proved to be a major success in its own right as a computer controlled pressure source. The triaxial testing system was continuously developed throughout the 1980s and also became a major success. This was particularly the case with users wishing to carry out advanced testing without first spending many years developing new equipment.

The continuing success of these first two products has enabled us to expand the product range comprehensively. We can now provide our users with bespoke high pressure triaxial testing systems, high frequency triaxial testing systems, consolidation testing systems and logging systems, commercial testing systems as well as state-of-the-art unsaturated systems and transducers. We continue to develop hardware and software based solutions to our users' problems. Our biggest market is our existing users who pay us the compliment of reinvesting in GDS products.

The flexibility of our software-based systems, in particular the new GDSLAB software, allows us to suggest a strategy for meeting your testing requirements, whatever they may be.

Internal organisation and customer support

GDS Instruments employs around 15 permanent members of staff at their offices in Hook, in the UK. The emphasis within the company is that of professionalism and products fit for purpose. To fulfil these goals employees at GDS Instruments include 4 qualified geotechnical engineers, 4 software designers, 3 hardware designers and 4 electrical/electronics specialists.

At GDS we pride ourselves on our customer support. We are able to provide excellent customer support and training due to our expertise in the field of geotechnical testing. We base this success on the fact that we train people on equipment we design and manufacture in house.

Products

In addition to complete systems we also supply individual components such as pressure controllers, testing machines, force actuators and test cells either from our existing range, or supplied designed to customers' specifications. We have a range of pressure/volume controllers with pressure ranges up to 150 MPa and with volume ranges of 200cc and 1000cc.

More recently we have developed a range of special products including special back pressured and high pressured shear boxes, dynamic cyclic simple shear machines and specialised displacement transducers for high pressure cells and hollow cylinder samples.

With a team of in-house programmers, the GDS software suites remain the main focus of our systems, and keep GDS ahead of the competition. Designed to be extremely flexible, GDSLAB can be used with the complete GDS range of equipment, but uniquely, may also be used with many other manufacturers' test equipment.

In addition to laboratory equipment, GDS also designs and develops geotechnical field equipment for geophysics testing. Both the GDS Continuous Surface Wave Systems and the Spectral Analysis of Surface Waves systems are designed for use in the field for site investigation. The systems provide a fast, portable means of testing the ground, particularly in relation to road, track and runway subgrade investigation and the quantitative monitoring of ground improvements, such as land reclamation and land fill sites.

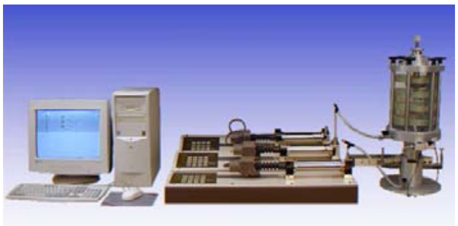
See www.gdsinstruments.com for the full range of GDS equipment. Some examples of equipment supplied as part of the standard GDS Instruments range are shown below.

Complete Bespoke Systems

Dynamic cyclic simple shear

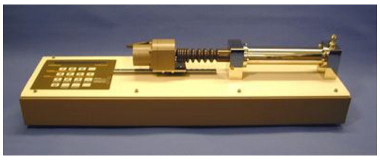
PC controlled triaxial system (GDSTAS)

2, 5, 10Hz Dynamic triaxial Testing system (DYNTTS)



Advanced PC controlled stress path testing system (ADVTTS)

System components



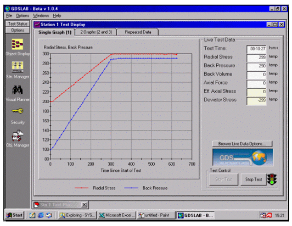
GDS Advanced Pressure/Volume controller, range from 100kPa to 150,000kPa

GDS axial loading Frame, range from 10kN to 500kN

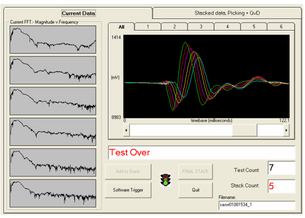
Field Geophysics

GDS Spectral Analysis of Surface Waves System

GDS Software (Laboratory and Field)



GDSLAB Laboratory control and data acquisition software



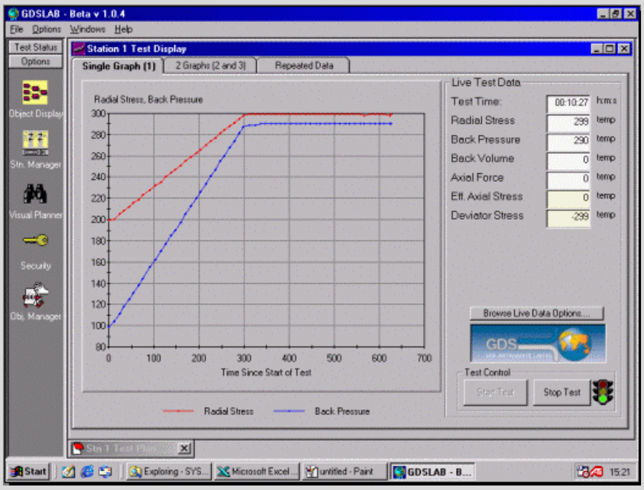
GDS Spectral Analysis of Surface Waves Software

Advanced Transducers

GDS Bender Element System

TEST MODULE OPTIONS	
Data Acquisition only	✓
Saturation/Consolidation	✓
Standard Triaxial	✓
Stress Paths	✓
Advanced Loading	✓
Permeability	✓
Unsat Testing	✓
K0 (zero lateral strain)	✓
Hollow Cylinder	✓
Oedometer Logging	✓
Dynamic Cyclic Triaxial	✓
Direct Shear Box	✓
Static Simple Shear	✓
Cyclic Simple Shear	✓

GDSLAB control and data acquisition software



What is it?

GDSLAB is control and data acquisition software for geotechnical laboratory applications. The main advantage of GDSLAB is that as well as the ability to integrate all existing GDS hardware, other manufacturers' hardware can also be used. Whether performing Triaxial, CBR, Direct Shear box, Simple Shear, Hollow Cylinder or simple Consolidation Logging tests, GDSLAB represents a breakthrough in geotechnical laboratory control software.

What are its uses?

GDSLAB can be integrated with existing or new laboratory equipment to provide data acquisition and control for standard or advanced testing. Commercial or research testing is possible with the choice of modules available. In addition, equipment manufactured by other leading manufacturers may be brought under the control of GDSLAB to enable testing to be carried out under computer control.

Alternatively, where computer control is not available, GDSLAB may be used to acquire data from your existing hardware then present data using GDSLAB REPORTS. *For the first time the test software will not be tied to the OEM software supplied.*

ENHANCED SOFTWARE FEATURES	
Multiple test stations from a single PC	✓
Batching of multiple tests	✓
Change graph axes 'on the fly'	✓
Change live test data displayed 'on the fly'	✓
Flexibility in allocating the hardware setup	✓
Intuitive graphical hardware configuration and transducer setup	✓
Only required test modules need to be purchased	✓
Sharing of multi-channel data acquisition devices between stations	✓

Required PC Specification

Operating System: Win 95 or higher (XP recommended)
Min PC SpecHardware: 233 MHz Pentium minimum
128 Megabytes Ram minimum
CD Rom

Note 1: Free serial ports/PCI slots/ISA slots/USB ports as required for individual hardware connection.
Note 2: Due to the flexible nature of the GDSLAB software, as many stations may be configured on a single PC as can be physically connected to it! In systems that have multiple and complex stations, a higher specification PC may be required.

How do you use it?

GDSLAB is a modular program that is initially purchased as a Kernel, or 'core' program. This kernel is the initial framework for GDSLAB, and includes data acquisition capability.

Optional test modules are then purchased as 'Add-ins' to bring to the software the ability to control particular tests (e.g. Fig. 1 'Satcon', Saturation and Consolidation module). Test modules integrate fully into GDSLAB to form a single combined program adding further functionality to the Kernel. Each Test Module is purchased according to the type of test you will be performing therefore only the desired test modules need to be purchased.

The modular approach means that as only the required software is purchased, thus keeping the cost to a minimum. Additional test modules may then be added to the package at any time in the future when required.

A full list of the test modules currently available can be found on page 1 of this datasheet (Test Module Options).

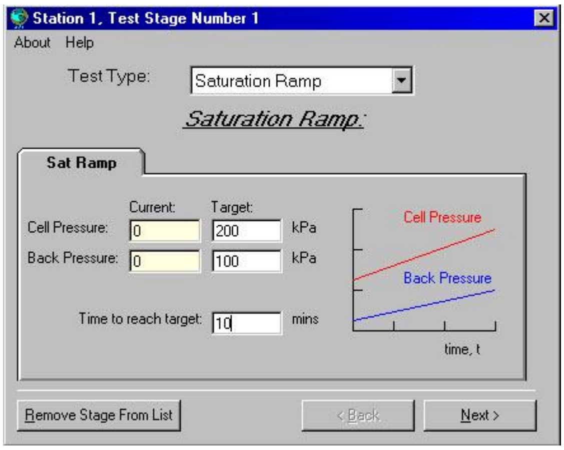


Fig.1: Saturation/Consolidation (Satcon) test module test setup screen.

GDSLAB configuration files (.ini files)

An ini file, or a number of ini files are created specifically for the users system setup. This ini file defines exactly the hardware that is connected to the PC and how the hardware is to be used. The ini file forms the basis for GDSLAB's flexibility in that hardware configurations can be tailored to the user's exact needs. GDSLAB then provides the user with a graphical display of the hardware in terms of the 'Hardware Display' (see below).

Hardware Display – an intuitive user interface

By clicking on any of the devices within the hardware/object display, information about the device will appear in a new window. Depending on the hardware arrangement, this may simply be an information box, or a box where communications (comms) settings must be entered (e.g. RS232 or IEEE parameters). These parameters are set to match the physical settings of the hardware.

Clicking on the "EYE" icon (the eye represents a read devices) will bring up the transducer details for that particular device. Specific transducer details are then entered in the ADVANCED tab such as Transducer Full Scale, Decimal Places and Transducer Upper Limit. The CALIBRATION tab is then used where either the transducer sensitivity is entered, or a full calibration is performed.

This graphical representation of the hardware attached to the PC makes inputting the hardware parameters, as well as diagnosing hardware problems, a simple experience for the user.

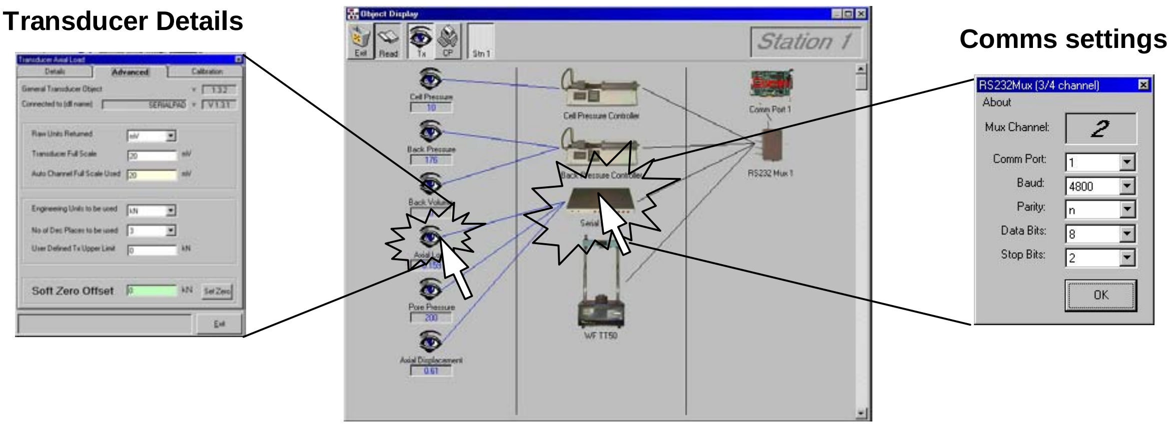


Fig. 2: Setting up devices using the hardware display screen

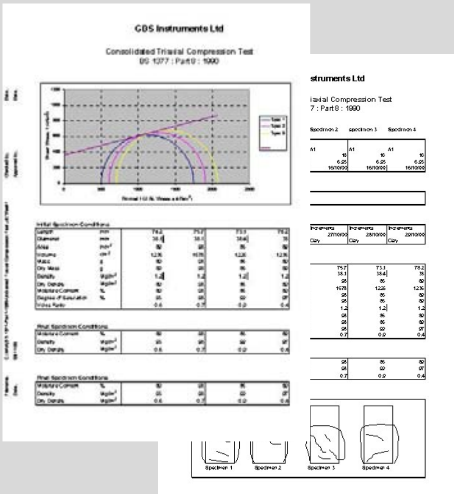
TEST REPORTS OUTPUT IN EXCEL FORMAT TO BRITISH STANDARDS (BS1377:1990):

- **Triaxial – UU, CU, CD** ✓
- **Oedometer** ✓
- **CBR** ✓

Future modules to include:

- Shearbox ✓
- Permeability ✓

GDSLAB REPORTS



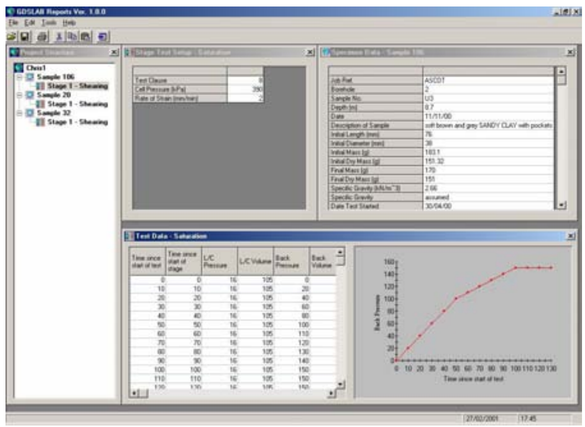
What is it?

GDSLAB REPORTS is a laboratory test results presentation package to National Standards e.g. BS 1377:1990. This program can be used to present data whether saved in a GDSLAB data file, or input by hand. Additionally, it can be used with other manufacturer's dataloggers.

What are its uses?

GDSLAB REPORTS is a program that combines the simplicity of a Windows user interface, with the power of Microsoft Excel. Data obtained using GDSLAB control and data acquisition software (or directly from your logger's software) may be selected, viewed and manipulated where necessary before being exported directly as an Excel spreadsheet.

The GDSLAB REPORTS user interface is designed to manage your test data files as well as provide a means for essential user input procedures such as locating t90.

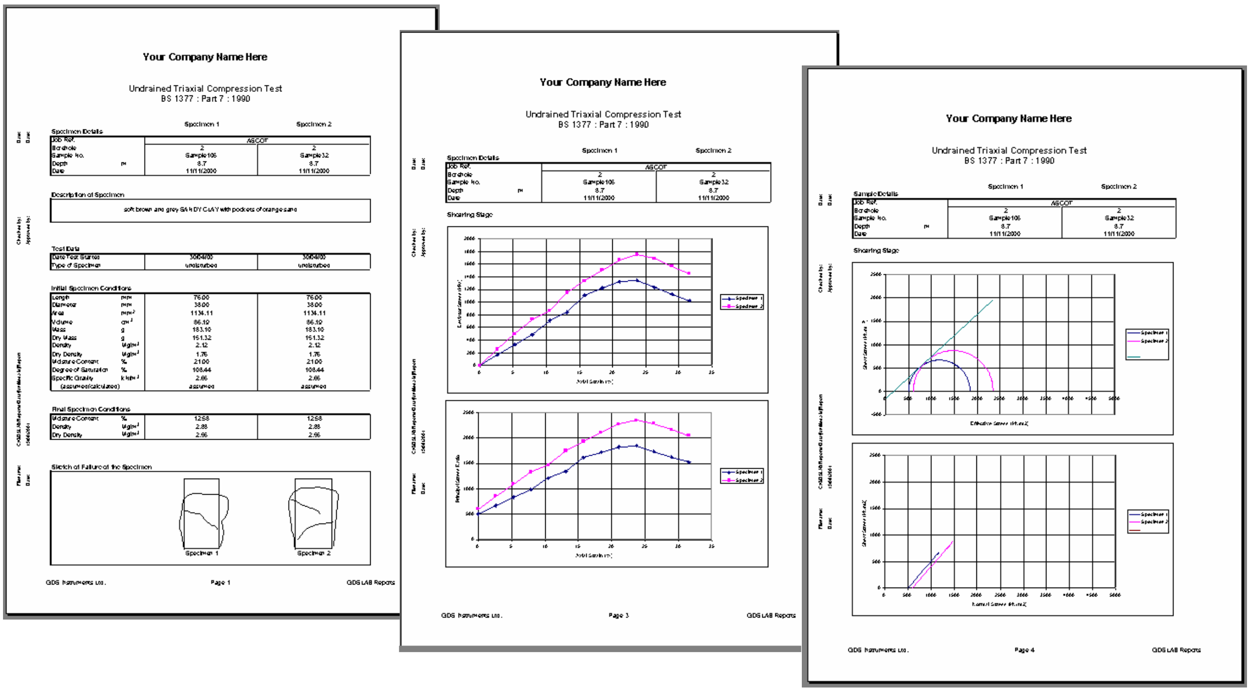


The Excel template spreadsheet created by GDSLAB REPORTS may then be selected for a particular national standard (eg. BS 1377). The template spreadsheet can be customised to a specific company format as required. Excel is widely accepted as the most popular spreadsheet program available today, and as such is seen as a simple interface, that many computer users can already easily manipulate. This also allows your reports to be distributed in electronic format without the need for specific software.

PC Specification

- **Operating System:** Win95, 98, NT, 2000, XP, Vista.
- **Office Suite:** Compatible with Office XP (2002) and above.
- **Hardware:** 233 MHz Pentium or similar, 32 Megabytes Ram (minimum), 64 Mb recommended, CD Rom.
- Microsoft Excel v8 or higher must also be installed on the PC (Office XP needed when using Windows XP)

Example of Reports Output



Why buy GDSLAB Reports?

- Test results automatically generated and output in Excel format, making them easily displayed, easily customised and easy to distribute to clients in electronic format.
- t50, t90 and t100 values calculated graphically.
- Reports can be created from data saved in GDSLAB, data downloaded from a datalogger or data can be manually input directly into GDSLAB Reports.
- GDSLAB Reports is modular so you only need to purchase the modules required for your testing requirements or your International Standard requirements.

Pressure range

1MPa ✓

Volume capacity

200cc ✓

Optional Smart Keypad

Enterprise Level Pressure/ Volume Controller (ELDPC)

What is it?

The GDS Enterprise Level Pressure/Volume Controller (ELDPC) is a general-purpose water pressure source and volume change gauge. With a maximum pressure of 1000kPa and a volumetric capacity of 200cm^3, the ELDPC fits neatly in the GDS range of pressure controllers below the premiere product namely the Advanced Pressure Controller (ADVDPC) and the mid-range Standard Pressure Controller (STDDPC). Table 1 shows a comparison between devices (see page 2).

What are its uses?

The ELDPC provides an extremely cost-effective replacement for conventional soil mechanics laboratory pressure sources and volume change gauges. It is ideal as a back pressure or cell pressure source where it can also measure the change in volume of the test specimen.

In line with existing GDS pressure controllers the ELDPC does not require a supply of compressed air to function. Configured both with or without the optional keypad, the device can be controlled directly from a computer using its own full speed USB 2.0 interface.

With the addition of the optional Smart Keypad the ELDPC can be configured as a completely stand-alone device. In this stand-alone mode, the instrument is a constant pressure source which can replace traditional laboratory pressure sources such as mercury column, compressed air, pumped oil and dead weight devices. It is also a volume change gauge resolving to 1 cu mm.

The reduced size of the ELDPC compared to any other controller in the GDS range makes it ideally suited for life in a commercial testing laboratory where bench space is usually at a premium. The ELDPC automatically protects itself from pressure and volume over-ranges.

Intuitive PC based software supplied allows full controller functionality to be accessed by means of the full speed USB 2.0 interface. The instrument may also be controlled via the optional Smart Keypad without the need of a PC.

The ELDPC is fully RoHS Compliant.

Technical specification

- **Pressure range**: 1 MPa
- **Volumetric capacity (nominal)**: 200cc for all pressure ranges
- **Resolution of measurement**: pressure = 1kPa, volume = 1cu mm
- **Accuracy of measurement**: pressure: <0.25% full range, Volume: < 0.4% measured value with <+/- 50mm^3 backlash
- **Closed-loop microprocessor control of pressure:** regulated to +/- 1kPa
- **Closed-loop microprocessor control of volume:** regulated to +/- 1cu mm
- **Size**: 550mm x 100mm x 125mm
- **Weight**: 5.5kg (empty)
- **Power**: Supply: 100-240V AC, 50-60Hz, 0.7A. Max Consumption: 20W. Typical Consumption: <12W.
- **Ambient temperature range**: 10°C to 30°C
- **Relative humidity**: 20% to 80% non condensing
- **User interface**: PC based software or Optional Smart Keypad featuring state-of-the-art Organic LED display technology with 180 degree viewing angle and 16 key input with audio feedback
- **Computer interface**: Full speed USB 2.0 compatible interface
- **Maximum operational speed:** Ultra high speed Fill/Empty up to 1500 cu mm/sec
- **Onboard processing:** 40 MIPS 16 bit DSC

How do you use it?

The instrument may be controlled via a PC or by using the optional Smart Keypad.

Via a PC

Simply install the GDS software onto your windows based PC and plug the instrument in via the USB interface. The windows based application will then allow you to operate the device. A display window shows the current pressure and volume.

For example, to set a constant pressure type “500” into the Pressure textbox and press enter or click Seek Pressure. The controller will then seek to a target pressure of 500kPa. The current pressure and volume are displayed above.

Using a Smart Keypad

Simply plug the Smart Keypad (see Fig. 1) into the ELDPC and the Smart Keypad will automatically recognise the controller and display the current pressure and volume.

For example, to set a constant pressure merely type “500” using the membrane keypad – the Smart Keypad will display the text “500 kPa”. Pressing the green enter key will the cause the controller to seek to the target pressure of 500kPa. The current pressure will be displayed in the top right corner.

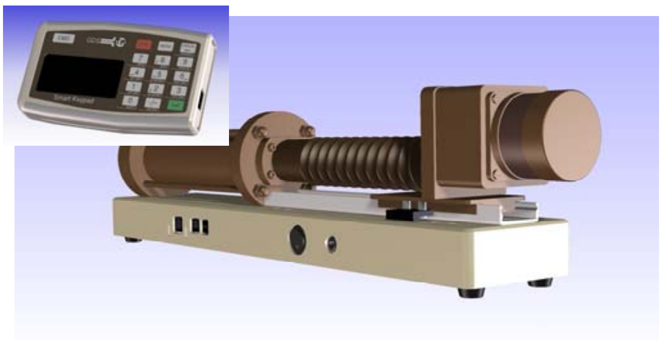


Fig. 1 ELDPC configured for use from a PC without the keypad. Optional keypad shown inset.

How does it work?

Liquid (normally deaerated water) in a cylinder is pressurised and displaced by a piston moving in the cylinder. The piston is actuated by a ball screw turned in a captive ball nut by an electric motor and gearbox that move rectilinearly on a ball slide (see Fig. 2).

Pressure is measured by an integral solid state transducer. Control algorithms are built into the onboard microcontroller to cause the controller to seek to a target pressure or step to a target volume change. Volume change is measured by counting the steps of the incremental motor.

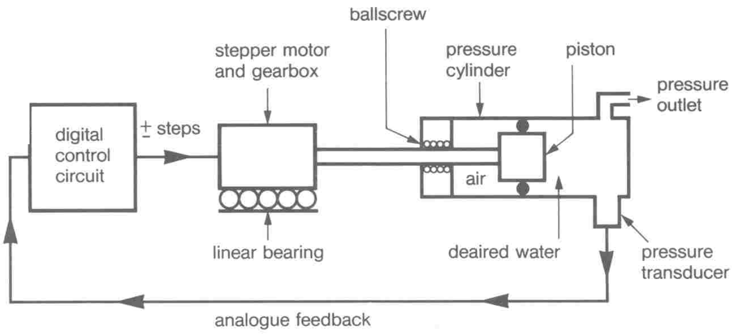


Fig. 2 Operational schematic of ELDPC

Why buy ELDPC?

- Lowest cost GDS pressure/volume controller to date
- May be configured with or without the Smart Keypad
- Volume resolution = 1cu mm (0.001cc)
- Pressure resolution = 1 kPa
- Can be used stand alone (with Smart Keypad), or computer controlled
- Compressed air not required
- Compatible with GDSLAB control and acquisition software

	ELDPC	STDDPC	ADVDPC
Available Pressure Ranges (MPa)	1	0.1, 1, 3 or 4	0.1, 0.5, 1, 2, 4, 16, 32, 64, 128 or 150
Volume capacity	$200cm^3$	$200cm^3$	200 or $1000cm^3$
Pressure accuracy	0.25%FRO	0.15%FRO	<0.1%FRO
Volume accuracy	0.4% measured +/- $50mm^3$	<0.25% measured +/- $30mm^3$	<0.1% measured +/- $12mm^3$
Data acquisition	1 channel 12 bit	1 or 2 Channel 13 bit	1 or 2 Channel 13 bit Enhanced to 14 bit
Communication	USB	RS232	RS232 or IEEE488
Keypad & Display	Optional	Included	Included
Size (mm)	550mm x 100mm x 125mm	600mm x 230mm x 220mm	860mm x 230mm x 220mm

Table 1 Comparison between the Enterprise Level (ELDPC), Standard (STDDPC) and Advanced (ADVDPC) pressure/volume controllers.

Options available for ADVDPC

Pressure ranges

500kPa	✓	16MPa	✓
1000kPa	✓	20MPa	✓
2000kPa	✓	32MPa	✓
3000kPa	✓	64MPa	✓
4000kPa	✓	128MPa	✓
8000kPa	✓	150MPa	✓

Volume ranges

200cc	✓	
1000cc	✓	(up to 2MPa only)

1000cc option for dedicated air pressure device up to 2MPa

Advanced Pressure/Volume Controller (ADVDPC)

What is it?

The GDS Advanced Pressure/Volume Controller (ADVDPC) is a microprocessor-controlled screw pump for the precise regulation and measurement of fluid pressure and volume change. As a standard research device in commercial and teaching soil mechanics laboratories, it offers the highest level of accuracy, resolution and control. The ADVDPC may be used with water, oil or air.

What are its uses?

In stand-alone mode, the ADVDPC is a constant pressure source which can replace traditional laboratory pressure sources such as mercury column, compressed air, pumped oil and dead weight devices. It is also a volume change gauge resolving to 1 cu mm.

Accordingly, the ADVDPC can be used in the geotechnical laboratory as a general-purpose source of water pressure as well as a volume change gauge. For example, the device is ideal as a back pressure source where it can also measure the change in volume of the test specimen.

For unsaturated soil testing, the fluid in the cylinder is air. Air pressure is precisely regulated under closed-loop control. In addition, air volume change is measured to 1 cu mm.

In addition, the instrument can be programmed through its own control panel to RAMP and CYCLE pressure or volume change linearly with respect to time. This means the device is also ideal for permeability testing by constant rate of flow or constant head.

Above all, the device has its own computer interface and can be controlled directly from a computer. Thus, the ADVDPC is the essential link between computer and test cell in GDS computer-controlled testing systems as well as in computer-controlled testing systems of your own devising.

Technical specification

- **Pressure ranges**: 0.05, 0.1, 0.2, 0.4, 0.8, 1, 2, 3, 4, 8, 16, 20, 32, 64, 128, 150MPa
- **Volumetric capacity (nominal)**: 200 cc for all pressure ranges. Optional 1000cc for pressure ranges < 2MPa
- **Resolution of measurement and control**: pressure = <0.1% full range, volume = 0.5cu mm (<8MPa) or 1cu mm (8MPa or higher)
- **Accuracy of measurement**: pressure = <0.1% full range, volume =< 0.1% measured value, or <0.25% for 1000cc (with +/-12mm^3 backlash up to 16MPa and +/-5mm^3 above16MPa)
- **Size**: 860mm x 230mm x 220mm
- **Weight**: 20kg
- **Power**: 92-265v, A.C. 48-440Hz, 65w maximum, single phase three wire earthed supply, 2A fuse x 2
- **Ambient temperature range**: 10°C to 30°C
- **Relative humidity**: 20% to 80% non condensing
- **Control panel**: 16 keypad membrane touch panel with audio feedback. Functions include zero pressure, target pressure, zero volume, target volume, fill, empty, test, ramp, stop, continue, reset, enter, +, -, >, <, yes, no
- **User interface:** 40 character, 1-line liquid crystal display
- **Computer interface**: IEEE-488 Standard, Talker/Listener or optional serial RS232 (IEEE only with RFM)

How do you use it?

The user interface is a control panel comprising a 40 character, 1-line liquid crystal display and a 16 key membrane touch panel with audio feedback.

The display is divided into three zones. The first zone shows a continually updated display of the current pressure. The second zone is used to prompt for information and to display entered information. The third zone shows a continually updated display of volume change since power-on or since the volume reading was last zeroed.

The 16 key keypad is used for entering TARGET PRESSURE, TARGET VOLUME, RAMP (linear time ramp of pressure or volume change) and CYCLE parameters. The keypad also gives access to on-board diagnostics for checking out each of the major hardware components of the system.

To set a constant pressure, for example, you press the function key TARGET PRESSURE and the message display will show "TARGET PRESSURE = kPA". Pressing the numeric keys, in the sequence 1,2,3,4, changes the display to read "TARGET PRESSURE = 1234kPa". Pressing the ENTER key then causes the controller to seek to the target pressure of 1234 kPa. The measured pressure is also displayed.

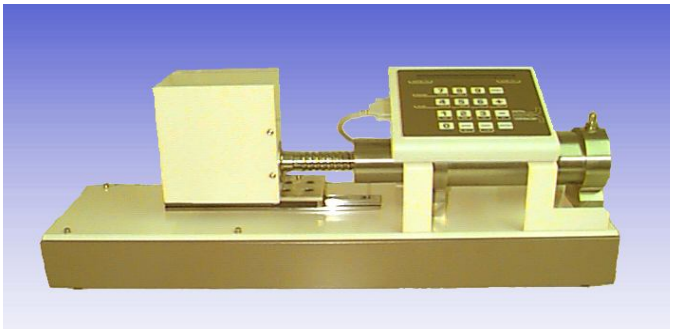


Fig. 1 The 64MPa/200cc ADVDPC

How does it work?

Liquid (normally deaerated water) in a cylinder is pressurised and displaced by a piston moving in the cylinder. The piston is actuated by a ball screw turned in a captive ball nut by an electric motor and gearbox that move rectilinearly on a ball slide (see Fig. 2).

Pressure is measured by an integral solid state transducer. Control algorithms are built into the onboard microprocessor to cause the controller to seek to a target pressure or step to a target volume change. Volume change is measured by counting the steps of the incremental motor.

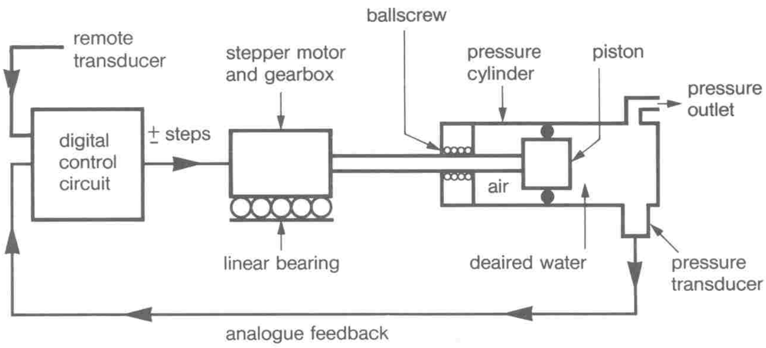


Fig. 2 Operational schematic of ADVDPC

Useful GDS helpsheets

Helpsheet 107: ADVDPC Quick Reference Guide.
Helpsheet 60: Advanced and Standard Controllers - comparison.

All datasheets and helpsheets available from the GDS website at www.gdsinstruments.com/support

Why buy ADVDPC?

- Volume resolution = 1cu mm (0.001cc)
- Pressure resolution = 0.1 kPa
- Can be used stand alone, or computer controlled
- All serial or IEEE communication parameters supplied to enable own software to be written if required
- Compressed air not required
- Compatible with GDSLAB control and acquisition software

Maximum operational speeds

All controllers have two basic stepping rates. The higher rate is 1000 steps/sec and applies to the functions of target volume and fill/empty. The lower rate is 500 steps/sec and applies to all other functions. Controllers with a pressure range below 5MPa have a step volume change of 0.5cu mm. Controllers with a pressure range of 8MPa and above have a step volume change of 0.1cu mm. For example, the 2MPa/200 cc controller has a fill/empty speed of 1000 x 0.5cu mm/sec = 500 cu mm/sec; whereas the 64MPa/200 cc controller has a fill/empty speed of 1000 x 0.1 cu mm/sec = 100 cu mm/sec.

Due to continued development, specifications may change without notice.

Options available for STDDPC

Pressure ranges

1MPa ✓ Available on request
2MPa ✓ Available on request
3MPa ✓ *Standard Option
4MPa ✓ Available on request

Volume

200cc ✓

Standard Pressure/Volume Controller (STDDPC) V2

Version 2, released 12/01/2010

What is it?

The GDS Standard Pressure/Volume Controller (STDDPC) is a general-purpose water pressure source and volume change gauge. It is designed for use in commercial and teaching soil mechanics laboratories. A stepping motor and screw-drive actuate a piston which directly pressurises water. The pressure is regulated under closed-loop control. The change in volume is measured to 1cu mm (0.001cc) by counting the steps to the stepping motor.

What are its uses?

The STDDPC, typically operating at 3MPa/200cc, provides a cost-effective direct replacement for conventional soil mechanics laboratory pressure sources and volume change gauges. Above all, the device has its own computer interface and so can be controlled directly from a computer. It is ideal as a back pressure source where it can also measure the change in volume of the test specimen. Also, it automatically protects itself from pressure and volume over-ranges.

In stand-alone mode, the instrument is a constant pressure source which can replace traditional laboratory pressure sources such as mercury column, compressed air, pumped oil and dead weight devices. It is also a volume change gauge resolving to 1 cu mm.

Recently upgraded to a version 2 unit, advantages over the version 1 standard controller include;

- USB connectivity,
- Faster Fill / Empty and pressure seek speeds,
- Lighter and with a smaller footprint.

How do you use it?

The instrument may be controlled via a PC or by using the optional Smart Keypad.

Via a PC
Compatible with the GDSLAB software suite, this windows

Technical specification

- **Pressure ranges**: 1, 2, 3, 4MPa
- **Volumetric capacity (nominal)**: 200cc for all pressure ranges
- **Resolution of pressure measurement**: 1kPa on display, 0.1kPa via software *(10 x improvement on version 1 STDDPC)*
- **Resolution of volume measurement**: 1cu mm
- **Accuracy of measurement**: pressure = <0.15% full range, Volume =< 0.25% measured value with +/- 30mm^3 backlash
- **Closed-loop microprocessor control of pressure:** regulated to 0.1kPa *(10 x improvement on version 1).*
- **Closed-loop microprocessor control of volume:** regulated to 1cu mm
- **Size**: 620mm x 100mm x 140mm
- **Weight**: 10.2kg
- **Power**: 100-240V~1.6A MAX, 50-60Hz
- **Ambient temperature range**: 10°C to 30°C
- **Relative humidity**: 20% to 80% non condensing
- **User interface**: PC based software or Optional Smart Keypad featuring state-of-the-art Organic LED display technology with 180 degree viewing angle and 16 key input with audio feedback
- **Computer interface**: USB computer interface for computer control and logging of pressure and volume
- **Maximum operational speed:** Control Fill/empty speed = 500 mm^3/s. Fast Fill/empty up to 1400 mm^3/s.

based application will allow you to operate the device. In its simplest form, a display window shows the current pressure and volume. For example, to set a constant pressure type "500" into the Pressure textbox and press enter or click Seek Pressure. The controller will then seek to a target pressure of 500kPa. The current pressure and volume are displayed above.

Using a Smart Keypad
Simply plug the Smart Keypad into the STDPC and the Smart Keypad will automatically recognise the controller and display the current pressure and volume. For example, to set a constant pressure merely type "500" using the membrane keypad – the Smart Keypad will display the text "500 kPa". Pressing the green enter key will cause the controller to seek to the target pressure of 500kPa. The current pressure will be displayed in the top right corner.

How does it work?

Liquid (normally deaerated water) in a cylinder is pressurised and displaced by a piston moving in the cylinder. The piston is actuated by a ball screw turned in a captive ball nut by an electric motor and gearbox that move rectilinearly on a ball slide (see Fig. 1).

Pressure is measured by an integral solid state transducer. Control algorithms are built into the onboard microprocessor to cause the controller to seek to a target pressure or step to a target volume change. Volume change is measured by counting the steps of the incremental motor.

Optional Digital Remote Feedback Module (Digi RFM)

Normally, the feedback to the main control circuit board comes from the internal pressure transducer. However, this input could come from a different source, such as a remote transducer. GDS has developed this into an elegantly-engineered enhancement which is the Remote Feedback Module (RFM).

The RFM (see Fig.2) enables the output of an external transducer to be measured and displayed by the controller. It also enables the piston action to be controlled from the feedback of the external transducer. Both the internal pressure transducer and the external transducer readings are displayed and transmitted over the computer interface.

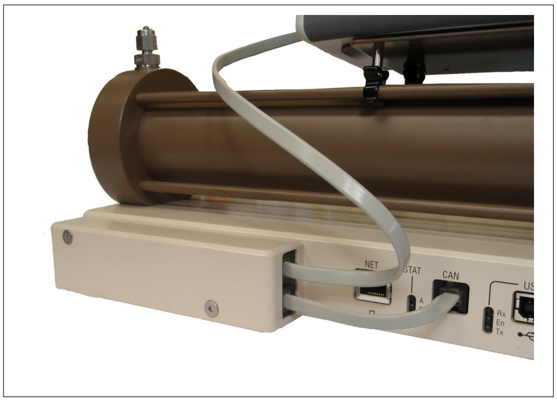


Fig. 2 Optional Digi RFM

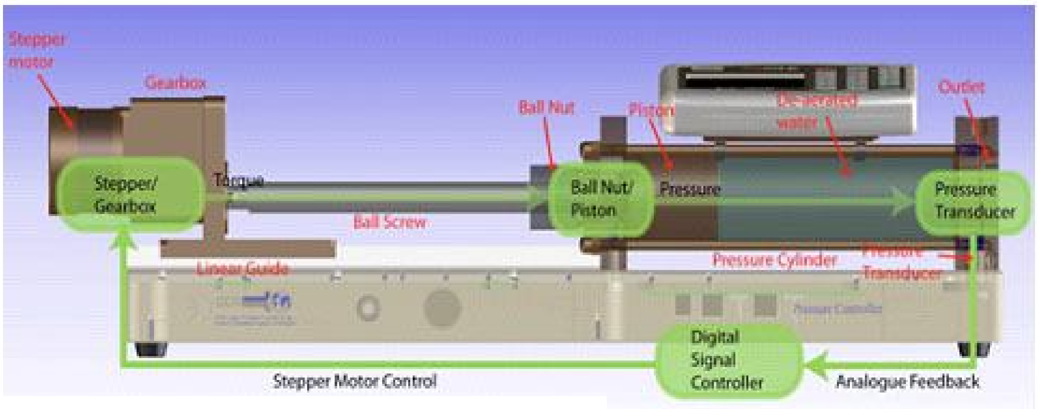


Fig. 1 Schematic of GDS Standard Level Controller.

Useful GDS helpsheets

***Helpsheet 60**:* Advanced, Standard and Enterprise Level Controller comparison.

Helpsheet 106: STDDPC Quick Reference Guide

Helpsheet 105: De-airing a GDS Controller

All datasheets and helpsheets available from the GDS website at www.gdsinstruments.com/support

Why buy STDDPC?

- Volume resolution = 1cu mm (0.001cc)
- Pressure resolution = 0.1 kPa as displayed on the software, 1kPa on smart keypad
- Can be used stand alone, or computer controlled
- Compressed air not required
- Compatible with GDSLAB control and acquisition software
- USB Interface

Due to continued development, specifications may change without notice.

Options available for GDSTAS

Load ranges

50kN	✓	500kN	✓
100kN	✓	750kN	✓
250kN	✓	1000kN	✓

Cell or back pressure ranges

500kPa	✓	16MPa	✓
1000kPa	✓	20MPa	✓
2000kPa	✓	32MPa	✓
3000kPa	✓	64Mpa	✓
4000kPa	✓	128MPa	✓
8000kPa	✓	150MPa	✓

Triaxial cells
from:

1700kPa	✓	to 128MPa	✓

for sizes:

38mm	✓	to 300mm	✓

Triaxial Automated System (GDSTAS) including ELTAS, STDTAS, ADVTAS and HPTAS

What is it?

The GDS Triaxial Automated System (GDSTAS) is a load frame-based triaxial testing system which may be configured exactly to the customers specification and budget. Using the GDS range of load frames, triaxial cells, pressure systems and the GDSLAB software, the basic system can be configured for low cost multi-station commercial testing right through to high range rock testing at research level. Using GDSLAB with optional software modules, GDSTAS can run advanced tests such as stress paths, slow cyclic and K0, all under PC control.

This system can be configured using any GDS devices, from a 50kN to 1000kN load frame and from a 500kPa to 150MPa pressure controller.

Overview

The GDS Triaxial Automated System, GDSTAS, has been designed to comply with international standards of test execution and data presentation, and to qualify for national laboratory accreditation schemes.

The system is controlled by the user's PC running MS Windows® and GDSLAB software.

The operator chooses the type of test from a test menu (eg U-U, C-U, multi-stage, stress path etc) and then enters the test parameters (of cell pressure, back pressure, testing rate and so on) and test termination conditions.

The test then proceeds automatically with all test data being saved to a file. On-line graphics are presented with up to three graphs displayed together with a block of current live test data. Tests can proceed overnight and during weekends and holidays. To enable spot-verification, all electronic measurements may be duplicated by mechanical gauges.

The computer directly controls the cell pressure, back pressure and testing rate. In addition to logging these parameters to the PC hard drive, the computer also logs axial displacement, axial load, pore pressure and volume change. Of course, additional transducers may be easily configured and logged during the test.

Technical specification

- computer-automated control of testing - not just data logging
- dedicated computer to each test station or multiple stations per PC
- MS Windows® software (GDSLAB) for test control and post-test processing
- cell pressure and back pressure truly independent
- spot-verification option
- well defined calibration procedures using Budenberg dead weight tester
- compliance with international standards
- future proof fully expandable software to allow additional testing or hardware to be incorporated at any time

System elements

The fundamental system hardware elements are shown in Fig. 1 below. The actual hardware used may be chosen to suit your testing and budgetary requirements. The more common arrangements are as follows:

- Enterprise Triaxial Automated System **(ELTAS)** which is based on 1MPa Enterprise Pressure/Volume Controller (ELDPC)
- Standard Triaxial Automated System **(STDTAS)** which is based on 3MPa Standard Pressure/Volume Controller (STDDPC)
- Advanced Triaxial Automated System **(ADVTAS)** which is based on 2MPa Advanced Pressure/Volume Controller (ADVDPC)
- High Pressure Triaxial Automated System **(HPTAS)** which is based on High Pressure Controllers (≥ 16MPa)

Each system may be chosen from a range of hardware supplied by GDS as follows (1-5):

1) Load frames

- 50kN and 100kN Velocity controlled devices with serial PC connectivity.
- 100kN, 250kN, 500kN, 750kN, 1000kN velocity, position and direct load feedback control with serial or IEEE PC connectivity.

2) Triaxial cells

- 1700kPa, specimens up to 50, 100 or 150mm (load frames > 50kN for 150mm cell due to size)
- 3400kPa, specimens up to 77mm
- 14MPa, specimens up to 50 or 100mm
- 20MPa, specimens up to 70mm
- 64MPa, specimens up to 54mm or 100mm
- 128MPa, specimens up to 50mm

3) Pressure/volume controllers

The cell pressure and back pressure controllers may be mixed and matched. There is the Enterprise Level Pressure/Volume Controller (ELDPC – see Fig. 2), with a pressure range to **1 MPa**, USB connectivity and 200 cc volumetric capacity.

Fig. 2 The ELDPC

A Standard Pressure/Volume Controller (STDDPC – see Fig. 3), with pressure ranges from **1 to 4MPa**, USB connectivity and 200 cc volumetric capacity.

Fig. 3 The STDDPC

Or there is the Advanced Pressure/Volume Controller (ADVDPC – see Fig. 4) with pressure ranges of **2MPa, 3MPa, 4MPa, 8MPa, 16MPa, 32MPa, 64MPa and 128MPa** with serial or IEEE PC connectivity and 200cc volumetric capacity. (Also, the ADVDPC 2MPa controller can be bought as 1000cc volumetric capacity item).

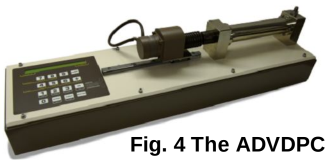


Fig. 4 The ADVDPC

The back pressure controller which applies back pressure, also measures volume change of the test specimen.

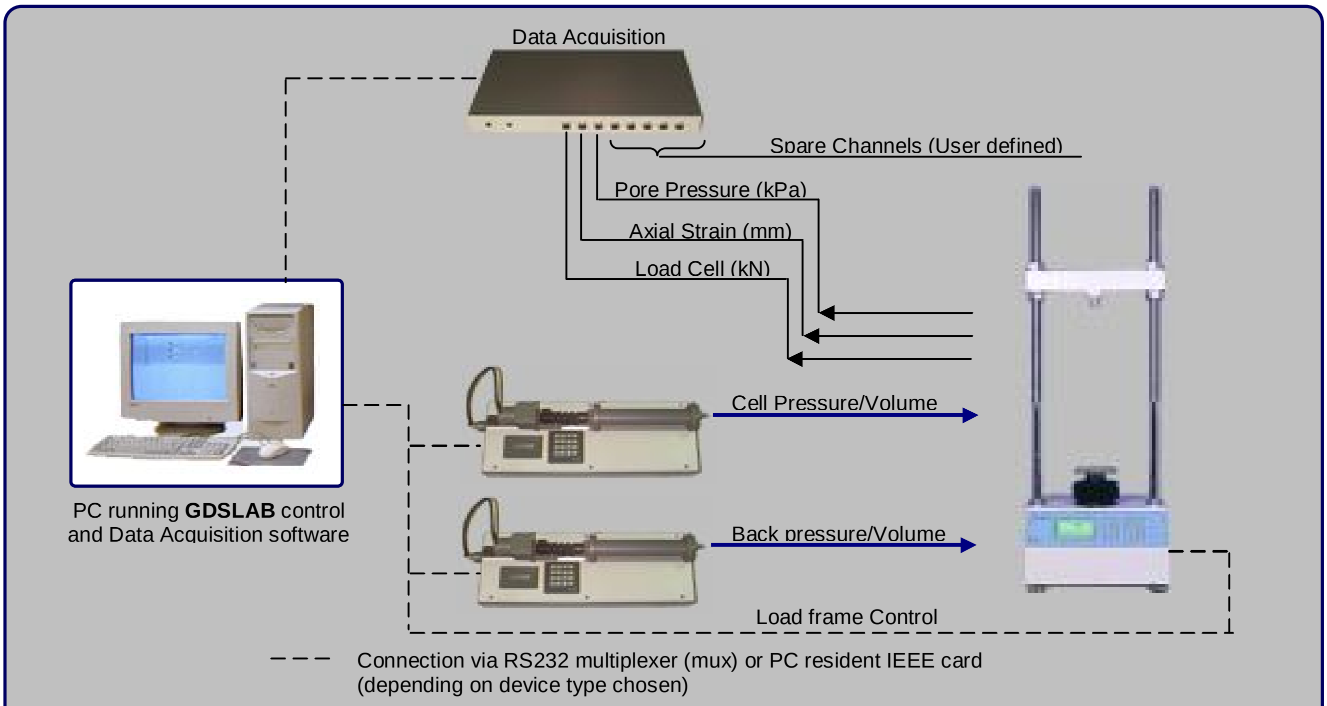


Fig. 1 Diagram of the GDSTAS hardware elements

4) Data acquisition devices

The standard GDS 8 channel data acquisition device, known as the “serial data pad”, may be used within any of the system combinations. This 16 bit device has 8 computer controlled gain ranges, specifically designed to suit transducers used in a triaxial test. i.e.

+/-10mV, +/-20mV, +/-30mV (load cells)
+/-100mV, +/-200mV (pressure transducers)
+/- 1V, +/- 5V, +/- 10V (displacement transducers)

5) Connecting devices

The system controller is any PC that runs MS Windows® v9x or above (Windows XP preferred). GDSLAB software is capable of running the hardware provided it can be connected to the PC. Multiple serial (RS232) devices may be connected using the GDS 4 channel multiplexer (mux), and up to 16 IEEE devices may be connected via a PC-resident IEEE card. The type of connectivity is of course determined by the device being connected

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:

- 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. 5).

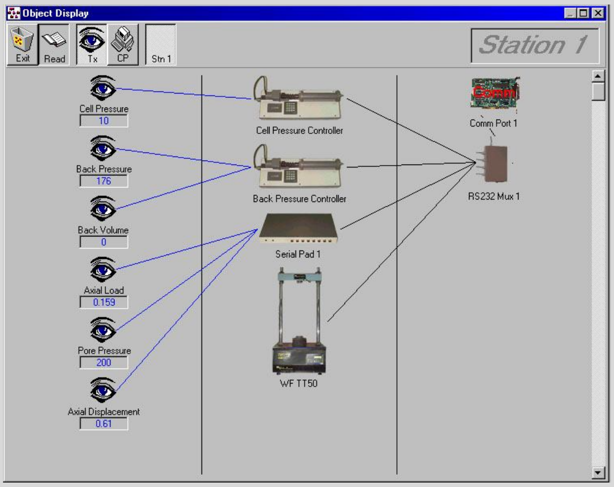


Fig. 5 Object display showing a standard STDTAS arrangement

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

GDSLAB REPORTS presentation software

GDSLAB REPORTS is a triaxial, shearbox and oedometer presentation package to National Standards (eg. BS 1377). This program is used to present data which is saved in a GDSLAB data file or input by hand.

GDSLAB REPORTS is a program which combines the simplicity of a MS Windows® user interface, with the power of MS Excel®. Data obtained using GDSLAB control and data acquisition software may be selected, viewed and manipulated where necessary (see Fig. 6) before being exported directly as an MS Excel® spreadsheet.

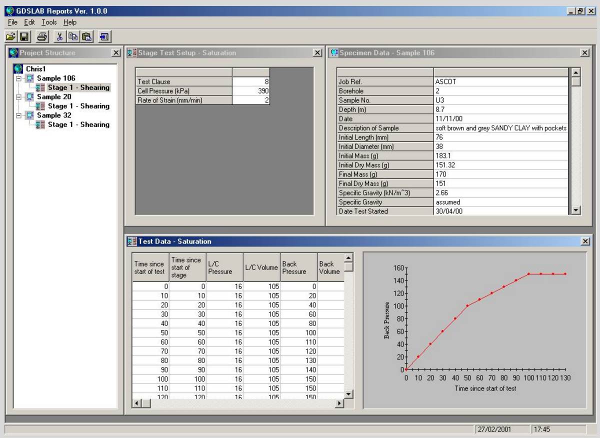


Fig. 6 GDSLAB Reports user interface

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

Upgrade to local strain measurement

Any GDSTAS system may be upgraded to perform Local Strain measurement using either Hall Effect or LVDT transducers (see Fig. 7). Both device types enable axial and radial deformation to be measured directly on the test specimen via lightweight aluminum holders.

Hall Effect transducers may be used in water up to 1700kPa. LVDT transducers come in 2 versions:

- **low pressure** (up to 3500 kPa) version for use in water
- **high pressure** (up to 200 MPa) version for use in non-conducting oil

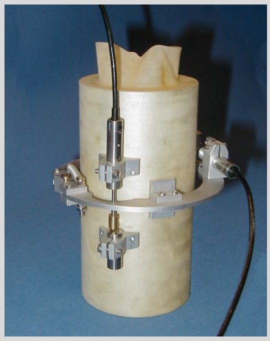


Fig. 7 Hall Effect and LVDT local strain transducers

For further information on local strain measurement, please refer to the dedicated Hall Effect Local Strain and LVDT Local Strain datasheets.

Upgrade to unsaturated testing

Any GDSTAS system may be upgraded to perform unsaturated triaxial testing with the addition of the following items:

- unsaturated pedestal with high air entry porous stone
- 1000cc Advanced Pressure/Volume Controller (for application of pore air pressure and measurement of air volume change) as in Fig. 8.

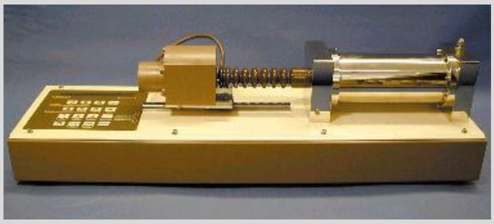


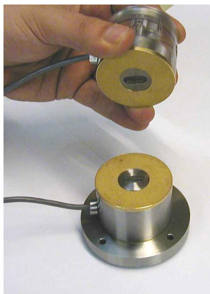
Fig. 8 1000cc Advanced Pressure/Volume Controller (ADVDPC)

For further information on unsaturated testing, including further unsaturated testing methods, please refer to the dedicated Unsaturated datasheet.

Upgrade to bender element testing

Any GDSTAS system may be upgraded to perform P and S wave bender element testing with the addition of the following items:

- bender element pedestal with bender element insert
- bender element top-cap with bender element insert
- high-speed data acquisition card
- signal conditioning unit which includes amplification of source and received signals (P and S-wave) with user controlled gain levels (via software).



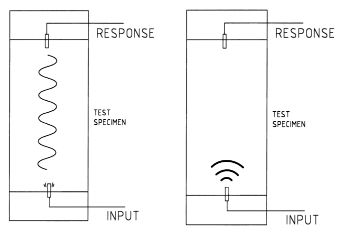


Fig. 9 P and S wave elements

For further information on bender element testing, please refer to the dedicated Bender Element Testing datasheet.

Why buy GDSTAS?

- Volume resolution = 1mm^3
- Possibility to upgrade to a dynamic system with the addition of a GDS Dynamic control system and pneumatic actuator which attaches to the load frame cross-head (See datasheet STDCTAS).
- Flexibility in the capacity of the system (specimen size, load, pressures etc) ensures a system is created to specifically suit the testing required and the budget.
- GDS worldwide technical support.

Due to continued development, specifications may change without notice.

Options available for GDSTTS

Load ranges

7kN ✓ 25kN ✓

Cell or back pressure ranges

500kPa ✓ 4000kPa ✓
1000kPa ✓ 8000kPa ✓
2000kPa ✓ 10MPa ✓
3000kPa ✓

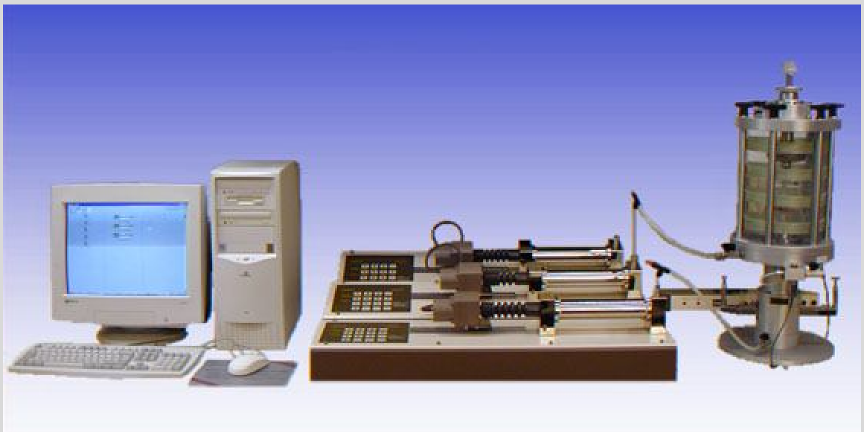
Triaxial cells
from:

2000kPa ✓ to 10MPa ✓

for sizes:

38mm ✓ to 100mm ✓

Triaxial Testing Systems (GDSTTS) including STDTTS, ADVTTS and HPTTS



What is it?

The GDS Triaxial Testing System (GDSTTS) is a fully automated advanced triaxial testing system designed principally for stress path testing due to the direct actuation of axial stress through the hydraulically controlled ram in the base of each cell. GDSTTS can run advanced tests such as stress paths, slow cyclic and K0, all under PC control. In fact, using the flexibility of GDSLAB software, almost any user-defined test may be performed. Due to the extensive GDS range of pressure controllers and triaxial cells, each system may be configured exactly to the customers specification and budget.

Overview

The system is based on the classic Bishop & Wesley-type stress path triaxial cell, and the GDS pressure/volume controller. Three of these pressure controllers link the computer to the test cell as follows:

- one for axial stress and axial displacement control.
- one for cell pressure control.
- one for setting back pressure and measuring volume change.

System elements

The fundamental system hardware elements are shown in Fig. 1 on the following page. The actual hardware used may be chosen to suit your testing and budgetary requirements. Common arrangements are as follows:

- Standard Triaxial Testing System (STDTTS) which is based on 3 x 3MPa Standard Pressure/Volume Controllers (STDDPC)
- Advanced Triaxial Testing System (ADVTTS) which is based on 3 x 2MPa Advanced Pressure/Volume Controllers (ADVDPC)
- High Pressure Triaxial Testing System (HPTTS) which is based on 3 x High Pressure Controllers

All elements of the ADVTTS system in particular are biased towards achieving the greatest resolution and accuracy, for the highest quality tests achievable in a research environment. The STDTTS system is a low cost version of ADVTTS.

Technical specification

- Accuracy of Pressure measurement = <0.1% full range (ADVTTS) or <0.15% full range (STDTTS)
- Resolution of Pressure measurement = 0.5kPa (ADVTTS) or 1kPa (STDTTS). For >8MPa see individual specs.
- Accuracy of Volume measurement = <0.1% measured value (ADVTTS) or <0.25% measured value (STDTTS)
- Resolution of Volume measurement = 0.5mm^3 (ADVTTS) or 1mm^3 (STDTTS and ADVTTS > 8MPa)
- Transducer Resolution = 16bit
- computer-automated control of testing - not just data logging
- MS Windows® software (GDSLAB) for test control and post-test processing
- Fully expandable software to allow additional testing or hardware to be incorporated at any time

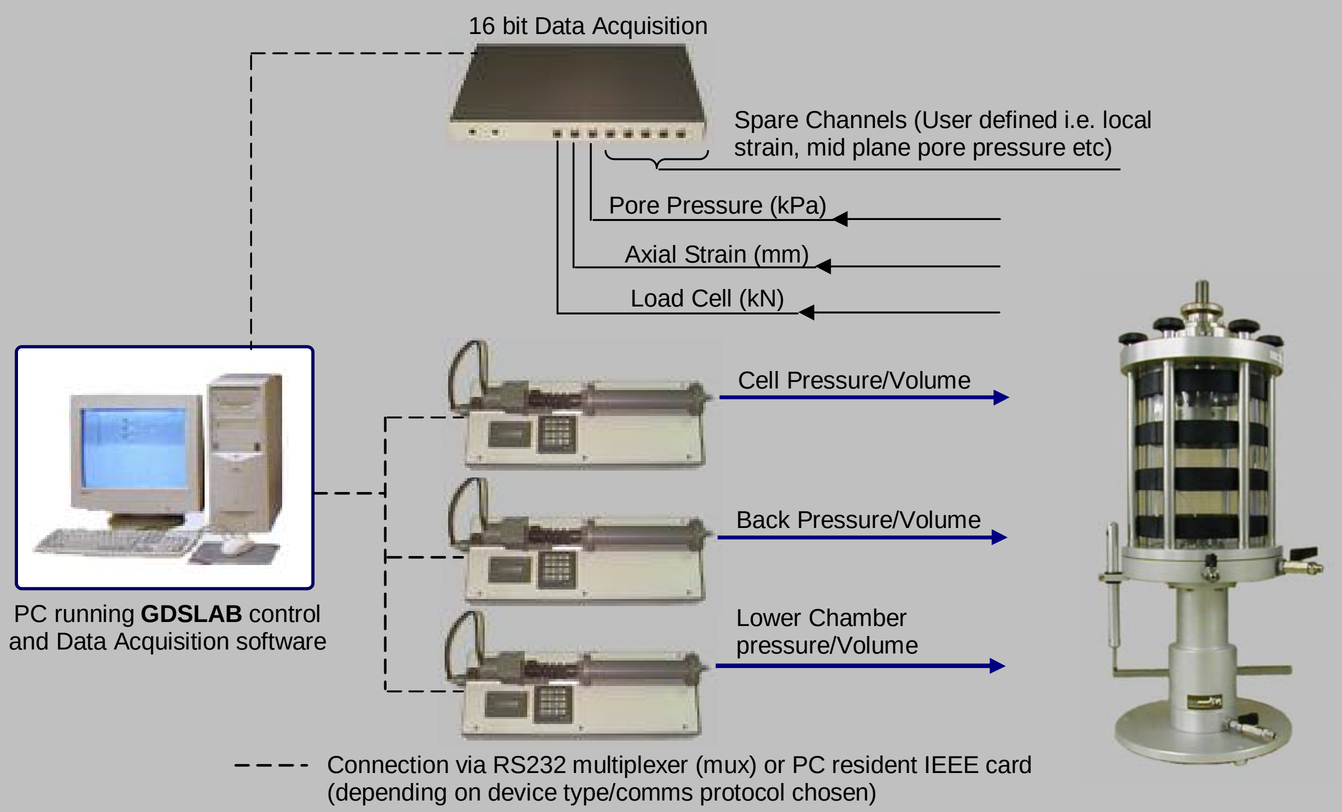


Fig. 1 Diagram of the STDTTS hardware elements

Bishop and Wesley triaxial cells

GDS manufactures 3 Bishop and Wesley stress path cells as follows:

- 7kN/2000kPa, for specimens up to 50mm (38mm and 50mm as standard). See Fig. 2.
- 25kN/2000kPa, for specimens up to 101.8mm (38, 50, 70 and 100mm as standard).
- 20kN/10MPa, for specimens up to 50mm (38mm and 50mm as standard). See Fig. 3.

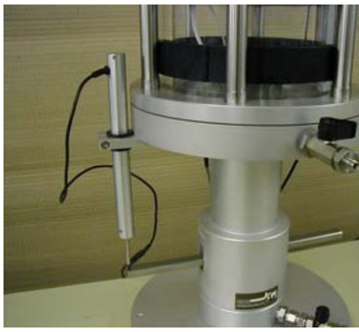



Fig. 2 GDS 38/50mm Bishop and Wesley cell

Updated GDS 2000kPa cells

Both the 7kN/2000kPa and the 25kN/2000kPa Bishop and Wesley cells have recently had a design review and as such a new, improved Bishop and Wesley cell has been developed by GDS. Design features of the new cells include:

- reduced axial ram friction
- improved vertical guidance
- improved lateral ram stiffness
- options for potentiometric or smaller LVDT transducers to be attached for measurement of axial displacement
- reduced backlash in ram adjustment head
- stainless steel pedestal as standard
- cell can be incorporated with the HKUST unsaturated soil testing inner cell
- full range of access rings available for entry/exit of additional transducer cables

Fig. 3 GDS 10MPa Bishop and Wesley cell

Pressure/volume controllers

The cell pressure and back pressure controllers may be mixed and matched. There is the Standard Pressure/Volume Controller (STDDPC – see Fig. 4), with pressure ranges from 1 to 4MPa, serial PC connectivity and 200 cc volumetric capacity.

Fig. 4 STDDPC

Or there is the Advanced Pressure/Volume Controller (ADVDPC – see Fig. 5) with pressure ranges of 2MPa, 3MPa, 4MPa, 8MPa, 16MPa, 32MPa, 64MPa and 128MPa with serial or IEEE PC connectivity and 200cc volumetric capacity. (Also, the ADVDPC 2MPa controller can be bought as 1000cc volumetric capacity item).

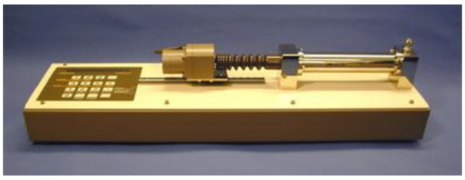


Fig. 5 ADVDPC

The back pressure controller which applies back pressure, also measures volume change of the test specimen.

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:

- SATCON (saturation and consolidation)
- standard triaxial
- stress path testing (p, q and s, t)
- advanced loading tests (cyclic, user defined)
- 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).

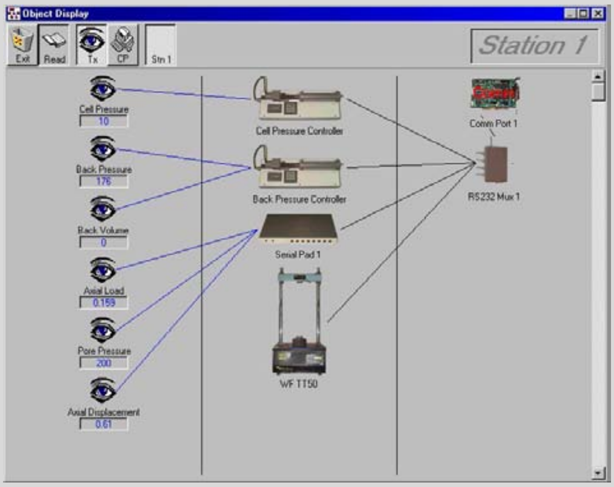


Fig. 6 Object display showing a standard STDTAS arrangement

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

GDSLAB REPORTS presentation software

GDSLAB REPORTS is a triaxial, shearbox and oedometer presentation package to National Standards (eg. BS 1377). This program is used to present data which is saved in a GDSLAB data file or input by hand.

GDSLAB REPORTS is a program which combines the simplicity of a MS Windows® user interface, with the power of MS Excel®. Data obtained using GDSLAB control and data acquisition software may be selected, viewed and manipulated where necessary (see Fig.7) before being exported directly as an MS Excel® spreadsheet.

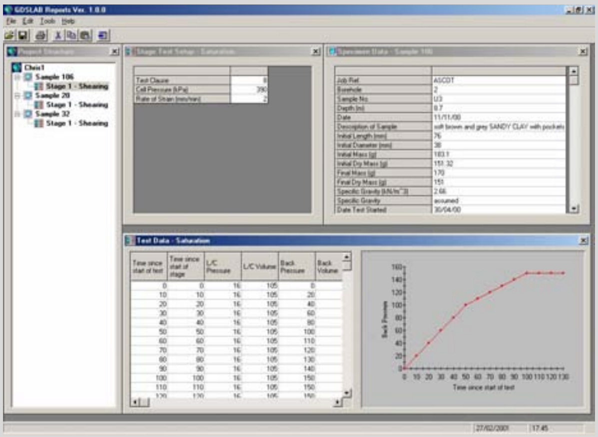


Fig. 7 GDSLAB Reports user interface

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

Upgrade to local strain measurement

Any GDSTTS system may be upgraded to perform Local Strain measurement using either Hall Effect or LVDT transducers (see Fig. 8). Both device types enable axial and radial deformation to be measured directly on the test specimen via lightweight aluminium holders.

Hall Effect transducers may be used in water up to 1700kPa. LVDT transducers come in 2 versions:

- **low pressure** (up to 3500 kPa) version for use in water
- **high pressure** (up to 200 MPa) version for use in non-conducting oil

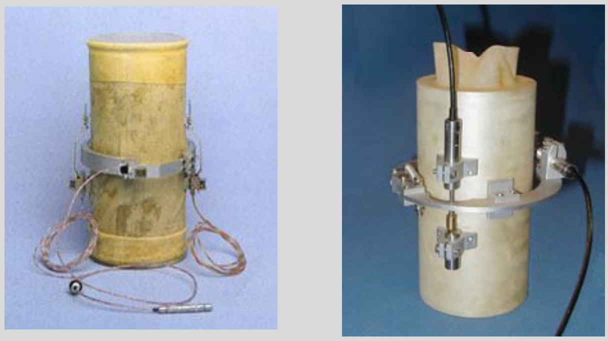


Fig. 8 Hall Effect and LVDT local strain transducers

For further information on local strain measurement, please refer to the dedicated Hall Effect Local Strain and LVDT Local Strain datasheets.

Upgrade to unsaturated testing

Any GDSTTS system may be upgraded to perform unsaturated triaxial testing with the addition of the following items:

- unsaturated pedestal with high air entry porous stone
- 1000cc Advanced Pressure/Volume Controller (for application of pore air pressure and measurement of air volume change) as in Fig. 9.
- Other unsat methods available (HKUST, double cell etc).

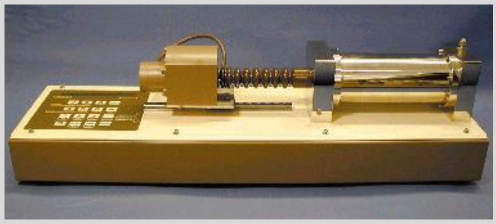


Fig. 9 1000cc Advanced Pressure/Volume Controller (ADVDPC)

For further information on unsaturated testing, including further unsaturated testing methods, please refer to the dedicated Unsaturated datasheet.

Upgrade to bender element testing

Any GDSTTS system may be upgraded to perform P and S wave bender element testing with the addition of the following items:

- bender element pedestal with bender element insert
- bender element top-cap with bender element insert
- high-speed data acquisition card
- signal conditioning unit which includes amplification of source and received signals (P and S-wave) with user controlled gain levels (via software).

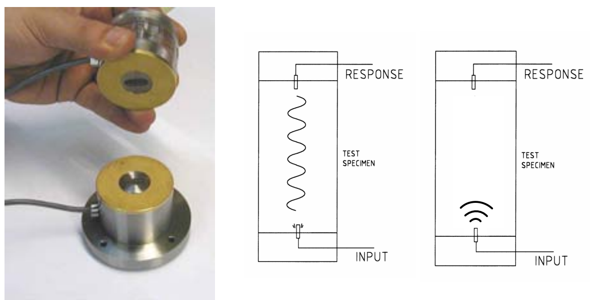


Fig. 10 P and S wave elements

For further information on bender element testing, please refer to the dedicated Bender Element Testing datasheet.

Why buy GDSTTS?

- ADVTTS remains the leading stress path system for research testing throughout the world
- STDTTS provides a low cost alternative with all the features of the ADVTTS system
- New improved GDS designed triaxial cells based on the original Bishop and Wesley concept
- Resolution of measurement of volume change in all systems = 0.5 or 1mm^3 (see specification on page 1)
- Flexibility in the capacity of the system (specimen size, load, pressures etc) ensures a system is created to specifically suit the testing required and the budget
- May be upgraded at any time for additional transducers, software modules, bender element testing, unsaturated testing and more – i.e. future proof!
- GDS worldwide technical support for peace of mind

Due to continued development, specifications may change without notice.

Large Diameter Cyclic Triaxial Testing System (LDCTTS)

Options available for LDCTTS

Load ranges

100kN ✓ **250kN** ✓

Custom range ✓

Load frequency

0 to 10Hz ✓

Sample dimensions

450mm height ✓

300mm diameter ✓

Custom sizes on request ✓

Volume change measurement

Inner cell 'HKUST' type ✓

International standards

ASTM D3999-91 ✓

prEN13286-7 ✓

What is it?

The GDS Large Diameter Cyclic Triaxial Testing System (LDCTTS) is hydraulically actuated with a large diameter triaxial cell suitable for testing samples with large particle sizes such as railway ballast. The system is capable of both monotonic (static) and dynamic triaxial tests as well as other advanced triaxial tests usually expected from a GDS system.

Using GDSLAB software with optional test control modules, GDSLDCT can run tests such as stress paths, slow cyclic, dynamic cyclic and K0, all under PC control.

Overview

The basic system consists of the following major components:

- GDS 10Hz hydraulic load frame (100kN/200kN)
- Hydraulic power pack to supply the load frame
- GDSDCS (dynamic control system) for data acquisition and control
- GDS single channel pneumatic regulator for cell pressure
- Optional GDS dual channel pneumatic regulator for both cell pressure and back pressure (in this case, single channel device above is not required)
- GDSLAB data acquisition and control software

The system is controlled by the user's PC running MS Windows® and GDSLAB software.

The operator chooses the type of test from a test menu (eg U-U, C-U, multi-stage, dynamic cyclic, stress path etc) and then enters the test parameters (of cell pressure, back pressure, testing rate and so on) and test termination conditions.

The test then proceeds automatically with all test data being saved to a file. On-line graphics are presented with up to three graphs displayed together with a block of current live test data.

The computer directly controls all parameters for the test in addition to logging these parameters to the PC hard drive. Of course, additional transducers may be configured easily and logged during the test.

Technical specification

- **Displacement range** = 100mm
- **Displacement resolution** = 16bit (i.e. <2µm)
- **Displacement accuracy** = <0.15% (i.e. <0.15mm)
- **Axial force resolution** = 16bit (i.e. <0.4N for 10kN load cell, <1.5N for 40kN load cell)
- **Axial force accuracy** = <0.1% of load cell range (i.e. 10N for 100kN load cell)
- **Control data points** = 10,000points/sec
- **Maximum saved data points** = 100points/cycle
- **Compliance with international standards**
- **MS Windows® software** = GDSLAB for automated test control and data collection
- **Future proof fully expandable software to allow additional testing or hardware to be incorporated at any time**

System capabilities

Load frame

- Direct closed-loop dynamic control of axial displacement or axial force to 10Hz, sinusoidal, triangular or user defined waveform.
- Performance specification conforming to the requirements of **ASTM Designation D3999-91** "Standard Test Methods for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus" and **prEN13286-7** “Unbound and Hydraulically Bound Mixtures – part 7 Cyclic Triaxial Test”. Method A of prEN13286-7 (variable confining pressure) requires the optional dynamic cell pressure actuator.

Triaxial cell

- Optional interchangeable (internal submersible) load cells to accommodate very soft to very stiff soils with ranges of 2, 4, 8, 16, 25, 32, 64, 128, 250kN are available. The load frame is supplied with an external load cell to match the model maximum load range as standard (i.e. 100 or 250kN).
- Double acting ram system holds the cell in place on the load frame whilst the lower ram applies forces to the specimen. The top ram allows for correct positioning of the submersible load cell. This means that load frames with base actuators do not have to overcome the weight and momentum of the whole triaxial cell, and the full load frame range may be applied directly to the specimen.
- 300mm diameter x 450mm height test specimen. Other sizes can be catered for by interchangeable base pedestals and triaxial extension top caps.
- Simple access for transducers, valves and pipework via 12 port transducer ring.
- Quasi-static closed-loop control of cell pressure

Fig. 1 shows a large diameter triaxial cell within a 100kN load frame.

GDS DCS – Digital Control System

- With 16 bit data acquisition (A/D) and 16 bit control output (D/A), the GDS DCS high speed digital control system runs at a control frequency of 10kHz per channel. This means that when running at 10Hz the system uses 1000 control points per cycle. When running at 1Hz, it uses 10,000 control points per cycle.

Fig. 1 LDCTTS testing system at the GDS factory

Hydraulic power unit

Pressure for the system is provided by a separate GDS Hydraulic Power Unit (see Fig. 2) which provides a constant source of pressure at 25MPa. This pressure source is used by the axial actuator to control pressure and displacement. It is also used to raise and lower the top beam. The hydraulic power pack is fully piped to include control valves, gauges, pressure and return line microfilters and water cooled heat exchanger. All electrical items are wired to a control box containing motor starters and fail safe shutdown interlocks, with local or remote control.
Typical oil flow = 36litre/min, electrical power = 18.5kW, 380V 3-phase, 50Hz, cooling water flow = up to 25litre/minute.

Fig. 2 GDS Hydraulic Power Unit

HKUST inner cell volume measurement

The HKUST (Hong Kong University of Science and Technology) volume change measurement method involves measuring the cell volume displaced by the sample in an inner cell within the main triaxial cell (see Fig. 3).

Measurement of the volume change is made using a high-accuracy differential pressure transducer (DPT). This enables the cell volume change to be measured from just the inner chamber thus minimizing the error due to temperature and pressure changes.

The inner chamber containing the triaxial sample is connected to a reference tube via the DPT. As the sample deforms it will displace water in the inner chamber causing the water level to rise or fall. By measuring the pressure in the inner chamber with respect to the pressure in the reference tube, with the correct calibration factor it is possible to determine the volume change in the inner chamber and, therefore, the volume change of the specimen.

The advantage of this type of volume change method is the high accuracy and resolution that can be achieved for very large specimen volume changes. It must be noted however that due to settling time of the reference tube this measurement system is appropriate for measuring sample volume change during static tests only. For dynamic measurement of sample volume it is recommended that the HKUST inner cell is replaced by an LVDT local strain transducer set.

Note: Fig. 3 is for illustration only as the schematic is for a small diameter sample.

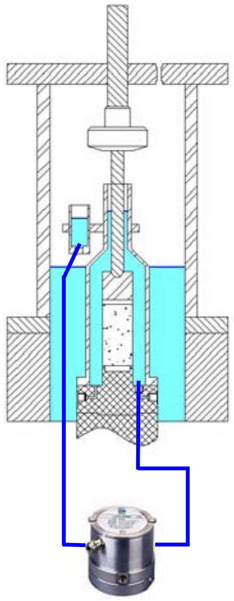


Fig. 3 HKUST sample volume change method

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:

- 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. 4).

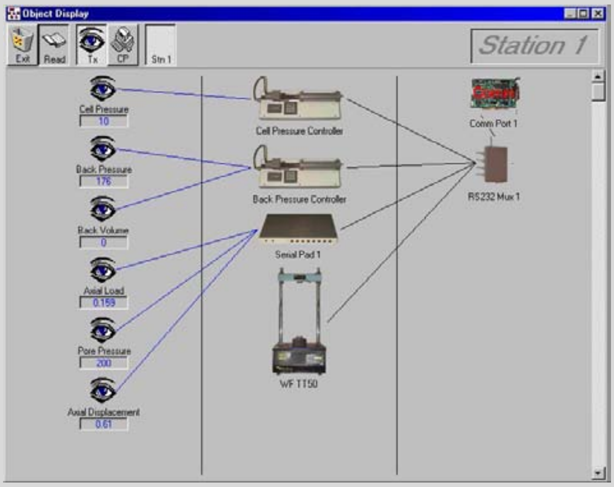


Fig. 4 Object display showing a triaxial test arrangement

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

Why buy GDSLDCT?

- Complete turn-key solution for dynamic measurement of large particle triaxial samples.
- Volume measurement by unique, proven method (HKUST)
- Flexibility in the capacity of the system (specimen size, load, pressures and so on) ensures a system is created to specifically suit the testing required and the budget.
- GDS worldwide technical support.

Due to continued development, specifications may change without notice.

Options available for GDSVIS

Axial load ranges

100kN ✓

250kN ✓

400kN ✓

Custom on request ✓

Daylight clearance for test cell

100kN
Max width = 500 mm
Max height = 735 mm
Min height = 0 mm

250kN
Max width = 750 mm
Max height = 1050 mm
Min height = 250 mm

400kN
Max width = 750 mm
Max height = 1050 mm
Min height = 250 mm

GDS Virtual Infinite Stiffness Loading System (GDSVIS)

What is it?

The GDS Virtual Infinite Stiffness Loading System (GDSVIS) is the loading frame/compression machine that you would expect from GDS. It has feedback control and continuous displays of axial load and platen displacement, IEEE or serial computer interface and, exclusive to GDS, Virtual Infinite Stiffness (VIS).

These outstanding features, coupled with GDSLAB software, GDS digital pressure controllers, and the GDS Data Acquisition System, give you unlimited possibilities in conventional and advanced PC-controlled triaxial testing of soil and rock.

What is VIS?

VIS (Virtual Infinite Stiffness) is a unique GDS development. To the observer, and in terms of the test specimen, it allows the axial loading system to operate as though to have infinite stiffness.

Technical specification

- **Load ranges**: 100kN (10ton), 250kN (25ton) and 400kN (40ton). Custom ranges available on request.
- **Load resolution**: +/- 1 in 10,000
- **Load cell accuracy:** non-linearity +/- 0.03%, hysteresis and non repeatability +/- 0.05%
- **Displacement range:** 100mm
- **Displacement resolution:** 0.1micrometre
- **Displacement accuracy:** 0.05% of full range
- **Max displacement rate:** TARGET: 3.75mm/min, RAMP: 1.20mm/mm, UP/DOWN: 6mm/min, RAMPTARGET LOAD control: 1.0mm/min
- **Max displacement rate:** there is no minimum rate
- **Max displacement rate:** platen diameter: 100kN = 140mm, 250kN = 145mm, 400kN = 145mm
- **Weight:** approx. 800 kgf to 2000 kgf (depending on model)
- **Nominal Size:** 2.3m x 1.0m x 0.96m
- **Resolution of measurement and control**: pressure = <0.1% full range, displacement = 0.1micrometre
- **Power**: 92-265v, A.C. 48-440Hz, 65w maximum, single phase three wire earthed supply, 2A fuse x 2
- **Control panel**: 16 keypad membrane touch panel with audio feedback. Functions include zero pressure, target pressure, zero volume, target volume, fill, empty, test, ramp, stop, continue, reset, enter, +, -, >, <, yes, no
- **User interface:** 40 character, 1-line liquid crystal display
- **Computer interface**: IEEE-488 Standard, Talker/Listener or optional serial RS232 (IEEE only with RFM)

How does VIS (Virtual Infinite Stiffness) work?

As above, VIS is a unique GDS development. To the observer, and in terms of the test specimen, it allows the axial loading system to appear to have infinite stiffness.

For the entire loading range, both the measurement and control of platen displacement is automatically corrected so that it corresponds to the deformation that occurs between the platen and the load button of the load cell. In this way, the platen displacement is corrected for strain in the load cell and side columns, bending flexure of the cross beams, and distortion within the motorised mechanical transmission.

The GDSVIS is computer calibrated to provide precise data on the load-deformation relationship of the entire load application and load measuring system. These measurements are made with the adjustable upper cross beam in the maximum and minimum positions. For each position, measurements are made with the platen at each end of its travel.

The calibration data is loaded into the read only memory (ROM) of the system which constantly monitors the axial load and uses the calibration to apply a correction to the platen displacement. Therefore, it appears to the observer (or controlling computer) that the measurement of platen displacement (resolved to 0.1 micrometre) is derived from a machine with infinite stiffness. In this way the system has the characteristic of Virtual Infinite Stiffness.

Measurement of stiffness in the triaxial test

Accurate determination of soil and rock stiffness is difficult to achieve in routine laboratory testing. Conventionally, the determination of axial stiffness of a triaxial test specimen is based on external measurements of displacement which include a number of extraneous movements. For example, the true strains developed in triaxial tests can be masked by deflections which originate in the compliances of the loading system and load measuring system. Such equipment compliance errors add to a variety of sample bedding effects to give a poor definition of the stress-strain behaviour of the material under test, particularly over the small strain range. Therefore, most triaxial tests tend to give apparent material stiffnesses far lower than those inferred from field behaviour (Jardine, Symes & Burland, 1984).

System features

- Simple to use under either load or displacement control
- Microprocessor controlled with built-in feedback of axial load and platen displacement
- VIS provides automatic correction for system compliance stored in ROM
- IEEE computer interface
- 100kN (10ton), 250kN (25ton) and 400kN (40ton) capacities
- Continuous displays of axial load and platen displacement
- Resolution of axial force +/- 1 in 10,000
- Resolution of platen displacement 0.1 micrometre
- Ramp and cycle axial load or platen displacement through function keys on the control panel
- Supported by GDS GDSLAB software

Applications in the geotechnical laboratory

Through the control panel (stand alone) or through the computer interface, you can enter either targets or linear time ramps of load or platen displacement. These RAMP functions can also be used to cycle load or displacement in a low frequency triangular wave form. Of course, via the computer interface, any wave form is possible.

All GDSVIS machines are fully compatible with GDSLAB control and data acquisition software. Conventional and advanced tests can be carried out including:

- classic compression and extension
- creep (constant axial total stress)
- stress paths defined in terms of the stress invariants p and q, or s and t
- cyclic stress paths
- low frequency cyclic loading

(Please refer to the GDSLAB dedicated datasheet for more details on control software).

Why buy GDSVIS?

- VIS (Virtual Infinite Stiffness) system is unique to GDS
- Load control as well as the more standard displacement control functions
- In addition to the VIS system, GDS load frames are extremely stiff and designed principally for rock testing to allow minimum backlash at the point of sample shearing (other, less stiff, load frames do not give good results at this critical point in the test due to the stretch of the load frame under high load)
- May be used stand-alone or under computer control
- Compatible with the well-developed GDSLAB software which provides a consistent interface across all of your geotechnical laboratory testing
- Excellent GDS user support (see testimonials at www.gdsinstruments.com)

Due to continued development specifications may change without notice

Options available for UNSAT

Sample sizes

38mm ✓ **50mm** ✓
70mm ✓ **100mm** ✓
Custom ✓

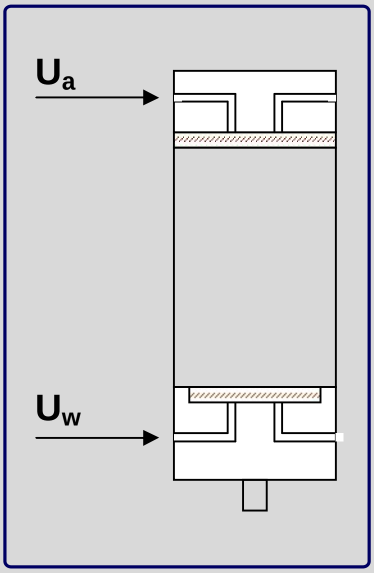
Air entry vs values

300kPa ✓ **500kPa** ✓
1500kPa ✓ **Custom** ✓

Volume change measurement methods

Direct air measurement ✓
HKUST inner cell ✓
Double cell ✓
On-sample measurement ✓

Unsaturated Triaxial Testing of Soil (UNSAT)



What is it?

GDS Unsaturated Triaxial Testing of Soil (UNSAT) is an extension to traditional triaxial testing in that soils from above the water table may be tested under conditions approaching the in-situ stress state and degree of saturation or partial saturation. All features and methods described in this datasheet can be used to upgrade GDS triaxial testing systems to enable the testing of unsaturated soil, or existing triaxial equipment from other manufacturers may be modified.

The required changes to upgrade a typical GDS triaxial testing system consists of software and hardware elements. Some of the hardware elements are optional. These optional elements are made available to add further rigour to the test procedures if this is required (for example mid-plane suction probe, atmospheric pressure transducer and local measurement of strain).

How is it configured?

The GDS UNSAT provides a number of state-of-the-art methods to allow flexibility in the method used to perform unsaturated testing.

The 4 main methods that GDS uses are as follows:

- **method A:** direct volume measurement using a GDS pore air pressure/volume controller
- **method B:** HKUST inner cell
- **method C:** double cell
- **method D:** on-sample strain transducers

Each of these methods is described in detail over the following pages.

Technical specification

Method A
Resolution of measurement of pore pressure/volumes (air & water): pressure = 0.2kPa, volume = 1cu mm
Accuracy of measurement of pore pressure/volumes (air & water): pressure = <0.1% full range, volume = 0.25%

Method B
Resolution of volume change measurement using 16 bit resolution: <2cu mm
Accuracy of volume change measurement: estimated at 32cu mm or 0.04% volumetric strain for a triaxial specimen 38mm in diameter, 76mm in height.

Method C
Resolution of measurement of cell volume: 1cu mm
Accuracy of measurement of cell volume: 0.25%

Method D
Resolution of on-sample displacement measurement using 16 bit data acquisition +/- 3.0mm = <0.1µm
Accuracy: Hall Effect = 0.8% FRO, LVDT = 0.1% FRO

Means for measuring total volume change

When testing unsaturated soils it is necessary to establish the total volume change of the test specimen. This can be achieved using the following techniques:

- control/measure the air and water pressures and volume changes directly within the test specimen. This involves using a special GDS pressure/volume controller to control the air pressure and air volume change in the test specimen. A second controller is used to control the pore-water pressure and volume change. The sum of the volume changes from these two controllers gives the total volume change in the test specimen. This method is known in this datasheet as ***method A***.
- measure the change in head of water in an inner cell around the sample and a reference tube using a low range, high accuracy differential pressure transducer. This method is known in this datasheet as ***method B***.
- measure the cell volume change and use this to establish the total specimen volume change. This technique is usually not very satisfactory because the cell stiffness is not infinite and therefore specimen loading changes and cell pressure changes cause a volumetric change in the cell. However, using a double cell and pressurising the outer cell to the same pressure as the internal cell, the internal cell wall can effectively be made to be infinitely stiff. This system needs excellent temperature stability. Small changes in temperature cause large changes in the volume of the cell water. This method is known in this datasheet as ***method C***.
- Measure the local diameter and axial deformation directly on the test specimen using our Hall Effect or LVDT local strain transducers. From the measurements of local strain it is possible to estimate the total volume change of the test specimen. This method is known in this datasheet as ***method D***.

High-air-entry porous disk

When testing unsaturated soils it is necessary to separate the pore-air and the pore-water so that differential pressures (known as matric suctions) can be maintained. This separation is achieved by the use of high-air-entry porous discs (HAEPD).

When a HAEPD is properly saturated it has the ability to maintain an air pressure on one side higher than the water pressure on the other side, without the air passing through the material. The maximum difference that can be held between these pressures is known as the 'air-entry value'. In a GDS system the HAEPD is bonded into the base pedestal (see Fig. 1). Other 'special' pedestals are available such as a HAEPD bonded into a bender element pedestal (see Fig. 2).

Fig. 1 HAEPD bonded into a standard triaxial pedestal

Fig. 2 HAEPD bonded into a bender element triaxial pedestal

GDSLAB 4D UNSAT software module

The GDSLAB UNSAT software module (see Fig. 3) provides the control and data acquisition of a general multiple stress path routine. This is a four dimensional stress path to enable simultaneous control of the pore air, pore water, radial and axial controllers.

The ability to control the pore air and pore water pressures enable the following tests to be carried out:

- desaturation ramps
- soil-water characteristic curve
- drained test saturated conditions
- drained test unsaturated conditions

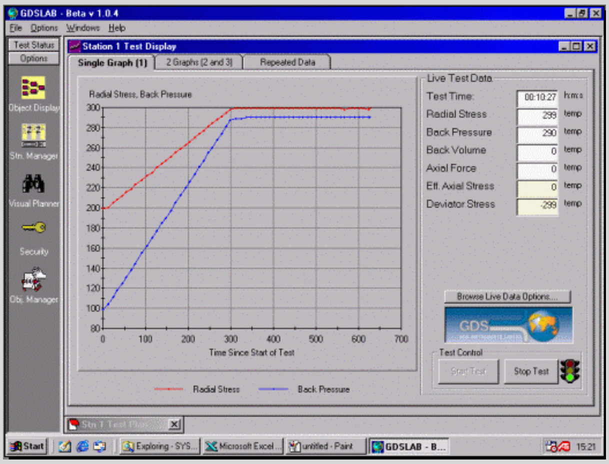


Fig. 3 Test display showing a 4D unsaturated stress path test in progress

Method A – direct volume measurement using a GDS pore air pressure/volume controller

How is it used?

For direct volume measurement, a special GDS 1000cc/2MPa digital pressure/volume controller filled with air is used to control the pore air pressure and measure pore-air volume change. In addition, a GDS advanced 200cc/2MPa digital pressure/volume controller filled with de-aerated water is used to control the pore water pressure (back pressure) and to measure the pore water volume change. By calculation of the combined pore-air and pore-water volume changes the total volume change of the test specimen can be evaluated.

Pore air pressure is connected to the top of the test specimen (see Fig. 4), and is always at a higher value than the pore water pressure connected at the base. This enables the top porous disk to be standard as water cannot pass into the air line due to the higher pressure of the air. Air cannot pass into the water line due to the HAEPD. The air pressure and water pressure are maintained at different values to generate the 'matric suction' value present in unsaturated soils.

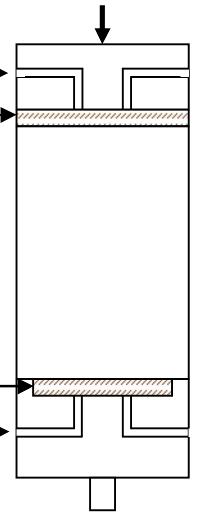


Fig. 4 Schematic of test specimen connections when using GDS Method A

The advanced 2MPa/1000cc air pressure/volume controllers.

The GDS air pressure controllers are 1000cc/2MPa devices. Mechanically, they are identical to the normal GDS pressure controller for de-aerated water. The built-in control software (or firmware) for the controllers has been specially designed to cater for the much lower stiffness of air (e.g. see Adams, Wulfsohn and Fredlund, 1996 – contact GDS for a copy of this paper).

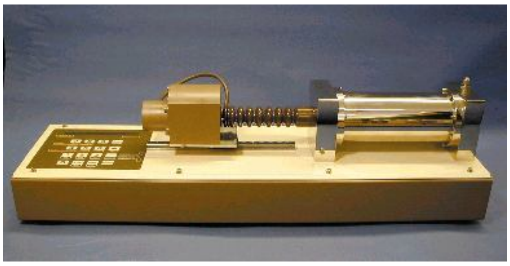


Fig. 5 2MPa/1000cc air pressure/volume controller

The following points should be noted when using air pressure controllers.

- The air pressure range is 2MPa with regulation to 1kPa. The volumetric range is 1000cc with regulation to 1cu mm (i.e. 0.001cc).
- The controllers have been specifically designed for controlling air pressure. This is because the pressure-seek algorithms built into the programming of the controller is different for air (which is very soft) from the algorithm used for water (which is very much stiffer than air).
- The controllers can be run up from zero pressure provided there is sufficient volumetric capacity in the controller. The 1000cc version is essential here. Alternatively, the controller could be pre-pressurised using a source of compressed air. This would "save" volumetric capacity used up in pressurising the air from zero.

Method A technical specification

Advanced 2MPa/1000cc air pressure/volume controllers
- **Pressure ranges**: 2MPa
- **Volumetric capacity (nominal)**: 1000cc
- **Resolution of measurement and control**: pressure = <0.1% full range, volume = 0.5cu mm
- **Accuracy of measurement**: pressure = <0.1% full range, volume = 0.25%

Items required for Method A UNSAT upgrade
- Pedestal with bonded HAEPD
- GDS 2MPa/1000cc air pressure/volume controller
- GDSLAB 4D UNSAT software module

Optional Items required for Method A UNSAT upgrade
- Local strain (Hall Effect or LVDT)
- Atmospheric air pressure transducer
- Access ring for triaxial cell

Method B – HKUST inner cell volume measurement

The HKUST (Hong Kong University of Science and Technology) volume change measurement method involves measuring the cell volume displaced by the sample in an inner cell within the main triaxial cell (see Fig. 6). Measurement of the volume change is made using a high accuracy differential pressure transducer (DPT). This enables the cell volume change to be measured from just the inner chamber thus minimizing the error due to temperature and pressure changes.

A GDS dual channel software controlled pneumatic regulator is used to control a) the cell pressure in both the inner and outer cell cavities and b) the pore air pressure in the sample.

The inner chamber containing the triaxial sample (see Fig. 7) is connected to a reference tube via the DPT (see Fig. 8). As the sample deforms it will displace water in the inner chamber causing the water level to rise or fall. By measuring the pressure in the inner chamber with respect to the pressure in the reference tube, it is possible with the correct calibration factor to determine the volume change in the inner chamber, and therefore the volume change of the specimen.

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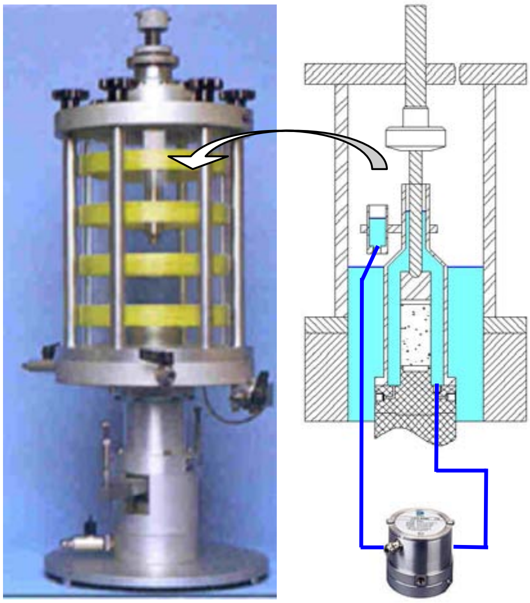


Fig. 6 Schematic of HKUST method showing external DPT

Fig. 7 HKUST inner cell

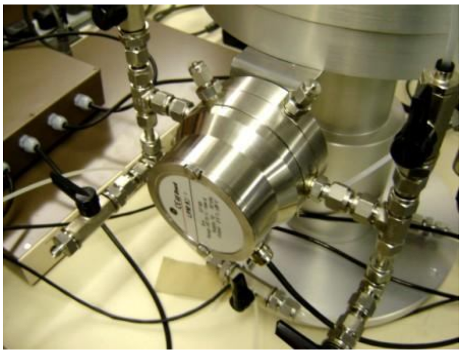


Fig. 8 High accuracy DPT attached to cell

Method B technical specification

- **DPT range**: +/- 1kPa (+/- 10cm of water head)
- **DPT accuracy**: <0.1% FSO
- **Theoretical resolution of volume change measurement (16 bit resolution)**: <2cu mm
- **Accuracy of volume change measurement**: estimated at $32mm^3$ or 0.04% volumetric strain for a triaxial specimen 38mm x 76mm

Items required for HKUST UNSAT upgrade
- HKUST pedestal with bonded HAEPD
- HKUST pedestal with bonded HAEPD
- High accuracy, low range DPT
- GDSLAB 4D UNSAT software module
- Dual channel pneumatic controller (laboratory air supply or compressor required)
- Cell access ring

Method C – double cell volume measurement

The volume change in the soil specimen is measured by monitoring the flow of water into or out of an internal triaxial cell using a GDS pressure/volume controller. The inner triaxial cell wall, top and base are made to be infinitely stiff due to the fact that the cell is positioned inside a second triaxial chamber exerting an equal pressure on the outside faces of the internal triaxial cell (see Fig. 9).

The principal of the double cell volume change measurement is similar to method A (earlier in this datasheet). Method A can also measure the specimen volume by measuring the change in cell volume, and uses this measurement as a secondary measurement of sample volume change. However, large errors may be introduced not only by the expansion of the triaxial cell but, more importantly, by the time dependant creep that occurs with Perspex pressure vessels. The time dependency of the creep makes it extremely difficult to accurately calibrate for in the test results.

Attempts have been made in the past to produce stiffer triaxial cell walls (i.e. stainless steel) and to produce a double walled cell. The stainless steel cell is heavy and non-transparent and will still be exposed to some deflection effects. The double walled cell has the advantage of an infinite stiff cell wall, but the cell top and base may not be sufficiently restrained. For these reasons, a double cell, i.e. 'a cell within a cell', is generally considered the best system to use when performing tests with Method C.

Fig. 10 shows the double cell setup with two GDS controllers. Fig. 11 shows an alternative, lower cost setup whereby the inner and outer cell pressures are applied using a single device, and an external volume change device is used to measure the inner sample volume change.

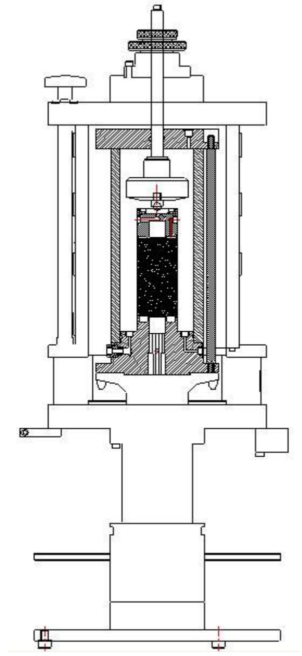


Fig. 9 Schematic of double cell within a GDS Bishop and Wesley triaxial cell

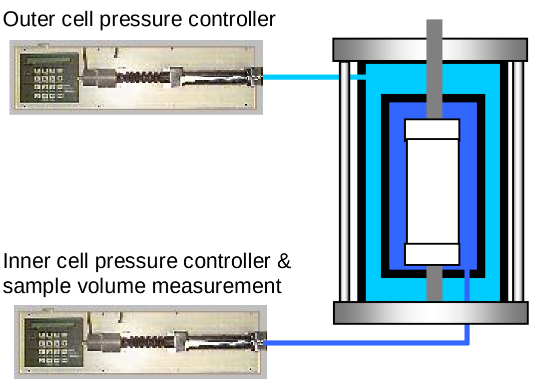


Fig. 10 Independent application of internal and external cell pressures. Volume reading from inner cell pressure/volume controller equates to ample volume change.

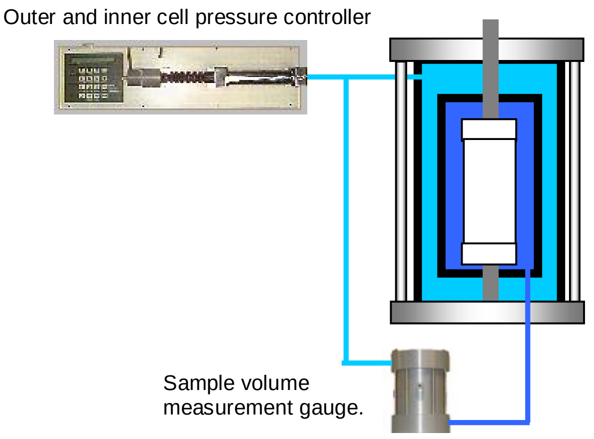


Fig. 11 Application of internal and external cell pressures using single pressure device. Volume change measured using external volume change gauge.

Method C technical specification

Advanced 2MPa/1000cc air pressure/volume controllers

- **Resolution of measurement and control**: pressure = <0.1% full range, volume = 0.5cu mm
- **Accuracy of measurement**: pressure = <0.1% full range, volume = 0.25%

Items required for Method C UNSAT upgrade

- GDS double cell
- Pedestal with bonded HAEPD
- GDS pressure/volume controllers to suit
- GDSLAB 4D UNSAT software module

Optional Items required for Method C UNSAT upgrade

- Local strain (Hall Effect or LVDT)
- Atmospheric air pressure transducer
- Access ring for triaxial cell

Method for measuring volume change	Advantages	Disadvantages
Method A GDS pore water pressure/volume controller for pore water volume changes ΔV_{water} GDS pore air pressure-volume controller for pore air volume changes ΔV_{air} (Total test specimen volume changes are then $\Delta V = \Delta V_{air} + \Delta V_{water}$)	• Good accuracy and good resolution (1cu mm) of pore water pressure and volume source • Good accuracy and good resolution (1cu mm) of pore air pressure and volume source	• Must measure air volume change after pressure change, otherwise difficult to calibrate for compression of volumes of air in the line and air pressure source • Correct data using atmospheric pressure changes measured by GDS absolute pressure transducer • Errors caused by air moving into solution
Method B Wet-wet differential pressure transducer beneath water columns subtending airspace inside an inner cell (HKUST Double Cell). Note: HKUST Double Cell is different to a Double *Walled* cell	• High accuracy and resolution over full range of volume change measurement due to shape of the inner cell and the use of very accurate differential pressure transducer • Insensitive to the difference in pressure between the inner and outer cells • Does not need two independent pressure control and measurements for cell pressure as in double *walled* cell (method C) • More stable and less temperature sensitive compared to double *walled* cell • Good for large test specimens	• Requires careful calibration. • Use high quality de-aired water in cell • Make sure air bubbles are purged out of all connectors and lines
Method C GDS cell pressure-volume controller for cell water volume changes ΔV_{cell} Option to use double walled or metal chamber	• Good accuracy and good resolution (1cu mm) of cell pressure and volume measurement from a GDS pressure/volume controller	• Must use metal (not acrylic) cell chamber, double walled cell or ideal the double cell described here • Use high quality de-aired water in cell and make sure air bubbles are purged out of chamber and all connectors and lines
Method D GDS Hall Effect or LVDT local strain transducers (axial and radial)	• Transducers are suitable for small strains • Provides a good estimate of small volumetric strain • Can be combined with methods A and C above (no space inside inner cell to be used with method B)	• Not suitable for large strains • Assumes right cylinder

Requirement for measurement of atmospheric pressure

The on-board pressure transducer in the air pressure controller measures pressure relative to atmospheric pressure (known as 'gauge' pressure). Of course, this is correct for the system measurement of pressure because transducers are using the same reference. However, where the air volume change is concerned, the gas laws relate to the absolute pressure of gas. If we assume that atmospheric pressure can change from 900 milibars to 1100 milibars (this is a large range) this represents about +/- 10kPa around atmospheric pressure. Assuming a volume of 200cc at 15kPa gauge (about 115kPa absolute), the gas laws can be expressed as PV=kRT=constant which gives PV=115*200=23000. If the atmospheric pressure changes by 10kPa the controller will still regulate gauge pressure to 15kPa relative to atmospheric pressure. But this will be now 125(100+10+15) kPa absolute. Now PV = 23000 = 125*V, which gives 184cc. Therefore, with no apparent change in controlled pressure, there will be a measured volume change of 16cc caused by a change in atmospheric pressure.

From this kind of calculation it may be deemed necessary to take into account the atmospheric pressure. By using an absolute pressure transducer connected to the acquisition system, the measurements of atmospheric pressure can be used to correct the saved results.

Upgrade to local strain measurement (method D)

Any GDS system may be upgraded to perform local strain measurement using either Hall Effect or LVDT transducers. Both device types enable axial and radial deformation to be measured directly on the test specimen via lightweight aluminum holders.

Hall Effect transducers may be used in water up to 1700kPa.

LVDT transducers come in 2 versions:

- Low pressure (up to 3500kPa) version for use in water
- High pressure (up to 200MPa) version for use in non-conducting oil

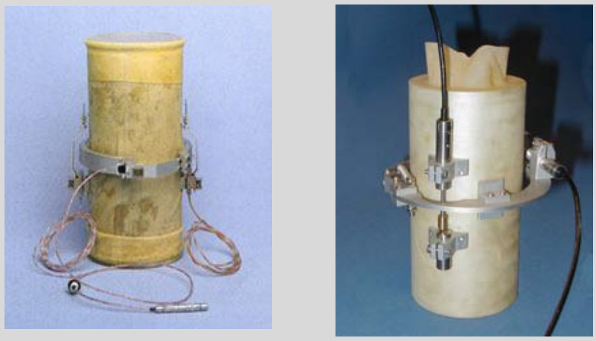
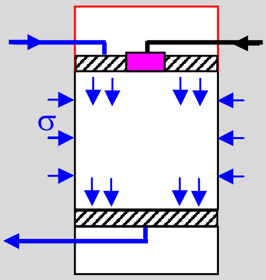


Fig. 12 Hall Effect and LVDT local strain transducers

For further information on local strain measurement, please refer to the dedicated Hall Effect local strain and LVDT Local Strain datasheets.

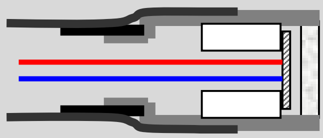
Unsaturated permeability:

For a full explanation of how to perform unsaturated permeability with a GDS UNSAT system, please refer to the separate datasheet.



Mid-Plane Suction Measurement:

For a full explanation of how to perform mid plane suction measurement, please refer to the separate datasheet entitled "GDS Mid-Plane Suction Probe".



Why buy GDS UNSAT?

- choice of different methods to suit your testing requirements and budget
- developed in conjunction with HKUST, specialists in unsaturated soil testing
- methods may be 'mixed and matched' to create a custom system
- due to GDS's knowledge of many different unsaturated test methods, we can objectively advise customers on the best method for their test requirements. We are not limited to a single solution.
- GDS has more than 50 customers worldwide using it's unsaturated soil testing systems and software.

Due to continued development specifications may change without notice

Options available for GDSCTS

Rowe and Barden cell sample sizes

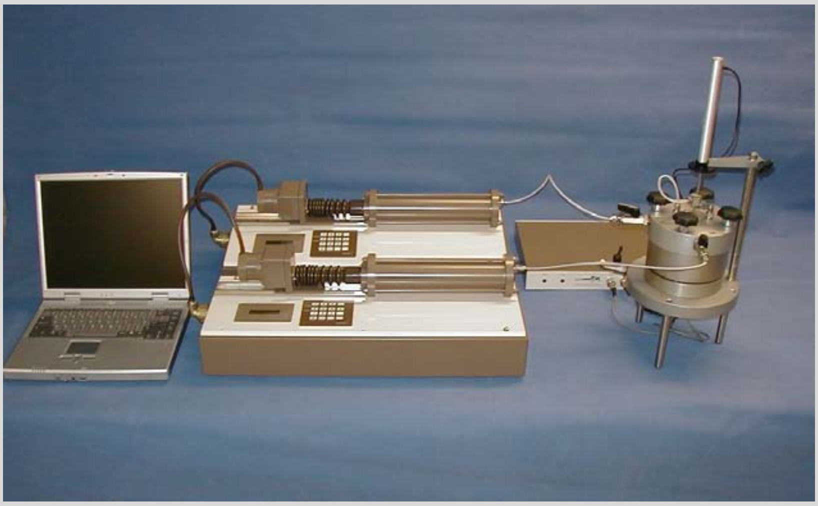
50mm	✓	63.5mm	✓
70mm	✓	76.2mm	✓
100mm	✓		

Cell or back pressure ranges

500kPa	✓	2000kPa	✓
1000kPa	✓	4000kPa	✓

Unsaturated testing upgrade ✓

Consolidation Testing Systems (GDSCTS) including STDCTS and ADVCTS



What is it?

The GDS Consolidation Testing System (GDSCTS) is a state-of-the-art, fully-automated consolidation testing system designed for soil. GDSCTS can run classic tests such as step loading to more advanced tests such as automated testing rate by controlled hydraulic gradient or cyclic loading, all under PC control. In fact, using the flexibility of GDSLAB software, almost any user-defined test may be performed. Due to the extensive GDS range of pressure controllers and consolidation cells, each system may be configured exactly to the customer's specification and budget.

Overview

The system is based on the Rowe and Barden type consolidation cell using GDS pressure/volume controllers. Two of these pressure controllers link the computer to the test cell as follows:

- one for axial stress and axial displacement control.
- one for setting back pressure and measuring volume change.

System elements

The fundamental system hardware elements are shown in Fig. 1 on the following page. In fact, the hardware used may be chosen to suit your testing and budgetary requirements. Common arrangements are as follows:

- Standard Consolidation Testing System (STDCTS) which is based on 2 x 3MPa Standard Pressure/Volume Controllers (STDDPC)

- Advanced Consolidation Testing System (ADVCTS) which is based on 2 x 2MPa Advanced Pressure/Volume Controllers (ADVDPC)

In particular, all elements of the ADVCTS system are biased towards achieving the greatest resolution and accuracy, for the highest quality tests achievable in a research environment. The STDCTS system is a low cost version of ADVCTS.

The GDS consolidation system can become a GDS stress path triaxial testing system by changing the test cell and adding a further 200cc pressure/volume controller.

Technical specification

- accuracy of pressure measurement = <0.1% full range (ADVCTS) or <0.15% full range (STDCTS)
- resolution of pressure measurement = 0.5kPa (ADVCTS) or 1kPa (STDCTS).
- accuracy of volume measurement = <0.1% measured value (ADVCTS) or <0.25% measured value (STDCTS)
- resolution of volume measurement = $0.5mm^3$ (ADVCTS) or $1mm^3$ (STDCTS)
- transducer resolution = 16bit
- computer-automated control of testing - not just data logging
- MS Windows® software (GDSLAB) for test control and post-test processing
- fully expandable 'future-proof' software to allow multiple test stations or additional hardware to be incorporated at any time.

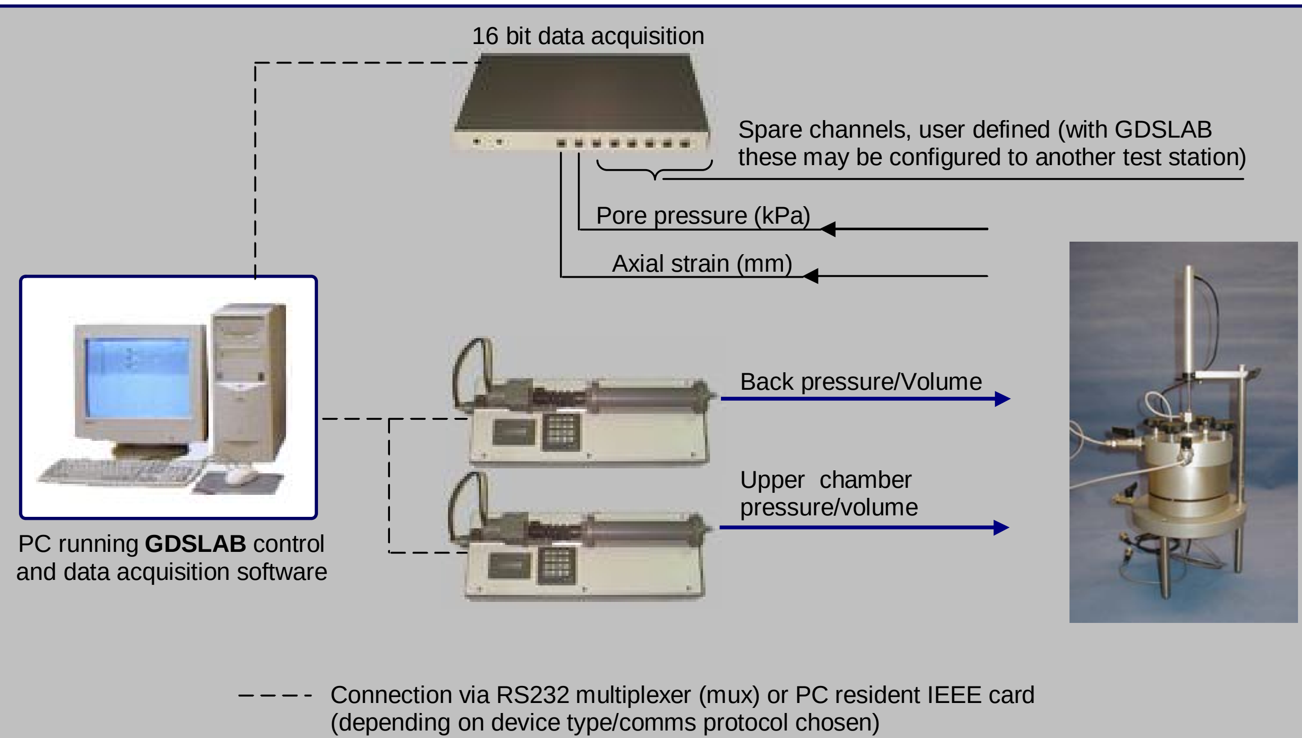


Fig. 1 Diagram of the STDCTS hardware elements

The GDS Rowe and Barden consolidation cell

The GDS Rowe & Barden consolidation cell can be used with either a rigid porous disk for constant strain (see Fig 2a) or flexible porous disk for constant stress (see Fig. 2b).

The cell (Figs 3 and 4) is available in a range of sizes for test specimens of 50, 63.5, 70, 76.2 and 100mm diameter. Back pressure is applied to the top drain of the cell so that field hydraulic gradients can be modeled. The bottom drain is provided with a tapping for a pressure transducer. The cell incorporates the novel Bishop and Skinner floating ring which allows the top bag to move with the specimen vertically. The main advantage of this method is that it allows measurement of the upper chamber volume change to be used as a calculation of axial strain.

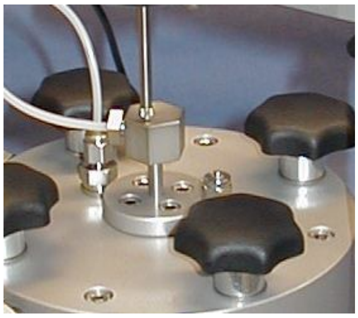


Fig. 3 GDS Rowe and Barden consolidation cell external axial displacement measurement point

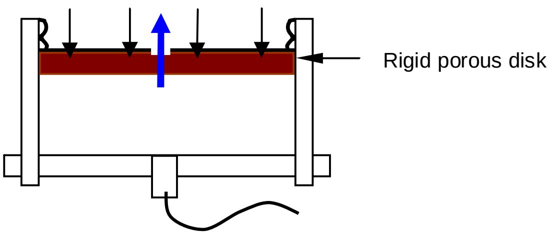


Fig. 2a (above) GDS Rowe and Barden cell showing rigid porous disk for constant axial strain.

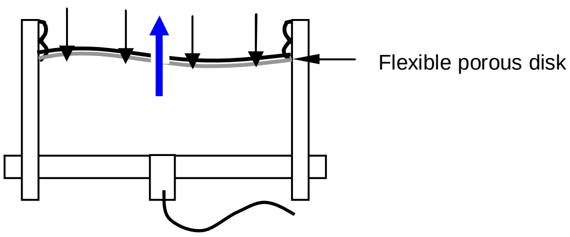


Fig. 2b (above) GDS Rowe and Barden cell showing the flexible porous disk for constant stress tests.

Fig. 4 GDS Rowe and Barden consolidation cell

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:

Consolidation:

- SATCON (saturation and consolidation)
- Advanced Rowe/Rowe and Barden consolidation

Triaxial:

- SATCON (saturation and consolidation)
- standard triaxial
- stress path testing (p, q and s, t)
- advanced loading tests (cyclic, user defined)
- 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. 5).

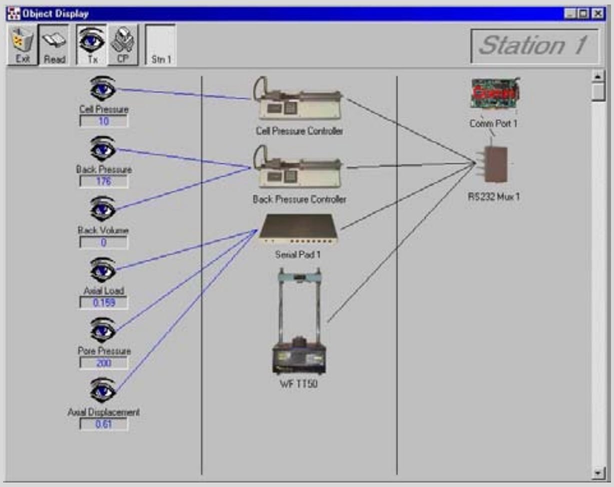


Fig. 5 Object display showing a standard STDTAS arrangement (Load Frame based stress path system)

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

Pressure/volume controllers

The cell pressure and back pressure controllers may be mixed and matched. There is the Standard Pressure/Volume Controller with pressure ranges from 1 to 4MPa, serial PC connectivity and 200 cc volumetric capacity. Or there is the Advanced Pressure/Volume Controller (ADVDPC – see Fig. 6) with pressure ranges of 2MPa, 3MPa, 4MPa, 8MPa, 16MPa, 32MPa, 64MPa and 128MPa with serial or IEEE PC connectivity and 200cc volumetric capacity. (Also, the ADVDPC 2MPa controller can be bought as 1000cc volumetric capacity item).

The back pressure controller, which applies back pressure, also measures volume change of the test specimen.

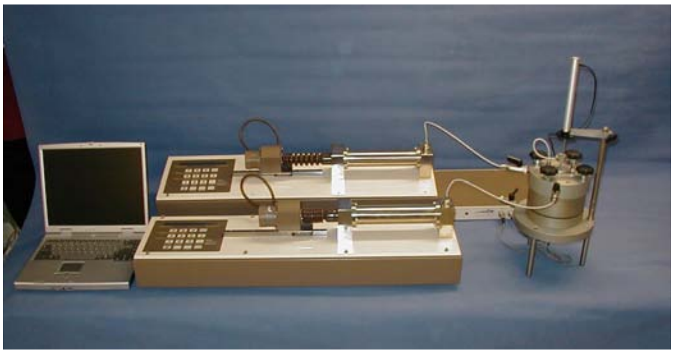


Fig. 6 Advanced Consolidation Testing System (ADVCTS) utilizes the GDS ADVDPC controllers (shown above)

Upgrade to unsaturated testing

Any GDSCTS system may be upgraded to perform unsaturated triaxial testing with the addition of the following items:

- Replacement base plate with high air entry porous stone
- 1000cc Advanced Pressure/Volume Controller, ADVDPC, (for application of pore air pressure and measurement of air volume change) as in Fig. 7.

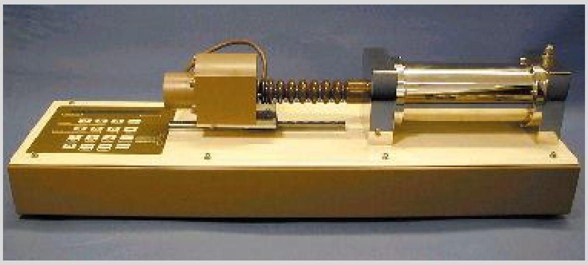


Fig. 7 1000cc Advanced Pressure/Volume Controller (ADVDPC)

For further information on unsaturated testing, please refer to the dedicated Unsaturated datasheet.

Why buy GDSCTS?

- ADVCTS remains the leading Rowe type consolidation system for research testing throughout the world
- STDCTS provides a low cost alternative with all the features of the ADVCTS system
- Resolution of measurement of volume change in all systems = 0.5 or 1mm^3 (see specification on page 1)
- Flexibility in the capacity of the system (specimen size, load, pressures etc) ensures a system is created to specifically suit the testing required and the budget
- May be upgraded at any time for additional transducers, software modules, triaxial testing, unsaturated testing and more – i.e. future proof!
- GDS worldwide technical support for peace of mind (see testimonials at www.gdsinstruments.com)

Due to continued development, specifications may change without notice.

Available CRS cell options

Low (1MPa) and High (20MPa) back pressure options

Low Pressure Cell – 1MPa

Maximum Load

50kN ✓

Cell sample sizes (1MPa Cell)

38mm ✓ **50mm** ✓
70mm ✓ **100mm** ✓

High Pressure Cell - 20MPa

Maximum Load

100kN ✓

Cell sample sizes

38mm ✓ **50mm** ✓

Unsaturated testing upgrade ✓

Constant Rate of Strain Cell (CRS)

What is it?

The GDS Constant Rate of Strain Cell (CRS) is a load frame based one dimensional consolidation cell capable of applying back pressure and measuring pore pressures up to 1MPa (low pressure version) or 20MPa (high pressure version). Coupled with GDS controllers and software the system will run the entire test from start to finish through a loading path specified by the user using constant rate of strain loading.

Overview

Instead of applying stress increments in stages as in a typical oedometer consolidation test the load can be gradually applied to the sample by increasing the axial displacement at a constant rate. Controlled back pressure (water) is applied to the sample and drainage is allowed through the base of the apparatus. The advantage of this method is that the time required to complete a consolidation test can be reduced significantly.

System elements

Typically, a GDS pressure controller is used to apply the back pressure. A standard load frame controls the vertical stress and strain. A force transducer placed at the end of a piston measures the force and pore pressure is measured by a transducer connected to the base filter stone. The sample itself is confined between two porous plates in a loose steel ring, which prevents horizontal deformation, and reduces friction.

Fig. 1 High Pressure (GDSCRS) option

Technical specification – Low Pressure

- Construction Material – Anodised aluminum with Perspex outer cell.
- Pressure relief valve included.
- For use with external load cell only.

Technical specification – High Pressure

- Construction Material – All stainless steel construction.
- Designed to be used with an internal submersible load cell for greater accuracy of load measurement (can be used with an external load cell).

Optional frequency ranges

2Hz ✓ 5Hz ✓
10Hz ✓

Optional load ranges

10kN ✓ 40kN ✓
16kN ✓ 60kN ✓
20kN ✓

Optional cell pressure rating

2000kPa ✓ 5000kPa ✓

Available specimen sizes

standard
38, 50, 70, & 100mm ✓

optional up to 150mm ✓

(other sizes available on request)

Electromechanical Dynamic Triaxial Testing System (DYNTTS) 2Hz, 5Hz or 10Hz

2Hz, 40kN, 2MPa DYNTTS system shown above

What is it?

The Electromechanical Dynamic Triaxial Testing System (DYNTTS) is a combined triaxial cell and dynamic actuator, the axial force and axial deformation being applied through the base of the cell. The cell itself is screw-driven from an integral base unit housing the motor drive. Where an optional dynamic radial actuator is not chosen, the cell is provided with a balanced ram to eliminate disturbance to constant cell pressure during dynamic testing. This software-based system is controlled from a PC running GDSLAB in MS Windows®. Data is saved and displayed in real-time for any number of cycles.

Useful Helpsheets/further information

- *"GDS software-based dynamic and seismic laboratory soil testing systems"*. A technical review of GDS dynamic systems including a section entitled "Electromagnetic, hydraulic or pnuematic control - which is best?"
- *Helpsheet 86*: Why Choose a GDS System?

All datasheets and helpsheets available from the GDS website at www.gdsinstruments.com/support

Independent closed loop control of axial stress *and* cell pressure (dynamic or static) ✓
Sine, havesine, triangular and square waveforms ✓
User defined waveforms ✓
Direct closed loop of axial displacement ✓
Direct closed loop of axial force ✓
ASTM D3999-91 and ASTM D5311-92 compliant ✓
12 access ports as standard ✓
Interchangeable submersible load cell ✓
Balanced ram to keep cell pressure constant ✓
Optional dynamic cell pressure available ✓
8 channel 16bit data acquisition ✓
Volume change measurement ✓
High accuracy electromagnetic control ✓
No manual tuning required ✓

Technical Specification

- **Displacement range** = 100mm
- **Displacement accuracy** = 35µm in 50mm (i.e. 0.07%)
- **Displacement resolution** = 0.208µm
- **Axial force accuracy** = <0.1% of load cell range (i.e. 1N for 10kN load cell)]
- **Axial force resolution** = 16bit (i.e. <0.4N for 10kN load cell, <1.5N for 40kN load cell)
- **Control data points** = 10,000 points/sec
- **Maximum saved data points** = 100 points/cycle

Technical features overview

- *Performance specification conforming to the requirements of ASTM Designation D3999-91 "Standard Test Methods for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus"*
- *Interchangeable load cells (optional) to accommodate very soft to very stiff soils with ranges of 1, 2, 4, 8, 10, 16, 25, 40 and 60kN*
- *Local strain measurement (optional) and mid-plane pore pressure measurement (optional)*
- *P and S wave measurements with Bender Element system (optional)*
- *Precise control of low consolidation stresses by differential pressure transducer (optional). Direct closed-loop control of axial displacement, deviator force, cell pressure, and back pressure*
- *All tests defined using GDSLAB control and data acquisition software. Data output is ASCII and compatible with Excel and other industry-standard spreadsheets*
- *38, 50, 70, 100mm diameter test specimens by interchangeable pedestals and triaxial extension top caps*
- *Simple access for transducers, valves and pipework via built in 12 port Transducer Ring. Plus 8 channels of 16bit data acquisition*

GDSLAB control software

The GDSLAB control and acquisition software from GDS 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 available are as follows:

- 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 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, as in Fig. 1.

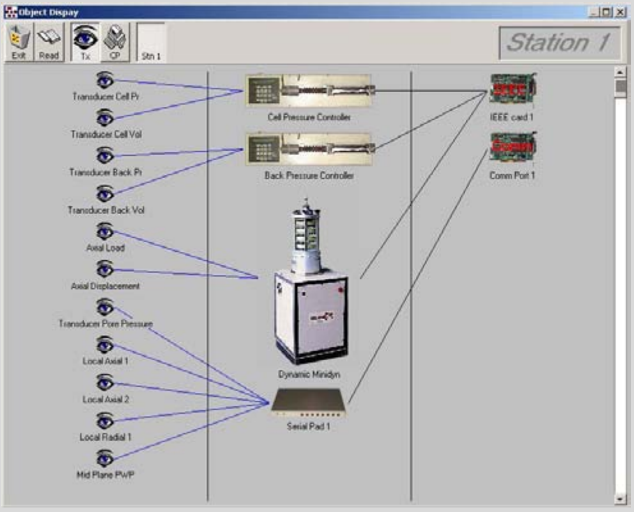


Fig. 1 GDSLAB object display showing a DYNTTS setup

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

GDSLAB dynamic test module

- Dynamic cyclic loading tests at frequencies up to 2Hz, 5Hz or 10Hz (depending on the model)
- Provides sinusoidal cyclic control of axial displacement or axial force and cell pressure with optional dynamic cell pressure controller
- Plotting saved results gives cyclic stress paths based on average cross-sectional area i.e. the area of the volumetrically equivalent right cylinder
- A complete cycle of data can be saved every N cycles where the value of N is defined by the user
- Dynamic stress paths (with optional dynamic cell pressure controller)
- Controlled data displayed in real-time, as in Fig. 2.
- Up to 1000 points saved per cycle
- Built in standard waveforms: Sinusoidal, triangular, square, havesine
- User defined waveforms using 1000 point ASCII file

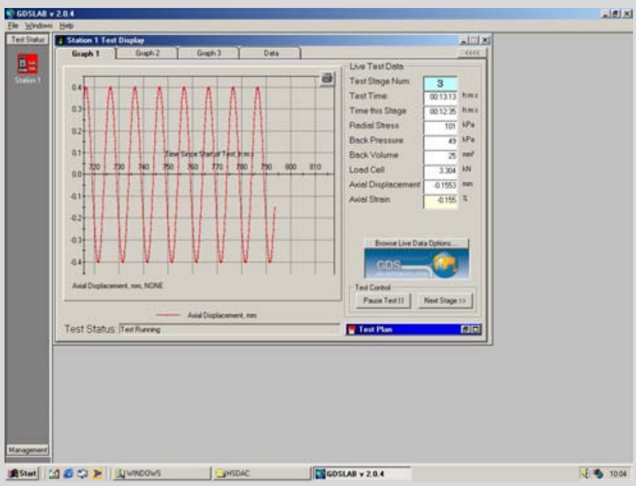
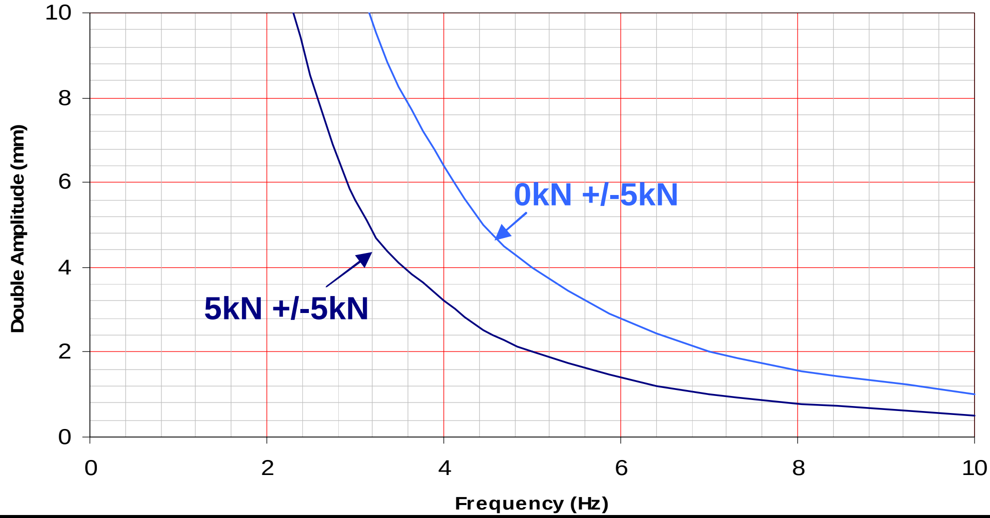


Fig.2 Test display showing a dynamic test in progress

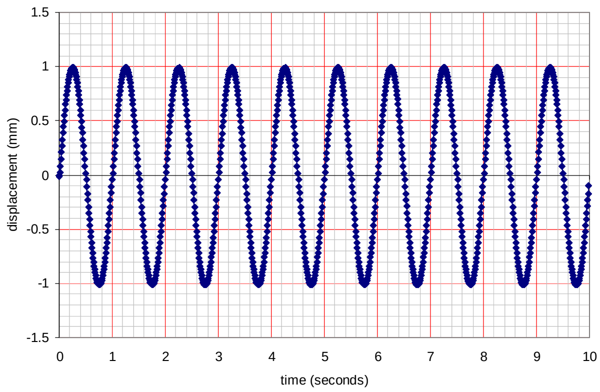
Typical system performance, showing frequency and amplitude

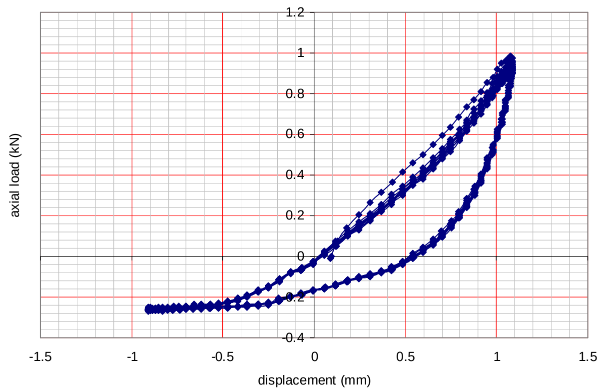


	with 5kN force datum		with zero kN force datum	
Frequency (Hz)	Amplitude (mm)	Double Amplitude (mm)	Amplitude (mm)	Double Amplitude (mm)
0.1	50	100	50	100
0.2	50	100	50	100
0.5	26.5	53	26.5	53
1	13.3	26.6	13.3	26.6
2	6	12	6	12
3	2.8	5.6	4.4	8.8
4	1.6	3.2	3.2	6.4
5	1	2	2	4
7	0.5	1	1	2
10	0.25	0.5	0.5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

Typical test results, showing displacement control at 1Hz

Axial displacement feedback control	
Frequency (Hz)	1.00
Peak to peak (mm)	2.000
Radial stress (kPa)	200.0





Specifications overview

- The axial load/deformation control sub-system is screw-driven through the base of the cell. The built-in dynamic axial loading system is driven by a brushless dc servomotor. Manual or programmed computer control is via the GDS data acquisition and control card installed in the PC. This control can be initiated from the GDSLAB software. The GDS Digital Control System (GDSDCS) downloads the control signal into firmware for sine, square, triangular and user defined control up to 2Hz, 5Hz or 10Hz (depending on the system model). For closed-loop load control, feedback is taken from the internal load cell output. For closed-loop deformation control, feedback is taken from the axial motor high speed shaft encoder. The axial load capacity has options of 10kN, 16kN, 20kN, 40kN and 60kN for the 2Hz and 5Hz machines, with the 10Hz machine being available in 10kN or 20kN. The axial displacement stroke is +/- 50mm.

- The radial pressure and back pressure control sub-system is by one GDS Standard pressure/volume controller (STDDPC) 200cc/2MPa to give precise control of cell pressure to 1kPa resolution. Manual control is via the 16 key keypad and 40 character LCD. Computer control is via the integral IEEE-488 GP-IB computer interface. Functions include target pressure, target volume change, ramp/cycle pressure and ramp/cycle volume change.

- Optional dynamic cell pressure available. See later section in datasheet for details.

- Where optional dynamic cell pressure control is not used, the cell is provided with a balanced ram. This compensates for the volumetric displacement of the loading ram into or out of the cell. Down the centre of the hollow ram, the cell fluid is hydraulically connected to a chamber through which the ram passes. In this chamber the ram has an annular piston attached to it. The annular area is exactly equal to the area of the ram. When the ram moves in the cell and causes a volume change, the annular piston causes an equal and opposite volume change. In this way, the net volume change in the cell is zero. In addition, cell pressure acting on the annular ring automatically compensates for the effect of cell pressure acting on the ram. This means that the axial force capacity of the cell is independent of cell pressure.

- On-board computer control is via the GDS Digital Control System (GDSDCS). See below for further details.

Pressure/volume controllers

The cell pressure and back pressure controllers may be 'mixed and matched'. There is the Standard Pressure /Volume Controller (STDDPC – see Fig. 2) with pressure ranges from 1 to 4MPa, serial PC connectivity and 200cc volumetric capacity.

Fig. 3 STDDPC

Or, there is the Advanced Pressure/Volume Controller (ADVDPC – see Fig. 4) with pressure ranges of 2 to 4MPa, serial or IEEE PC connectivity and 200cc volumetric capacity. (Also, the ADVDPC 2MPa controller can be bought as a 1000cc volumetric capacity item).

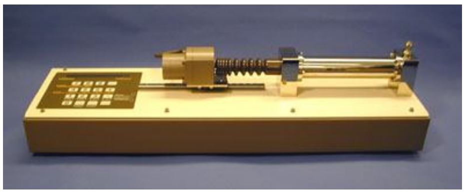


Fig. 4 ADVDPC

The back pressure controller, which applies back pressure, also measures volume change of the test specimen.

GDS Digital Control System (GDSDCS)

The GDS dynamic systems are all based around the high speed GDS Digital Control System (GDSDCS) with closed-loop feedback of displacement and load.

With 16 bit data acquisition (A/D) and 16 bit control output (D/A), the GDSDCS runs at a control frequency of 10kHz per channel. This means that when running at 10Hz the system uses 1000 control points per cycle. When running at 1Hz, it uses 10000 control points per cycle

The advantage of the GDSDCS 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, over the complete range, use the same high specification control system. A result of this is that the accuracy and resolution of the test is only a function of the actuator used, whether it is a low-cost pneumatic actuator, high-accuracy elecromechanical actuator or high-capacity hydraulic actuator.

Optional dynamic cell pressure

The dynamic capability of the actuator is described in terms of the maximum double amplitude of volume change. At 10Hz the maximum double amplitude of volume change is 24,000cu.mm. At 5Hz the maximum double amplitude of volume change is 96,000cu.mm. The system performs at speeds defined by these frequencies and double amplitudes. How this translates into radial stress control depends entirely on the cell fluid and soil stiffness and specified radial stress double amplitude. For stiff soils at small radial stress double amplitudes, higher frequencies will be possible than for soft soils at large radial stress double amplitudes. As a guide only, tests performed at GDS indicate that for a datum of cell pressure of 1000kPa, the following combinations of frequency and double amplitude of cell pressure can be achieved: at 10Hz, 400kPa; at 5Hz, 800kPa. The typical variation of cell pressure with axial displacement is +/-5kPa at 5-10Hz and +/-3kPa at <5Hz.

Electromechanical dynamic cell pressure actuator
The electromechanical dynamic cell pressure range is 1.4MPa. For closed loop cell pressure control, feedback is taken via the cell pressure 2MPa range transducer installed directly in the cell. This hydraulic actuator is driven by a brushless dc servomotor.

Low cost pneumatic dynamic cell pressure actuator
The pneumatic dynamic cell pressure range is 1MPa. For closed loop cell pressure control, feedback is taken via the cell pressure 2MPa range transducer installed directly in the cell. This actuator is driven by an air servo valve working with an air water interface.

Upgrade to local strain measurement

Any DYNTTS system may be upgraded to perform local strain measurement using either Hall Effect or LVDT transducers (see Fig. 5). Both device types enable axial and radial deformation to be measured directly on the test specimen via lightweight aluminum holders.

Hall Effect transducers may be used in water up to 1700kPa. LVDT transducers come in 2 versions:

- Low pressure (up to 3500 kPa) version for use in water
- High pressure (up to 200 MPa) version for use in non-conducting oil

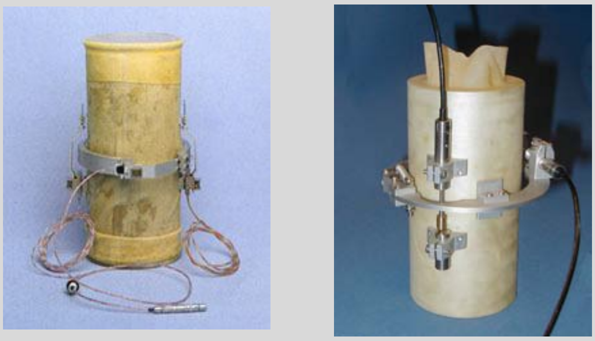


Fig. 5 Hall Effect and LVDT local strain transducers

For further information on local strain measurement, please refer to the dedicated Hall Effect local strain and LVDT local strain datasheets.

Upgrade to unsaturated testing

Any DYNTTS system may be upgraded to perform unsaturated triaxial testing with the addition of the following items:

- Unsaturated pedestal with high air entry porous stone.
- 1000cc digital air Pressure/volume controller (ADVDPC) for the application of pore air pressure and measurement of air volume change (see Fig. 6).
- Optional HKUST double cell (for more information on this please see the data sheet 'Unsaturated Triaxial Testing of Soil (UNSAT).
- Optional double walled cell.

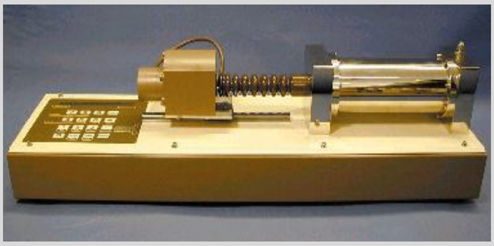


Fig. 6 1000cc air pressure controller (ADVDPC)

For further information on unsaturated testing, please refer to the dedicated Unsaturated datasheet.

Upgrade to bender element testing

Any DYNTTS system may be upgraded to perform P and S wave bender element testing with the addition of the following items (see Fig. 7):

- Bender element pedestal with *new* inserted element
- Bender element top cap with *new* inserted element
- High-speed data acquisition card

Signal conditioning unit, amplification of source and received signals (P and S wave) with user-controlled gain levels (via software).

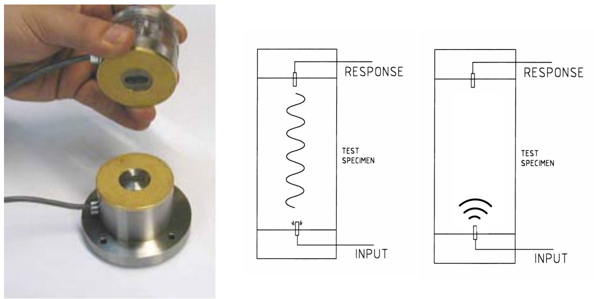


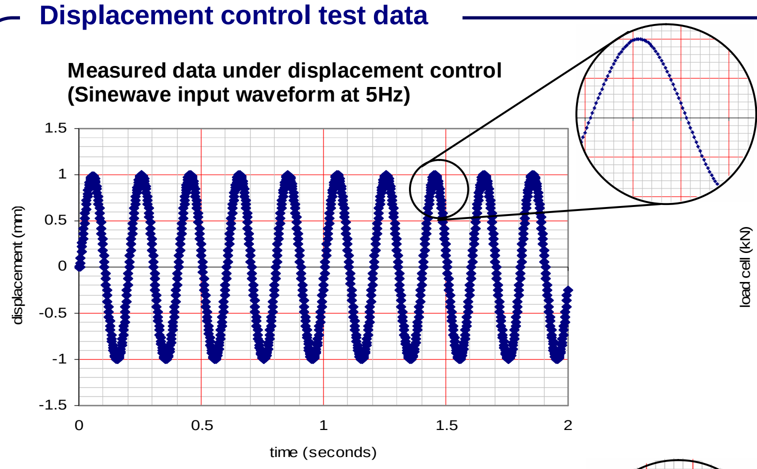
Fig. 7 P and S wave elements

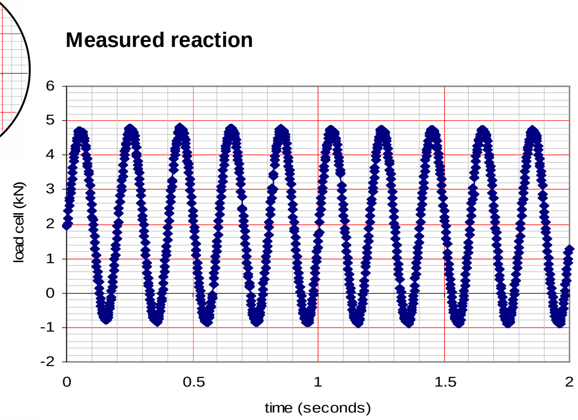
For further information on bender element testing, please refer to the dedicated Bender Element Testing datasheet.

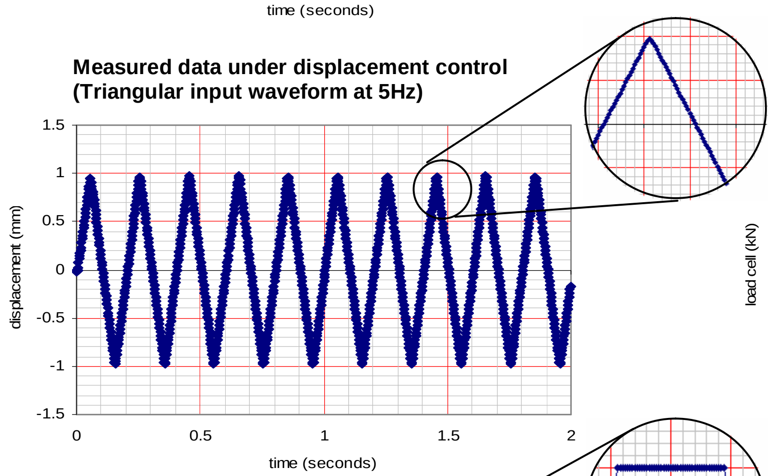
Why buy DYNTTS?

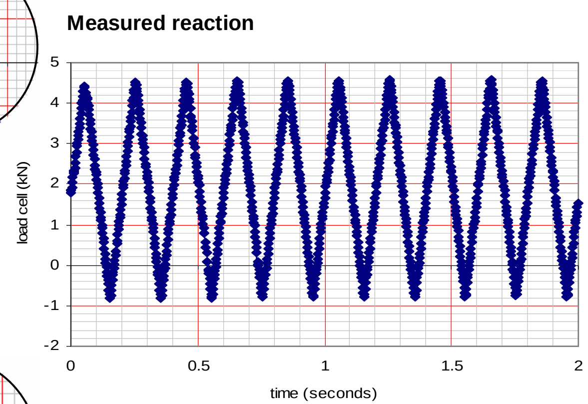
- GDSDCS – no requirement for manual tuning
- As well as extremely good control of axial displacement and axial load for dynamic testing, the DYNTTS system is excellent for performing static and small strain triaxial tests
- With GDS software and hardware, there are unlimited possibilities for upgrading the system in the future (i.e. bender elements, unsaturated testing, mid plane PWP, local strain and so on)
- Independent control of each axis (i.e. axial, radial) whether dynamic or static testing
- Optional on-site training by experienced geotechnical engineers
- Reputation for world class technical support – check the website for testimonials
- 24 hour technical support by e-mail

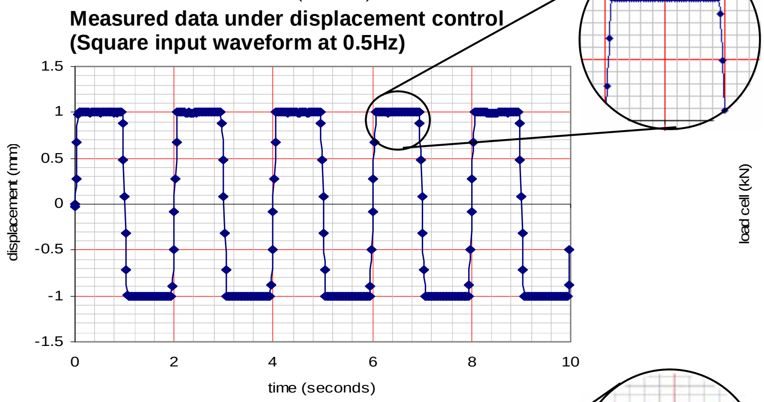
Displacement control test data

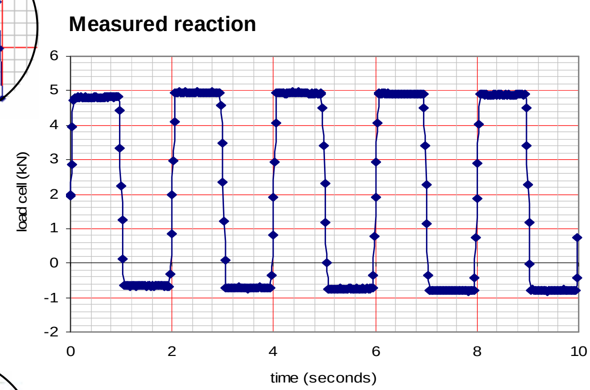


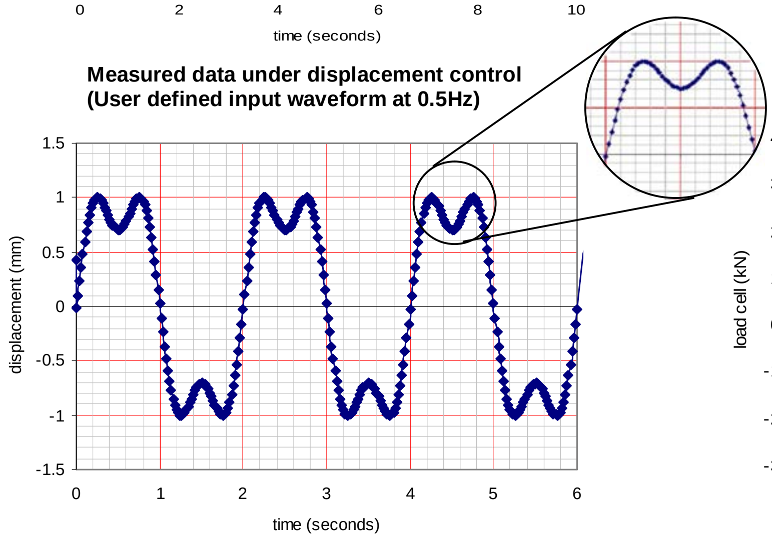


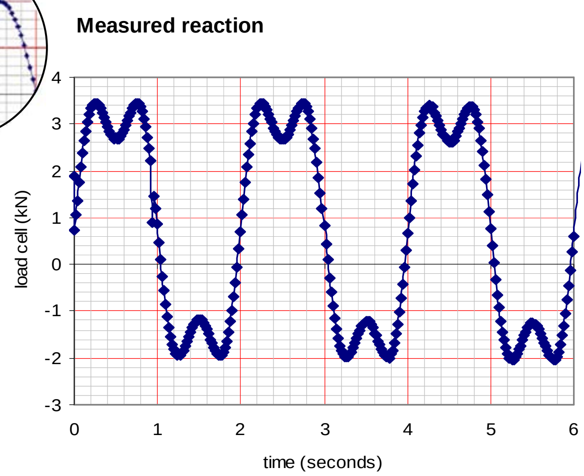








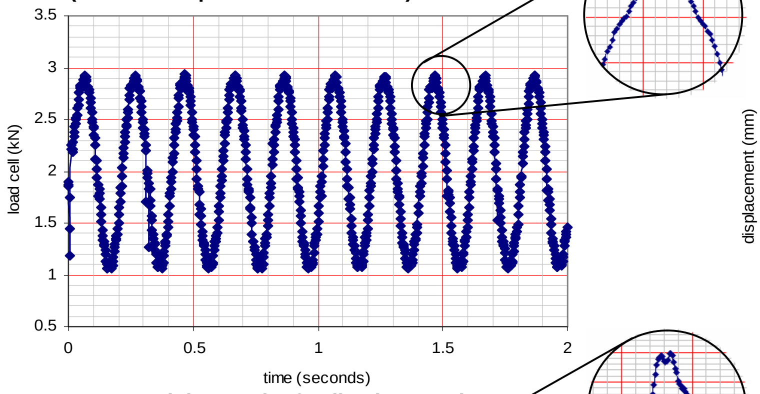




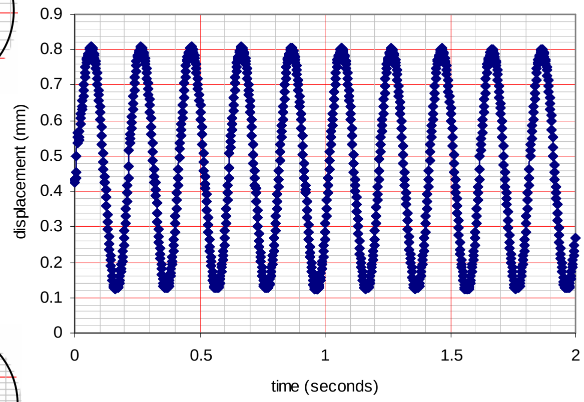
Note: Above test data obtained using elastic test specimen to demonstrate machine performance capability.

Feedback control test data

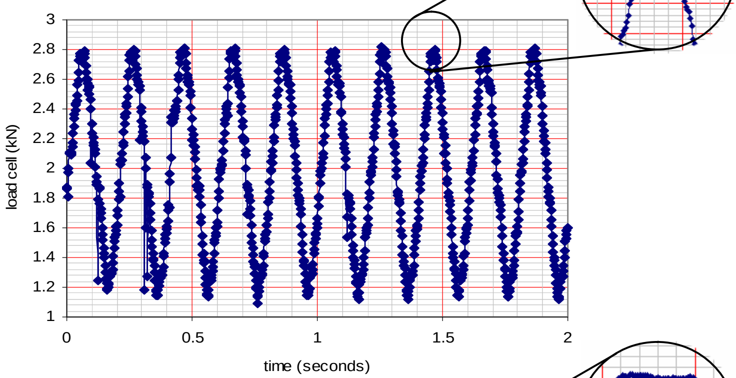
Measured data under feedback control (Sinewave input waveform at 5Hz)



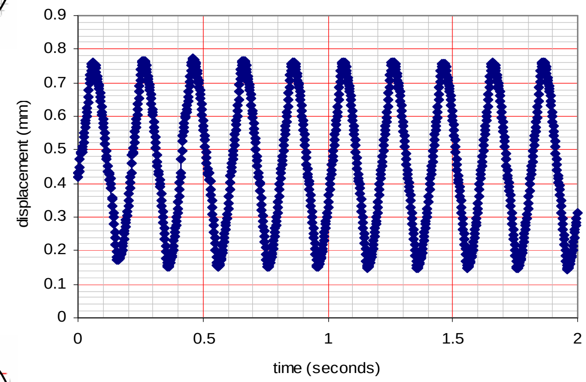
Measured displacement reaction



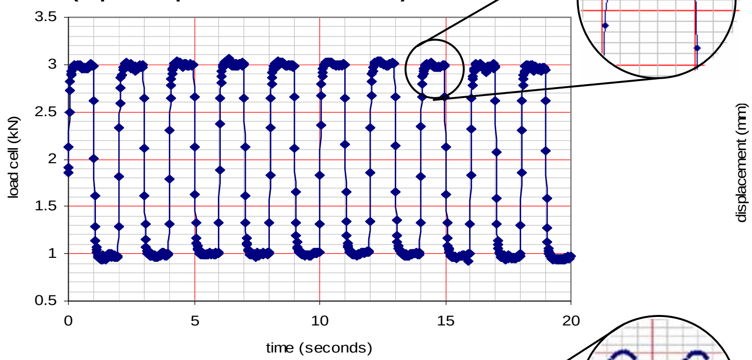
Measured data under feedback control (Triangular input waveform at 5Hz)



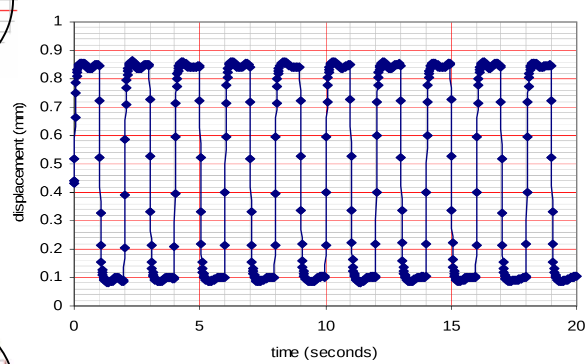
Measured displacement reaction



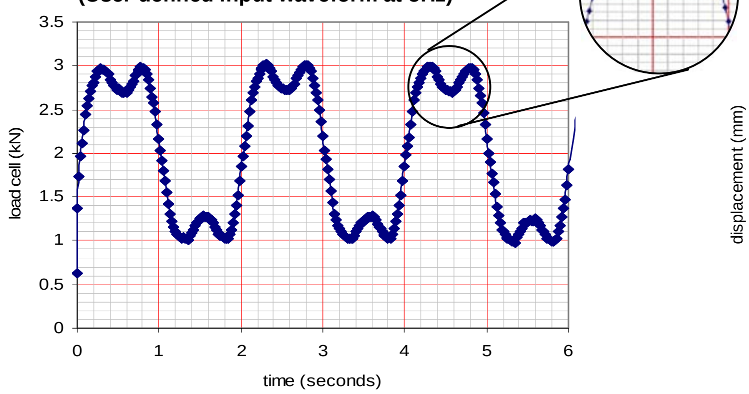
Measured data under feedback control (Square input waveform at 0.5Hz)



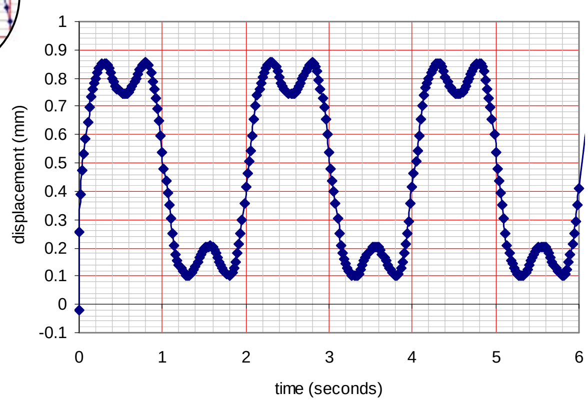
Measured displacement reaction



Measured data under feedback control (User defined input waveform at 5Hz)



Measured displacement reaction



Note: Above test data obtained using elastic test specimen to demonstrate machine performance capability.

Options available for GDSHLF

Axial load ranges

20kN	✓	40kN	✓
60kN	✓	100kN	✓
250kN	✓	Custom	✓

Axial frequency range (max)

10Hz ✓ 20Hz ✓

Radial frequency range (max)

10Hz ✓ 20Hz ✓

GDS Hydraulic Axial/Radial Loading Frame (GDSHLF)

What is it?

The GDS Hydraulic Axial/Radial Loading Frame (GDSHLF) can be synchronised with the cell pressure (radial stress) to give an advanced capability of dynamic stress paths. A number of optional advanced transducers can be added to the standard system to give measurement of local axial strains and mid-plane pore pressures.

The GDSHLF 10, 20Hz / 20, 40, 60, 100 or 250kN dynamic triaxial testing system consists of a dynamic load frame with 20, 40, 60, 100 or 250kN load capacity and +/- 50 mm stroke capability**.** The load frame contains a dynamic cell pressure actuator built into the base. To give the very advanced capability of dynamic stress paths, the axial force/displacement can be synchronised with the cell pressure (radial stress). Also, the system is capable of both dynamic tests and quasi-static (low speed/creep) tests.

These outstanding features, coupled with GDSLAB control and data acquisition software, GDS digital pressure controllers, and the GDS data acquisition system, give you unlimited possibilities in conventional and advanced PC-controlled triaxial testing of soil and rock.

Technical specification

- **Load ranges**: 20kN (2ton), 40kN (4ton), 60kN (6ton), 100kN (10ton) and 250kN (25ton). Custom ranges available on request
- **Axial force accuracy** = <0.1% of load cell range (i.e. 1N for 10kN load cell)
- **Axial force resolution** = 16 bit (i.e. <0.4N for 10kN load cell, <1.5N for 40kN load cell)
- **Displacement range:** 100mm
- **Displacement resolution:** <2micrometre
- **Displacement accuracy:** 0.05% of full range
- **Control data points** = 10,000 pts/sec
- **Maximum saved data points** = 100 pts/cycle
- **Data acquisition =** 8 or 16 channel, 16bit
- **Control modules =** closed-loop control feedback system integrated with each independent actuator control unit (shear and axial).
- **Weight*:*** approx. 800 to 2000kgf (depending on model)

How does it work?

` Axial force and axial deformation are applied through an oil filled hydraulic actuator mounted on the cross beam of the load frame, where the pressure is supplied from a separate hydraulic power unit. The system dynamically controls axial displacement or axial force. The cell is also provided with a built-in hydraulic actuator to dynamically control cell pressure. The cell fluid is hydraulic oil. The radial pressure (cell pressure) actuator is made without seals in order to be maintenance-free and very low friction. Oil is allowed to seep past the actuator piston and is recycled using an oil make-up system.

GDSLAB control and data acquisition software

The user interface for the 10Hz GDSHLF is via GDSLAB control and data acquisition software (see Fig. 1). GDSLAB provides sinusoidal cyclic control of axial displacement or axial force for dynamic cyclic loading tests at frequencies up to 10Hz. It also provides complex cyclic loading control with axial load and radial stress changing simultaneously with a user-defined phase relationship.

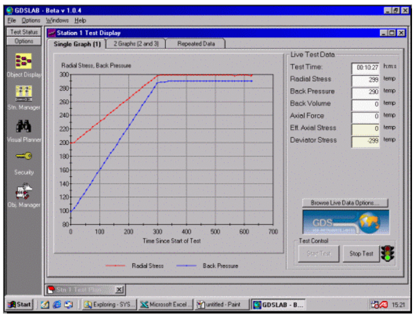


Fig. 1 GDSLAB control and data acquisition software

Hydraulic power unit

Pressure for the system is provided by a separate hydraulic power unit, which provides a constant source of pressure at 25MPa (see Fig. 2). This pressure source is used by the axial and radial actuators to control pressure and displacement. It is also used to raise and lower the top beam (in high pressure only).

Fig. 2 GDS 25MPa hydraulic power unit

System features

- Dynamic control of axial displacement or axial force to 20Hz, sinusoidal waveform
- Dynamic control of radial stress to 20Hz, sinusoidal waveform. The dynamic control of cell pressure means that for those tests where the cell pressure is constant but the axial actuator is moving dynamically the cell pressure actuator automatically adjusts the volume of oil in the cell to maintain a constant cell pressure
- Performance specification conforming to the requirements of ASTM Designation D3999-91 "Standard Test Methods for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus"
- Optional interchangeable (internal submersible) load cells to accommodate very soft to very stiff soils with ranges of 2, 4, 8, 16, 25, 32, 64, 100 and 250kN are available. The load frame is supplied with an external load cell to match the model maximum load range as standard (i.e. 20, 40, 60, 100 or 250kN)
- Optional local strain measurement and mid-plane pore pressure measurement
- Optional precise control of low consolidation stresses by differential pressure transducer
- Optional acquisition of Gmax using s-wave and/or p-wave pedestals and top-caps
- Direct (dynamic, 10Hz) closed loop control of axial displacement, axial force and cell pressure
- Quasi static closed loop control of back pressure
- 38,50,70,100mm diameter test specimen sizes can be catered for by interchangeable base pedestals and triaxial extension top caps. Other test specimen sizes can be accommodated by special order
- Simple access for transducers, valves and pipework via 12 port Transducer Ring
- 8 channels of 16bit data acquisition as standard, additional channels available on request

Why buy GDSHLF?

- GDS load frames are extremely stiff and designed principally for rock testing to allow minimum backlash at the point of sample shearing (other, less stiff, load frames do not give good results at this critical point in the test due to the stretch of the load frame under high load)
- Compatible with the well-developed GDSLAB control and data acquisition and reporting software which provides a consistent interface across all of your geotechnical laboratory testing
- GDS worldwide technical support for peace of mind (see testimonials at www.gdsinstruments.com)

Due to continued development specifications may change without notice

Actuator System:
Electro-mechanical ✓
5Hz Fequency ✓

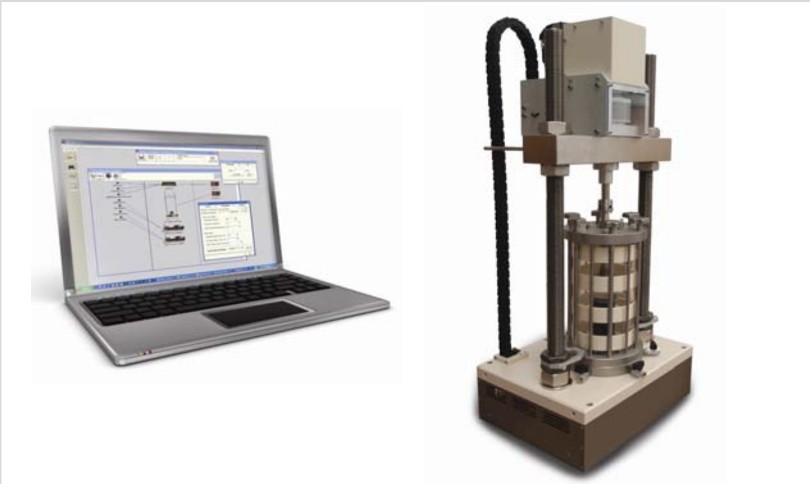
Available Load ranges:
5kN ✓
10kN *(optional)* ✓

Optional Cell Sizes:
76mm ✓
100mm ✓
150mm ✓

Software
Fully automated ✓

Available options
Bender Elements ✓
Unsaturated ✓

Enterprise Level Dynamic Triaxial System (ELDyn)



What is it?

The GDS Enterprise level Dynamic triaxial testing system has been designed to fulfill the demand within the geotechnical laboratory testing industry for a lower cost, more basic dynamic triaxial testing system. ELDyn provides a simple route to allow cyclic loading of triaxial samples under either load or strain control while monitoring the effects on the specimen pore pressure.

Features

The ELDyn triaxial testing system builds on over 15 years of GDS experience in designing, manufacturing, controlling and supporting electro-mechanical dynamic systems.

Based on an axially-stiff load frame with a beam mounted electro-mechanical actuator which has a full stroke capability of 100 mm and a maximum axial load capability of +/- 5 kN at 5Hz (upgradeable to +/-10 kN).

The ELDCS, Dynamic Control System, provides a 4-channel dynamic data logger with 16 bit data acquisition for an Internal Submersible Load Cell and a Pore Pressure Transducer. An optional displacement transducer can be fitted and logged on one of the spare channels, although not entirely necessary due to the encoder on the axial actuator.

Further data acquisition channels may be added using a synchronized data bus connection.

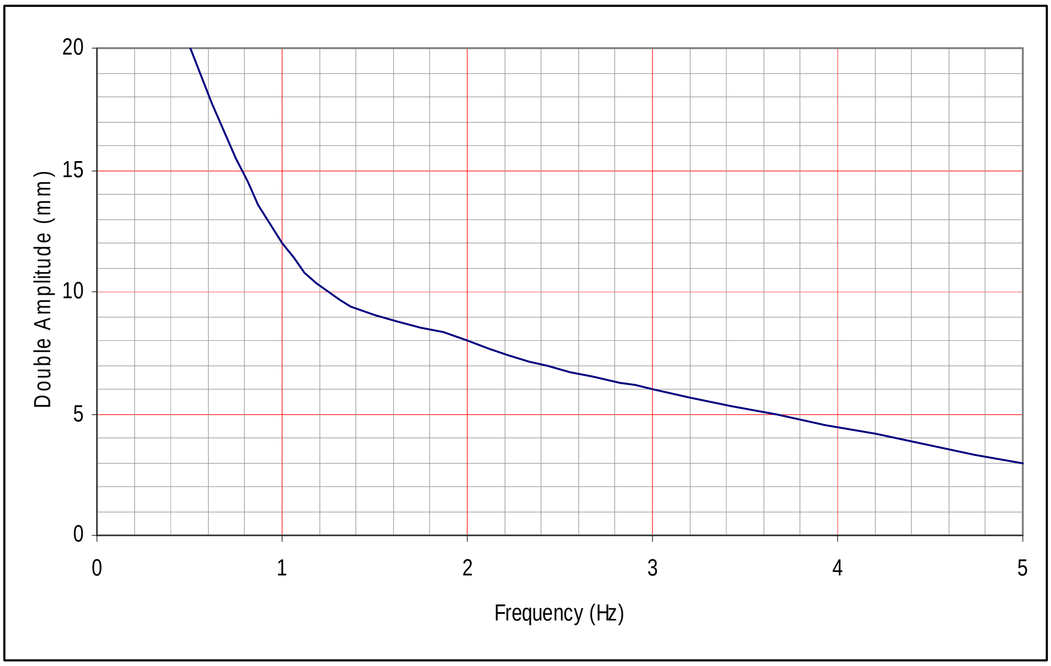
As well as dynamic triaxial tests, the ELDyn system can be utilised to carry out traditional triaxial tests such as UU, CU and CD as well as more advanced tests such as stress paths, K0 and Resilient Modulus tests.

Due to the high precision electro-mechanical actuator the ELDyn system supersedes most systems using pneumatic actuators in terms of life costs and overall useable performance.

Technical Specifications

- **Maximum Operating Frequency**: 5Hz
- **Minimum Operating Frequency**: Static tests, i.e. < 0.001Hz
- Highly accurate dynamic, electro-mechanical actuator
- Standard Triaxial cells can be used (upgraded to dynamic seals and bearings)
- Available sample sizes (depending on cell selection):
  - Φ38 x 76mm (or Φ39.1 x 78.2mm)
  - Φ50 x 100mm
  - Φ70 x 140mm (or Φ61.8 x 123.6mm
  - Φ100 x 200mm (or Φ101 x 202)mm
  - Φ150 x 300mm
- 16-Bit dynamic data logging
- 16 Bit dynamic actuator control channel
- Cell pressure range to 2MPa (dependent of cell choice)
- Small laboratory foot print
- No hydraulic power pack required

Typical system performance, showing frequency and amplitude



GDSLAB dynamic test module

- Dynamic cyclic loading tests at frequencies up to 5Hz.
- Provides sinusoidal cyclic control of axial displacement or axial force.
- Plotting saved results gives cyclic stress paths based on average cross-sectional area i.e. the area of the volumetrically equivalent right cylinder
- A complete cycle of data can be saved every N cycles where the value of N is defined by the user
- Controlled data displayed in real-time, as in Fig. 3.

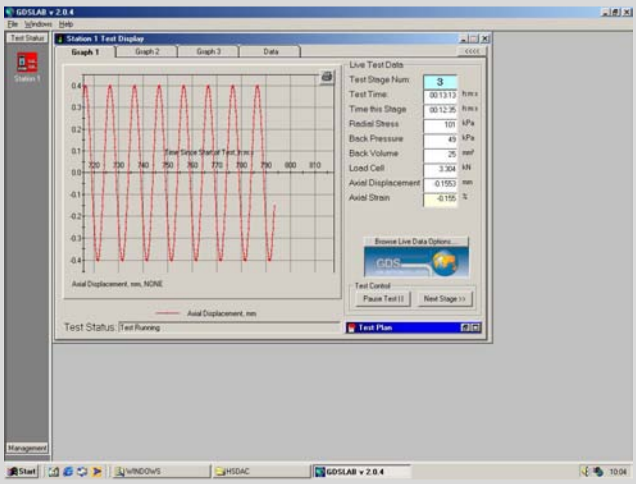


Fig.3 Test display showing a dynamic test in progress

Why buy ELDyn?

- GDS ELDCS – no requirement for manual tuning
- As well as extremely good control of axial displacement and axial load for dynamic testing, the ELDCS system is excellent for performing static and small strain triaxial tests
- With GDS software and hardware, there are unlimited possibilities for upgrading the system in the future (i.e. bender elements, unsaturated testing, mid plane PWP, local strain and so on)
- Optional on-site training by experienced geotechnical engineers
- Reputation for world class technical support – check the website for testimonials
- 24 hour technical support by e-mail

GDSLAB control software

The GDSLAB control and acquisition software from GDS 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 available are as follows:

- 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 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, as in Fig. 2.

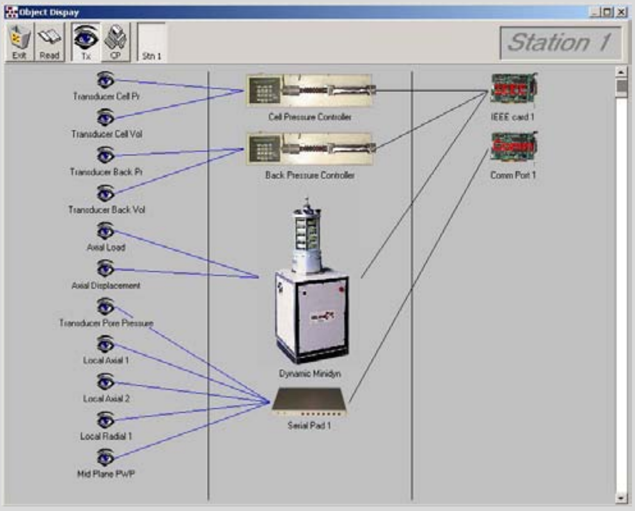


Fig. 2 GDSLAB object display showing a DYNTTS setup

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

Upgrade to bender element testing

Any ELDyn system may be upgraded to perform P and S wave bender element testing with the addition of the following items (see Fig. 4):

- Bender element pedestal with *new* inserted element
- Bender element top cap with *new* inserted element
- High-speed data acquisition card

Signal conditioning unit, amplification of source and received signals (P and S wave) with user-controlled gain levels (via software).

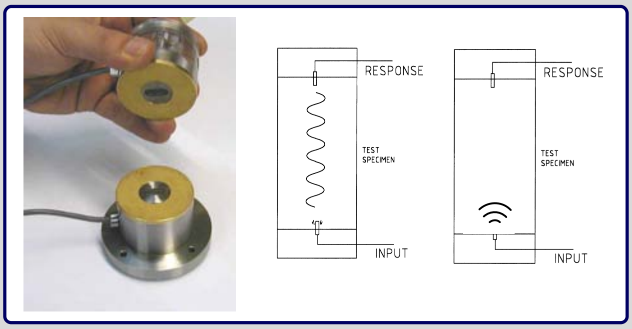


Fig. 4 P and S wave elements

For further information on bender element testing, please refer to the dedicated Bender Element Testing datasheet.

Upgrade to unsaturated testing

Any ELDyn system may be upgraded to perform unsaturated triaxial testing with the addition of the following items:

- Unsaturated pedestal with high air entry porous stone.
- 1000cc digital air Pressure/volume controller (ADVDPC) for the application of pore air pressure and measurement of air volume change (see Fig. 5).
- Optional HKUST double cell (for more information on this please see the data sheet ‘Unsaturated Triaxial Testing of Soil (UNSAT).
- Optional double walled cell.

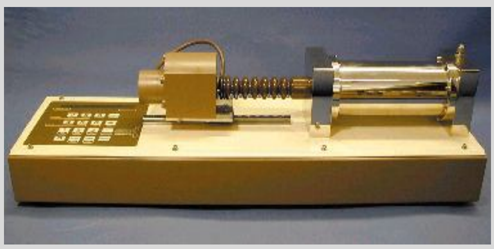


Fig. 5 1000cc air pressure controller (ADVDPC)

For further information on unsaturated testing, please refer to the dedicated Unsaturated datasheet.

S and P -Wave velocity ✓

Dedicated software ✓

Sample sizes from 38mm ✓

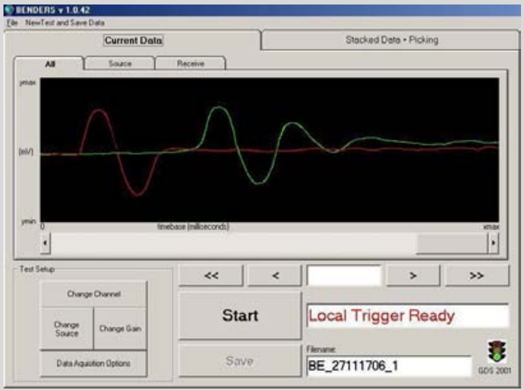
New Specification

2 Million Samples/Sec ✓

USB control box ✓

Developed in conjunction with GeoDelft

Bender Element System (BES)



What is it?

The GDS Bender Element system enables easy measurement of the maximum shear modulus of a soil at small strains in a triaxial cell. Measurement of soil stiffness at very small strains in the laboratory is difficult due to insufficient resolution and accuracy of load and displacement measuring devices. The capability exists to regularly carry out measurements of small strain stiffness in the triaxial apparatus using local strain transducers, but this can be expensive and is generally confined to research projects.

The addition of Bender Elements to a triaxial testing system makes the routine measurement of Gmax, maximum shear modulus, simple and cost effective.

The GDS encapsulated element and insert

- The GDS Bender elements are bonded into a standard insert (see Fig.1). This method of manufacture has 2 advantages:
  - It makes the bender element insert a modular device that can then be easily fitted into a suitably modified pedestal/top-cap.
  - Should an element fail, it is simple and quick to replace the complete insert.
- Elements are manufactured to allow both S and P-wave testing to be performed (in opposing propagation directions).
- The length of the bender element that protrudes into the soil has been optimised without compromising the power transmitted by or received to the elements. This is achieved by fixing the element further down inside the insert and then filling the remaining volume with flexible material. This allows the element to achieve maximum flexure at its tip, whilst only protruding into the sample by a reasonable distance. Advantages of this include prolonged life by increased resilience to breakage and easier sample preparation, particularly on very stiff samples where only a small recess for the element is required.

Fig. 1 GDS Titanium Bender Element and Insert

Technical Specifications

- **Data acquisition speed =** 2,000,000 samples/second, simultaneous sampling of both source and received signals
- **Resolution of data acquisition (bits) =** 16 bit
- **Connectivity of control box =** USB
- **Available gain ranges for data acquisition =** from x10 to x 500
- **Titanium inserts for reduced weight (particularly important for the top-cap)**

GDSBES control software

The functionality of the GDSBES software (Fig. 2) includes:

- User friendly dedicated bender element system software
- Stacking of data (manual or automatic)
- Manual picking of data
- Flexibility in control of the transmitted signal and the received data
- User defined source control signal
- Software control of 16 hardware gain levels.
- Automated optimal gain level selection
- Signals normalized to allow easier picking of traces
- Signal reversal to allow easier picking of traces

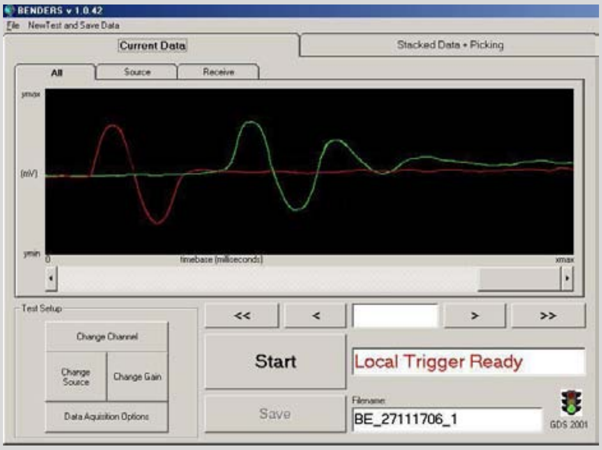


Fig. 2 GDSBES software during testing

To cater for the many different approaches to bender element testing that have been developed around the world, the GDS Bender Element software allows the following source signal types to be used as follows (see Fig. 3):

- Sine wave
- Square wave
- User defined

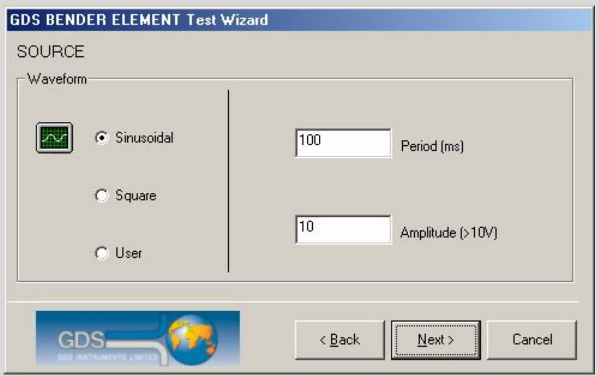


Fig. 3 Example page from the GDSBES software test setup wizard

Each test the above wave types can be used on a single shot basis or automatically repeated to build a 'stack' of data. For the S-wave elements the source shot can be reversed to simplify picking by using the reversal method.

The standard wave types (sinusoid and square) can be controlled using the following parameters:

- Amplitude
- Period
- Repeat Time (0 seconds (continuous) to 60 seconds)

The User Defined wave type option allows the user to test using non-standard waveforms. A digitised waveform, in an ASCII text file, can be read by the software and used as the waveform for the source element.

Bender elements for Horizontally Propagating Waves

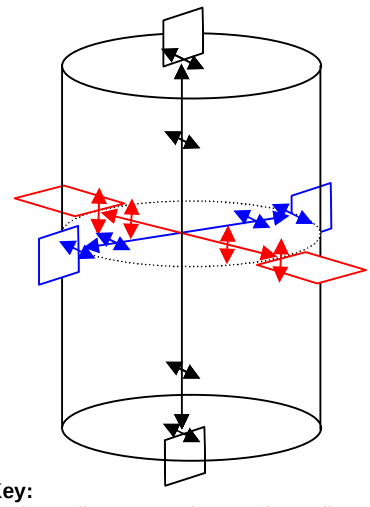
The development of the GDS horizontally propagating elements, when used in addition to the axial element inserts, allows the user to quantify the degree of stiffness anisotropy present in the soil specimen. As with the standard GDS inserts, the horizontal inserts are also manufactured from Titanium, but in a smaller setting to further reduce weight.

The horizontal elements are simple to mount using specially manufactured rubber grommets (see Fig. 4). The installation procedure requires the membranes to be cut, then the inserts to be sealed using an o-ring.

Fig. 4 Horizontal elements mounted to specimen

These elements may be orientated on the sample either horizontally or vertically to produce two different polarisations, i.e. horizontal polarisation or vertical polarization, but both with horizontally propagating waves (see Fig. 5).

The horizontal elements can be controlled using the same GDS BES software. As with the standard GDS bender elements, combined S and P-wave elements are used.



Key:
Horizontally Propagating, Horizontally Polarised
Horizontally Propagating, Vertically Polarised
Vertically Propagating, Horizontally Polarised

Fig. 5 Horizontal bender element polarisation options

GDSBES Hardware

The full GDS-BES system is made up of the following; Bender Element Inserts, adapted pedestal and topcap and an external USB control box.

The Bender Elements are encapsulated and mounted in inserts that can be fixed in either the topcap or the base pedestal. Both inserts are manufactured from Titanium so that they can be mounted in either base pedestal or top-cap. As well as its is used for its high axial rigidity, Titanium is used for its low weight to minimize the imposed axial load when fitted to a sample top-cap.

If the bender element insert is to be fitted to another manufacturers' equipment (that we are not familiar with) full mounting information can be provided to GDS to enable us to manufacture custom pedestals for your specific equipment.

System Purchase Options:

The GDS Bender Element System can be supplied in different levels of completeness depending on the users requirements:

- **Level 1**, encapsulated bender elements mounted in the inserts only. For use where a customer already has a driving system, signal conditioning, and data acquisition system (e.g. an oscilloscope).
- **Level 2**, The full GDS bender element system including the bender element inserts, signal conditioning and control box and GDS-BES software.

Receiver Control

Where a full GDS bender element system is being used the software will switch input gain levels (of the received signal), set the level of the output signal voltage and control switching between the P and S wave modes for the combined wave type elements. The software will select an appropriate sampling rate, which the user may override if required.

The acquired data is presented to the user for picking of both the source (feedback) signal and the received signals. Picking of the source signal gives an absolute zero to the calculation of travel time and does not rely on trigger detection.

Acquired data can be saved in ASCII format for plotting or use in reporting.

GDS BES Software Video

A software video CD is available which demonstrates the use of the GDSBES software. This CD as with other GDS software and hardware demonstration CD's are available by request from www.gdsinstruments.com.

Alternatively, the video can seen in low resolution format on-line at

www.gdsinstruments.com/videos/video_index_software.htm

Why buy a GDS BES

- USB interface so the system can be 'hot swapped' to any PC in the lab with a USB interface.
- 2 Mega samples/second, 16 bit resolution
- Titanium element inserts to reduce weight of top-cap.
- Packaged, 'turn-key' control system.
- Sine, square and user defined wave forms.
- Combined P and S-wave elements.
- Pedestals and top-caps can be made for other manufacturers cells as well as GDS cells.
- Horizontally propagating elements available.

Due to continued development specifications may change without notice

Options available for SS-HCA

Axial Load/Torque

- **10kN/100Nm** ✓
- **10kN/200Nm** ✓
- **12kN/200Nm** ✓
- **15kN/400Nm** ✓

Dynamic upgrade frequencies

- **0.5Hz** ✓
- **1Hz** ✓
- **2Hz** ✓
- **5Hz** ✓

Sample Height/Outer Ø/Inner Ø

- **200/100/60mm** ✓
- **400/200/160mm** ✓
- **Custom** ✓

Additional Notes

Complete Triaxial System ✓

Hollow Cylinder Apparatus (GDS SS-HCA)

What is it?

The GDS Small-Strain Hollow Cylinder Apparatus (SS-HCA) allows for rotational displacement and torque to be applied to a hollow cylindrical specimen of soil. Using this device it is possible to control the magnitude and direction of the three principal stresses. Studies can for example be made of the following:

- The anisotropy of soil samples.
- The effects of principal stress rotation.
- The effects of intermediate principal stress.

The SS-HCA has been designed to be a high quality, low cost hollow cylinder apparatus. It has specifically been designed to be capable of testing at very small axial strains (down to 0.00004%).

The GDS SS-HCA can apply a uniquely wide range of stress paths on the test specimen. The loading systems are computer controlled and strains can be measured directly on the test specimen. These strains can also be servo-controlled. Studies can therefore be made under the following test conditions:

- Plane strain.
- Simple shear.
- Very small shear strain.

Two versions of the SS-HCA are available, a dynamic (SS-HCA d) and a lower cost "static" (SS-HCA s) version. The SS-HCA d has been developed to be a complete dynamic hollow cylinder apparatus (dynamic axial and rotational axes) at a price approaching that of a standard dynamic triaxial system.

Technical specification

- **Axial/Torque force range:** 5kN/100Nm, 10kN/200Nm, 12kN/200Nm, 15kN/400Nm
- **Specimen sizes (height /outer dia./inner dia.):** 200/100/60mm or 400/200/160mm
- **Transducer Resolution** (based on 3kN/30Nm load cell). Dynamic values as a guide only as depend on machine spec.
  - **Axial Load:** Dynamic SS-HCA d = <3N, Static SS-HCA s = <0.7N
  - **Axial Displacement Encoder:** Dynamic SS-HCA d = <1µm, Static SS-HCA s = <0.08µm
  - **Torque:** Dynamic SS-HCA d = <0.03Nm, Static SS-HCA s = <0.008Nm
  - **Rotational Encoder:** Dynamic SS-HCA d = <0.04 degrees, Static SS-HCA s = <0.00011 degrees
- **Optional Local strain transducers:**
  - Hall effect 6mm range
  - LVDT 5mm or 10mm range
  - Non-contacting proximity transducers 0.9 to 6mm range
- **Optional transducers** for measuring inner sample strain
- **Optional large cell** with i.d. of 500mm to provide additional space around sample for local instrumentation research
- **18 port built in transducer access ring**
- **Size**:700 X 700 X 1000mm (cell de-mounted), 1450mm (cell mounted), 2350mm with optional cell top lifting frame.
- **Weight approx.:** 500kg

Features

The SS-HCA s (static) and SS-HCA d (dynamic) are both designed around the same central core of components. All of these components have been designed to give the machine high levels of axial and torsional stiffness coupled with the minimum amount of “backlash” and friction. All of these design considerations result in both machines being well suited for small strain testing right through to high load and strain testing.

Both systems can be provided with the same optional sample sizes, transducers and celltop counter balanced lift.

The SS-HCA s and SS-HCA d are both fully supported by and integrated into GDSLAB Control and Acquisition software

SS-HCA s (Static version)

The static version of the SS-HCA uses two high quality stepping motors controlled by a GDS-DPC motherboard. Axial displacements, axial loads, rotation and torque are applied through the same mechanical system as for the SS-HCA d.

For the SS-HCA s, data acquisition uses the GDS Serial Pad. This provides 8 channels of 16 bit user definable data acquisition. Up to 7 additional data acquisition pads can be configured to the system for a total of 64 channels.

The SS-HCA s provides a low cost HCA testing testing system without compromising the quality of the equipment. The SS-HCA s is particularly suited to very small strain testing in axial stress, axial strain, rotation or torque controlled tests.

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:

- SATCON (saturation and consolidation)
- standard triaxial
- stress path testing (p, q and s, t)
- advanced loading tests
- unsaturated testing
- K0 consolidation
- Permeability
- Hollow Cylinder (static and dynamic)

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. 1).

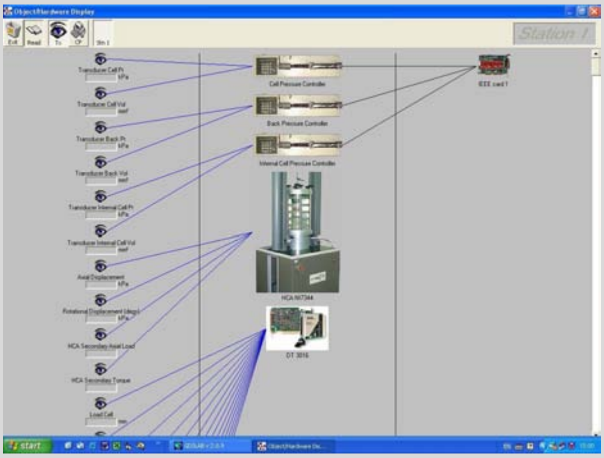


Fig. 1 Object display showing a GDS SS-HCA arrangement

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

GDSLAB static HCA test module

- Independent control of the 5 principal parameters, i.e. Axial, rotational, outer cell pressure, inner cell pressure and back pressure.
- Axial Control by: Axial Stress (kPa), Axial Displacement (mm), Axial Load (kN)
- Rotational Control by: Rotational Stress (kPa), Rotational Load (Nm), Rotational Displacement (degs)
- A phase shift offset angle may be introduced between axial and rotational axes when slow speed cyclic tests are being performed (see Fig. 2)

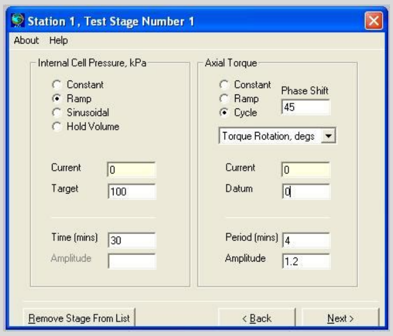


Fig. 2 HCA static test setup module

SS-HCA d (Dynamic version)

The heart of our dynamic SS-HCA system is a 16 bit Digital Control System (DCS). The DCS controls and measures torque, angular rotation, axial force and axial displacement, and is connected to the PC via a high speed USB connection. The data acquisition and control system resides external to the computer in order to give a realtime environment for control away from interference by the computer operating systems. The DCS gives direct closed loop servo control of axial force and displacement as well as torque and angular rotation.

The SS-HCA d has two servo motors, one controlling axial movement and one controlling torsional movement. Axial force and deformation are applied through an actuator in the base of the cell. The torque is applied by the rotation of the same ram imposing the vertical force. Axial force and torque are measured by an internal submersible combined load and torque transducer. Axial displacement and rotation are measured using high resolution encoders read by the DCS.

For dynamic testing, to further reduce backlash on the torque motor as the rotational load passes from positive to negative torque, an additional encoder for rotational feedback is installed. This second rotational encoder is positioned directly on the main ram which is used as the primary feedback control for the main motor, ensuring the motor control and the read value for the rotation is measured as close to the specimen rotation as possible.

GDS DCS – Digital Control System

The 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), the GDS DCS runs at a control frequency of 10kHz per channel. This means that when running at 10Hz the system uses 1000 control points per cycle. When running at 1Hz, it uses 10000 control points per cycle

The advantage of 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 of our dynamic systems, over our complete range, use the same high specification control system. A result of this is that 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 electro-mechanical actuator or high capacity hydraulic actuator.

GDSLAB dynamic HCA test module

- Dynamic cyclic loading tests at frequencies up to 5Hz (depending on the model).
- Provides sinusoidal cyclic control of axial displacement or axial force and rotational displacement/torque (see Fig. 3).
- A complete cycle of data can be saved every N cycles where the value of N is defined by the user.
- Controlled data displayed in real-time.
- Up to 1000 points saved per cycle.
- Built in standard waveforms: Sinusoidal, triangular, square, havesine.
- User defined waveforms using 1000 point ASCII file.
- Dynamic control of inner and/or outer cell pressure may be performed with the addition of optional dynamic pressure actuators.

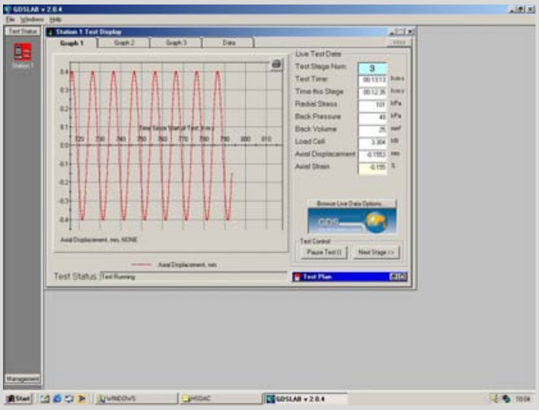


Fig. 3 GDSLAB test display showing dynamic cyclic test in progress

Pressure/volume controllers

Pressure control for the outer and inner cell pressure and the back pressure are provided using GDS Digital pressure controllers.

The cell pressure and back pressure controllers may be mixed and matched. There is the Standard Pressure/Volume Controller (STDDPC – see Fig. 4), with pressure ranges from **1 to 4MPa**, serial PC connectivity and 200 cc volumetric capacity.

Fig. 4 The STDDPC

Or there is the Advanced Pressure/Volume Controller (ADVDPC – see Fig. 5) with pressure ranges of **2MPa, 3MPa or 4MPa** with serial or IEEE PC connectivity and 200cc volumetric capacity. (Also, the ADVDPC 2MPa controller can be bought as 1000cc volumetric capacity item – required when using the larger sample sizes such as 400/200/160mm).

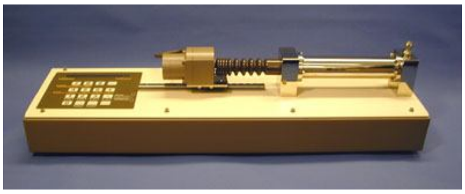


Fig. 5 The ADVDPC

The back pressure controller applies back pressure and also measures volume change of the test specimen, while the inner cell pressure controller measures volume change inside of the hollow specimen.

Example of hollow cylinder specimen after testing in a GDS SS-HCA

Fig. 6 Hollow Cylinder Test Specimen

Sample Preparation:

The SS-HCA can be supplied with equipment for making toroidal samples in either cohesive (using the GDS soil Lathe, pictured in Fig. 7) or non-cohesive materials (using an internal, collapsible sample former).

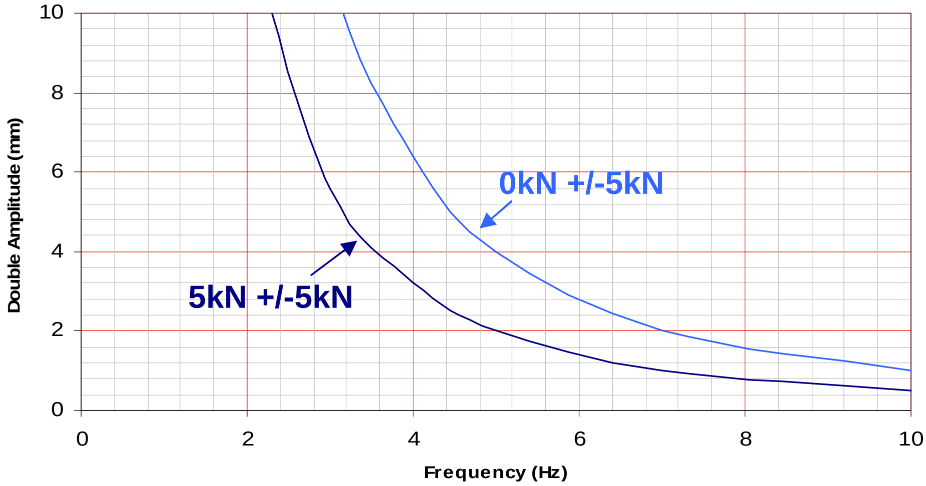
The manual soil lathe is suitable for all available sample sizes up to 400/200/160. The correct platens then need to be fixed to the lathe in order to prepare the required sample size. Platens for specific sample sizes are purchased separately to the lathe.

Fig. 7 HCA soil lathe

Why buy SS-HCA?

- Infinite rotation (i.e. >360 degrees possible)
- SS-HCA is a breakthrough in terms of price and performance.
- The precise control allows testing at very small axial and torsional strains.
- Software is supplied (GDSLAB) to fully control the HCA and can be programmed to control any stress or strain within the cell
- Flexibility in the capacity of the system (specimen size, load, pressures etc) ensures a system is created to specifically suit the testing required and the budget.
- Unsaturated testing may also be carried out using the SS-HCA (additional equipment may be required).
- May be used as a combined hollow cylinder/triaxial testing system.
- GDS worldwide technical support.

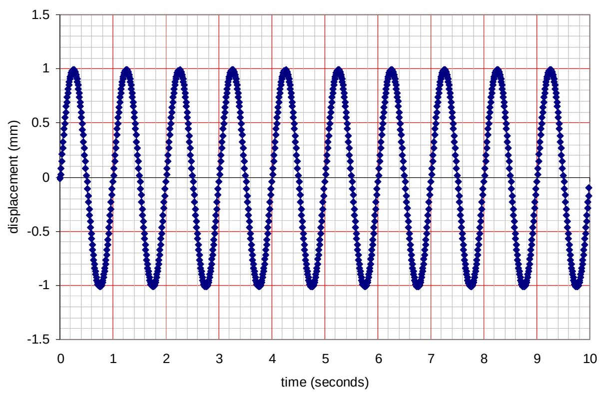
SS-HCA d, Example dynamic system performance for axial axis based on a 5Hz machine.
Note: performance will vary for machines other than 5Hz.

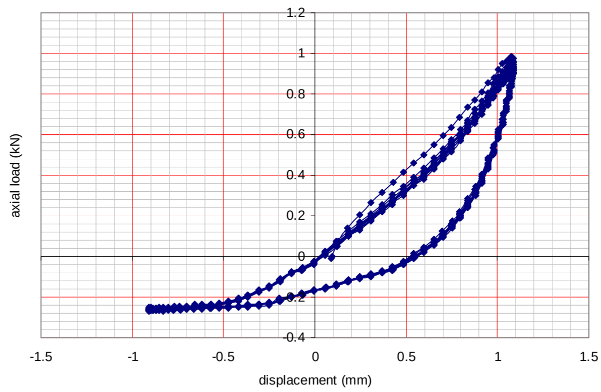


	with 5kN force datum		with zero kN force datum	
Frequency (Hz)	Amplitude (mm)	Double amplitude (mm)	Amplitude (mm)	Double amplitude (mm)
0.1	50	100	50	100
0.2	50	100	50	100
0.5	26.5	53	26.5	53
1	13.3	26.6	13.3	26.6
2	6	12	6	12
3	2.8	5.6	4.4	8.8
4	1.6	3.2	3.2	6.4
5	1	2	2	4
7	0.5	1	1	2
10	0.25	0.5	0.5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

Typical test results

Axial displacement feedback control	
Frequency (Hz)	1.00
Peak to peak (mm)	2.000
Radial stress (kPa)	200.0





Due to continued development, specifications may change without notice.

Available specimen sizes (dxh)

- **50mm x 100mm** ✓
- **70mm x 140mm** ✓
- **Custom** ✓

Power amplifier

- **Current driven** ✓

Software

- **Fully automated** ✓

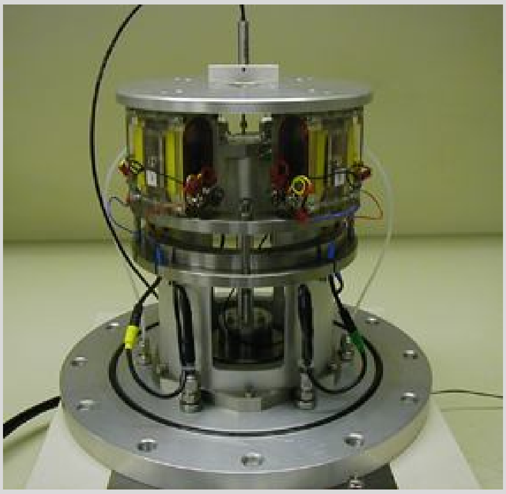
Available tests

- **Torsion** ✓
- **Flexure** ✓
- **Damping** ✓

Optional tests

- ***Torsional shear*** ✓

Resonant Column Apparatus (RCA)



What is it?

The GDS Resonant Column Apparatus (RCA) is used to excite one end of a confined solid or hollow cylindrical soil specimen. The specimen is excited in torsion or flexure (bending) by means of an electromagnetic drive system. Once the fundamental resonant frequency is established from measuring the motion of the free end, the velocity of the propagating wave and the degree of material damping are derived. The shear modulus (torsion) or Young's modulus (flexure) is then obtained from the derived velocity and the density of the sample.

Features

GDS RCA software (see Fig. 1) is used for control and data acquisition of the RCA apparatus. The software allows testing to occur via a simple, user-friendly interface. The tests that may be performed using the GDS RCA software are as follows:

- Resonance in torsion.
- Resonance in flexure.
- Damping Ratio in torsion.
- Damping Ratio in flexure.
- Slow speed (<2Hz) torsional shear.

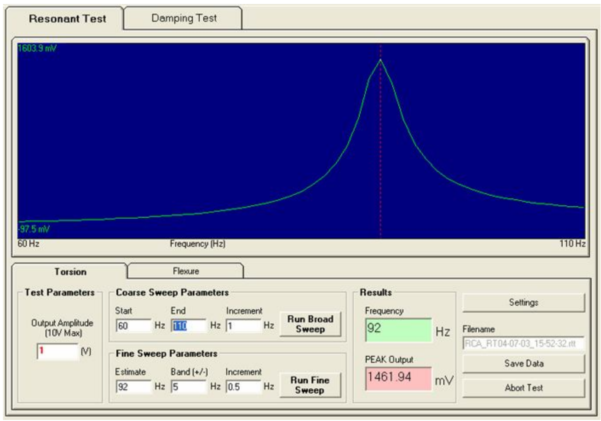


Fig. 1 GDS RCA software resonance test data

Technical Specifications

- Standard cell capable of 1MPa gaseous cell pressure (other cells available up to 25MPa)
- Electromagnetic drive system incorporating precision wound coils and composite sintered neodymium iron boron (NdReB) "rare-earth" magnets
- Transconductance current driven amplifier
- Inner cell for silicon oil (to aid membrane sealing)
- Energisation mode of coils is switchable by software to provide torsional and bending (longitudinal) tests
- Internal LVDT for measurement of sample deformation
- Internally mounted, counter-balanced accelerometer
- 1 off transconductance current driven drive amplifier
- 1 off high-speed 16-bit data acquisition/control card with associated GDS RCA control box/interface panel
- 3 off calibration weights and calibration bars provided of differing stiffness to enable calibration of system Io value
- 1 off computer controlled proportional gas valve to control cell pressure from software
- Back pressure by GDS Standard pressure/volume controller (STDDPC)
- Options for environmental temperature chamber (-20 degs C to +40 degs C) and an axial loading actuator and frame
- Standard specimen sizes: 50mm x 100mm and 70mm x 140mm (diameter x height) - other sizes available on request

Damping by free vibration

When performing damping ratio tests (see Fig. 2), the apparatus is designed to minimise the influence of equipment damping. During free vibration decay (after the power is normally shut off at resonance) 'back' EMF is usually generated in the coils by the movement of the magnets. This causes large equipment damping errors. In the GDS resonant column the software switches the hardware to provide an 'open circuit' through the coils during free vibration decay, which prevents 'back' EMF generation.

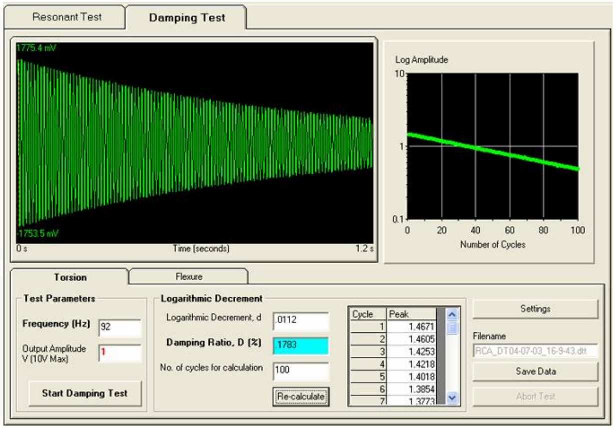


Fig.2 GDS RCA software damping test data

A software video CD is available which demonstrates the use of the GDS RCA software. This CD as with other GDS software and hardware demonstration CDs are available by request on-line at www.gdsinstruments.com

Torsional / flexural vibrations

During torsional tests, four pairs of coils are connected in series so that a net torque is applied to the sample. To apply flexural vibrations, the coils are switched (automatically) so that only two magnets are used applying a horizontal force to the specimen hence inducing flexural excitation. This allows the same coil and magnet arrangement to be used in both flexural and torsional vibration (see Fig. 3).

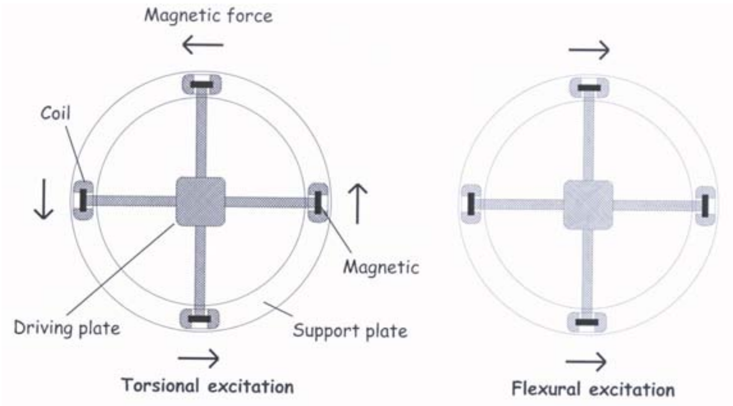


Fig. 3 Drive schematic for torsional and flexural excitation

State-of-the-art current-driven amplifier

RCA systems that GDS supplies are current driven using a transconductance power amplifier. This is due to the fact that the impedance of the RCA system changes with frequency. At higher frequencies, using a constant voltage, the current will be seen to reduce. As the torque is directly proportional to current, the torque will also reduce. This change to using a current driven power amplifier reflects the current thinking in the state-of-the-art resonant column testing throughout the world.

Calibration equipment

To derive Io and Iy experimentally, a test is performed on a calibration bar to compute its resonant frequency in torsion and flexure respectively. This is achieved by calibrating the apparatus by substituting metal calibration bars in place of the specimen whose mechanical properties are known.

The GDS RCA provides 3 calibration weights and 3 calibration bars of differing stiffness in order for Io and Iy to be calibrated by the end user (see Fig. 4).

Fig. 4 Calibration bars and weights

Why buy a GDS RCA?

- Designed to provide maximum rigidity, providing minimum losses and a more consistent Io v frequency.
- Minimum equipment damping by shutting off coils to reduce 'back EMF' during damping tests.
- Flexural tests equally as simple as Torsional tests.
- Upgrade to torsional shear tests available.
- Complete turn-key system i.e. 'works out the box'.
- Latest RCA developments as standard (i.e. current driven amplifier).
- Easy to use software which gives the use 'hands-on' appreciation of how the RCA test.
- Technical support from GDS staff familiar with RCA testing.

Due to continued development specifications may change without notice

Options available for VISFA

Load ranges

10kN ✓
25kN ✓
50kN ✓

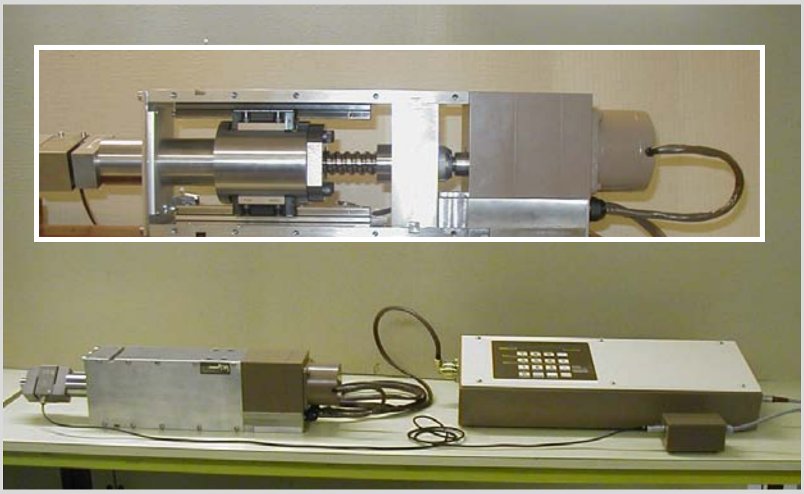
Displacement ranges

100mm ✓

Optional functionality

VIS ✓

Force Actuator (GDSFA)



What is it?

The GDS Force Actuator (GDSFA) is a general purpose loading system with feedback control and continuous displays of force and displacement. The unit has an IEEE 488 GPIB or RS232 computer interface, and a unique GDS development as an option: Virtual Infinite Stiffness (VIS). These outstanding features coupled with our software, GDS digital pressure/ volume controllers, and the GDS Data Interface give you unlimited possibilities in conventional and advanced PC controlled testing of soil and rock.

How does it work?

The GDSFA comprises a stepping motor and gearbox which drives a ball screw. Rotation of the screw displaces a ball nut which is captive in a thrust cylinder that slides on a linear guide. The complete mechanism is rigidly fixed to a base plate. The base plate is attached to the experimental rig and the thrust is applied by the thrust cylinder.

Force is measured by a load cell which can either be fixed to the end of the thrust cylinder or which can be fixed to some other part of the apparatus under test. The motor and gearbox is fixed to the base plate. Displacement is gauged by counting the steps to the stepping motor. The base plate is located into the experimental rig using a keyway and is bolted in place.

Technical specification

- **Load ranges**: 10kN (1ton), 25kN (2.5ton) and 50kN (5ton). Custom ranges available on request
- **Load resolution**: +/- 1 in 10,000
- **Load cell accuracy:** non-linearity +/- 0.03%, hysteresis and non repeatability +/- 0.05%
- **Displacement range:** 100mm
- **Displacement resolution:** 0.1micrometre
- **Displacement accuracy:** 0.05% of full range
- **Max displacement rate:** TARGET: 3.75mm/min, RAMP: 1.20mm/mm, UP/DOWN: 6mm/min, RAMPTARGET LOAD control: 1.0mm/min
- **Min displacement rate:** there is no minimum rate
- **Weight***:* approx. 50kgf
- **Nominal Size***:* Actuator 0.87m x 0. 15m x 0.1 5m, Control box 0.87m x 0.23m x 0.15m
- **Resolution of measurement and control**: pressure = <0.1% full range, displacement = 0.1micrometre
- **Power**: 92-265v, A.C. 48-440Hz, 65w maximum, single phase three wire earthed supply, 2A fuse x 2
- **Control panel**: 16 keypad membrane touch panel with audio feedback. Functions include zero pressure, target pressure, zero volume, target volume, fill, empty, test, ramp, stop, continue, reset, enter, +, -, >, <, yes, no
- **User interface:** 40 character, 1-line liquid crystal display
- **Computer interface**: IEEE-488 Standard, Talker/Listener or optional serial RS232 (IEEE only with RFM)

How does VIS (Virtual Infinite Stiffness) work?

As above, the VIS option is a unique GDS development. To the observer, and in terms of the test specimen, it allows the axial loading system to appear to have infinite stiffness.

For the entire loading range, both the measurement and control of platen displacement is automatically corrected so that it corresponds to the deformation that occurs between the platen and the load button of the load cell. In this way, the platen displacement is corrected for strain in the load cell and side columns, bending flexure of the cross beams, and distortion within the motorised mechanical transmission.

The GDSFA is computer calibrated to provide precise data on the load-deformation relationship of the entire load application and load measuring system.

The calibration data is loaded into the read only memory (ROM) of the system which constantly monitors the axial load and uses the calibration to apply a correction to the displacement. Therefore, it appears to the observer (or controlling computer) that the measurement of displacement (resolved to 0.1micrometre) is derived from a machine with infinite stiffness. In this way the system has the characteristic of Virtual Infinite Stiffness.

System features

- Simple to use under either load or displacement control
- Microprocessor controlled with built-in feedback of axial load and displacement
- Optional VIS provides automatic correction for system compliance stored in ROM
- IEEE computer interface
- 10kN (1ton), 25kN (2.5ton) and 50kN (5ton) capacities
- Continuous displays of axial load and displacement
- Resolution of axial force +/- 1 in 10,000
- Resolution of displacement 0.1micrometre
- Ramp and cycle axial load or displacement through function keys on the control panel
- Supported by GDSLAB control and data acquisition software

General applications

Through the control panel or through the computer interface you can enter linear time ramps of load or displacement. These RAMP functions can also be used to cycle load or displacement in a low frequency triangular wave form. Of course, via the computer interface, any wave form is possible. Under the control of your PC almost any test can be carried out. GDS control and data acquisition and reporting software is available for a wide variety of applications.

Why buy GDSFA?

- Optional VIS (Virtual Infinite Stiffness) system is unique to GDS
- Simple to use keypad interface
- Load control by direct load cell feedback as well as the more standard displacement control functions
- May be used stand-alone or under computer control
- Compatible with the well-developed GDSLAB software which provides a consistent interface across all of your geotechnical laboratory testing
- GDS worldwide technical support for peace of mind (see testimonials at www.gdsinstruments.com)

Due to continued development, specifications may change without notice.

Options available

Sample Sizes

38mm	✓	50mm	✓
70mm	✓	76mm	✓
100mm	✓	150mm	✓
Custom	✓		

Displacement Range

+/-3.0mm ✓

Pressure Range

Up to 1700kPa ✓

Hall Effect Local Strain Transducers

What is it?

The GDS Hall Effect Local Strain Transducers provide on-sample small strain measurements of axial and radial strains. Accurate determination of soil stiffness is difficult to achieve in routine laboratory testing. Conventionally, stiffness of a triaxial test specimen is based on external measurements of displacement which include a number of extraneous movements. True soil strains can be masked by deflections which originate in the compliances of the loading system and load measuring system. Such equipment compliance errors add to a variety of sample bedding effects to give a poor definition of the stress-strain behaviour of the material under test, particularly over the small strain range. Most triaxial tests therefore tend to give apparent soil stiffnesses far lower than those inferred from field behaviour (Jardine, Symes & Burland, 1984).

Why measure small strain?

Recent work has demonstrated the rather surprising finding that soils can be equally as brittle as rocks and that an understanding of their behaviour at levels of shear strain below 0.05% is very important. Indeed, K-zero for normally consolidated clays may reach peak strength in the triaxial apparatus at axial strains as low as 0.1%. Moreover, even when the behaviour is not brittle, the strains prior to yield are usually very small (loc. cit).

Why measure locally on the specimen?

In the conventional triaxial test, surface friction arises between the unlubricated ends of the test specimen and the end platens of the test apparatus. The ends are therefore restrained laterally and hence vertically also. Accordingly, the test specimen deforms non-uniformly with a gradient of axial and radial deformation from zero at the ends to a maximum at the middle.

It is widely believed that triaxial test specimens with a height to diameter ratio of 2 have end zones which are more or less restrained while the middle third is more or less unrestrained. Therefore, it is highly desirable that radial and axial deformations are measured locally in this region if realistic deformation moduli are to be found.

The measurement of axial deformation based on the relative movement between the top cap and the base pedestal is subject to bedding errors. These errors arise because of the difficulty in providing perfectly plane, parallel and smooth ends on the triaxial test specimen. The top cap can rest on surface asperities of the test specimen or make contact imperfectly, perhaps on one edge of the specimen. Owing to this "point" loading effect, rapid deformation will occur during the early stages of triaxial compression until the top cap is properly bedded down.

Technical specification

- **Range =** +/- 3.0mm
- **Resolution using 16 bit data acquisition +/- 3.0mm =** <0.1µm
- **Accuracy =** 0.8% FRO
- **Radial Caliper Weight, 38mm caliper =** 24g, 70mm caliper = 46g
- **Axial Apparatus Weight (1 off)** = 16g
- **Transducer Weight (1 off encapsulated Hall Effect Chip)** = 5g

The axial strain measuring device

As shown in Fig. 1, a spring-mounted pendulum holds a magnet assembly. This is suspended from an upper pad fixed to the test specimen by pins and bonded to the membrane by adhesive. The spring allows relative motion between the fixing pad and the pendulum without the need to introduce a bearing. This is a very important feature of the device as it guarantees no slack in the system while ensuring that friction remains very low.

The lower part of the gauge consists of a metallic container holding the linear output Hall Effect semiconductor encapsulated in epoxy resin. This is mounted on the specimen by means of a pinned fixing pad (Clayton & Khatrush, 1986).

The radial strain measuring device

As shown in Fig. 1, the device comprises a caliper similar to that originally designed by Bishop & Henkel (1962) and described in their book "The measurement of soil properties in the triaxial test". This type of caliper has been used for many years to indicate lateral deformation in the triaxial test.

The caliper is mounted on the test specimen by means of two diametrically opposed pads fixed to the test specimen by pins and bonded to the membrane by adhesive.

The Hall Effect transducer is positioned across the opening of the caliper where it measures the opening and closing of the jaws. Both the axial and radial devices are designed so that self-weight is partly counteracted by buoyant uplift.

Fig 1: Radial and axial local strain transducers mounted directly on a triaxial test specimen

The Hall Effect deformation transducer – explanation of the principal

If a metallic or semiconductor plate, through which current is flowing, is placed in a magnetic field where flux lines are directed perpendicular to the plate and the current flow, the charge carriers will be deflected so that a voltage is produced across the plate in a direction normal to the current flow. This is known as the Hall Effect after E H Hall who discovered the effect in 1879. Hall Effect semiconductors are used widely to measure magnetic flux density. Linear versions of these devices are typically direct current (DC) energised and deliver a DC output which varies linearly with magnetic flux density over a specified range.

The devices have been applied to the measurement of local axial and radial deformation in the triaxial test. The work was pioneered by Dr C R I Clayton and his colleagues at the University of Surrey where they have been used successfully for over ten years.

Why buy GDS Hall Effect Local Strain Transducers?

- Axial and radial deformation measured directly on the triaxial test specimen.
- Light and compact assembly.
- The Hall Effect semiconductor chip is very light, remarkably small and is compensated against changes in ambient temperature and changes in DC voltage supply.
- High output, high resolution.
- Designed for use with the GDS data acquisition system.
- Proven performance over 10 years at the University of Surrey.

References

Bishop, A.W. & Henkel, D.J. (I 962). The measurement of soil properties in the triaxial test. Edward Arnold, London, Second Edition, 228p.

Clayton, C.R.I. & Khatrush, S.A. (1 986). A new device for measuring local axial strains on triaxial specimens. Geotechnique 36, No.4, 593-597.

Jardine, R.J., Symes M J. & Burland, J.B. (1 984). The measurement of soil stiffness in the triaxial apparatus. Geotechnique 34, No.3, 323-340.

Options available

Sample Sizes

50mm	✓	70mm	✓
76mm	✓	100m	✓
150mm	✓	Custom	✓

Displacement Ranges

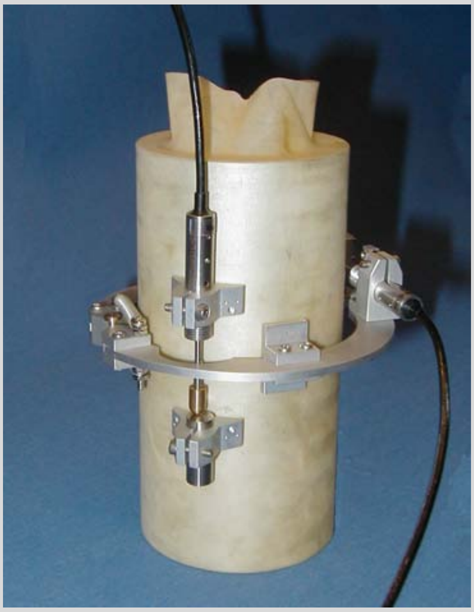
+/-2.5mm ✓ **+/-5.0mm** ✓

Submersion Options

Low pressure version for use in water up to 3500kPa

High pressure version for use in non-conducting oil up to 200MPa

LVDT Local Strain Transducers



What is it?

The GDS LVDT Local Strain Transducers provide on-sample small strain measurements of axial and radial strain. Accurate determination of soil stiffness is difficult to achieve in routine laboratory testing. Conventionally, stiffness of a triaxial test specimen is based on external measurements of displacement which include a number of extraneous movements. True soil strains can be masked by deflections which originate in the compliances of the loading system and load measuring system. Such equipment compliance errors add to a variety of sample bedding effects to give a poor definition of the stress-strain behaviour of the material under test, particularly over the small strain range. Most triaxial tests therefore tend to give apparent soil stiffnesses far lower than those inferred from field behaviour (Jardine, Symes & Burland, 1984).

Why measure small strain?

Recent work has demonstrated the rather surprising finding that soils can be equally as brittle as rocks and that an understanding of their behaviour at levels of shear strain below 0.05% is very important. Indeed, K-zero normally consolidated clays may reach peak strength in the triaxial apparatus at axial strains as low as 0.1%. Moreover, even when the behaviour is not brittle, the strains prior to yield are usually very small (loc. cit).

Why measure locally on the specimen?

In the conventional triaxial test, surface friction arises between the unlubricated ends of the test specimen and the end platens of the test apparatus. The ends are therefore restrained laterally and hence vertically also. Accordingly, the test specimen deforms non-uniformly with a gradient of axial and radial deformation from zero at the ends to a maximum at the middle.

It is widely believed that triaxial test specimens with a height to diameter ratio of 2 have end zones which are more or less restrained while the middle third is more or less unrestrained. It is highly desirable therefore that radial and axial deformations are measured locally in this region if realistic deformation moduli are to be found.

The measurement of axial deformation based on the relative movement between the top cap and the base pedestal is subject to bedding errors. These errors arise because of the difficulty in providing perfectly plane, parallel and smooth ends on the triaxial test specimen. The top cap can rest on surface asperities of the test specimen or make contact imperfectly, perhaps on one edge of the specimen. Owing to this "point" loading effect, rapid deformation will occur during the early stages of triaxial compression until the top cap is properly bedded down.

Technical specification

- **Range =** +/- 2.5mm or +/-5.0mm
- **Resolution using 16 bit data acquisition:** +/- 2.5mm = <0.1µm, +/- 5.0mm = <0.2µm
- **Accuracy =** 0.1% FRO
- **Radial Caliper Weight, (based on a nominal 70mm caliper) =** 74g
- **Axial Apparatus Weight (1 off) =** 26g
- **Transducer Weight (1 off LVDT) =** 20g

The axial strain measuring device

As shown in Fig. 1 below, the axial LVDT is suspended from an upper pad fixed to the test specimen by pins and bonded to the membrane by adhesive. The LVDT armature has a weighted rounded brass end, which rest freely on the lower pad anvil. Aluminum fixing struts may be attached between the upper and lower pads to allow help alignment of the pads when being fixed in place. Once in position, the fixing struts may be removed.

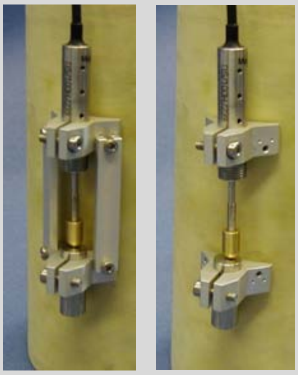


Fig 1: Axial local strain transducers mounted directly on a triaxial test specimen

The radial strain measuring device

As shown in Fig. 2 below, the radial LVDT and caliper is mounted on the test specimen by means of two diametrically opposed pads fixed to the test specimen by pins and bonded to the membrane by adhesive.

The LVDT is positioned across the opening of the caliper where it measures the opening and closing of the jaws. Both the axial and radial devices are designed so that self-weight is partly counteracted by buoyant uplift.

Fig 2: Radial local strain transducers mounted directly on a triaxial test specimen

Connecting LVDT's to a DC data acquisition system

The principal output of a Linear Variable Differential Transformer (LVDT) is an AC waveform. In addition, although an LVDT is an electrical transformer, it requires AC power of an amplitude and frequency quite different from ordinary power lines to operate. Supplying this excitation power for an LVDT is one of several functions of the GDS LVDT signal conditioning equipment, or 'GDS LVDT box', supplied as standard with the transducers from GDS. Other functions include converting the LVDT's low level AC voltage output into more convenient high level DC signals, decoding directional information from the 180 degree output phase shift as an LVDT's core moves through the null point, and providing an electrically adjustable output zero level.

GDS supplies the required calibrated signal conditioning equipment for the LVDT's to output a +/-10V DC signal. This output level is perfectly suitable to all GDS, and most other manufacturer's data acquisition equipment. The LVDT box can be recalibrated by the user for different output levels below 10V if necessary.

Why buy GDS LVDT Local Strain Transducers?

- Axial and radial deformation measured directly on the triaxial test specimen
- Light and compact assembly
- High output, high resolution
- Designed for use with the GDS Data Acquisition System
- Robust caliper design
- Inherently robust LVDT's as they have no physical contact across the sensing element and therefore zero wear
- Water version can be used up to 3500kPa
- Non-conducting oil version (pressure relieved) can be used up to 200MPa

Mid Plane Pore Pressure Probe

Pressure ranges

0 to 1500kPa ✓
0 to 700kPa ✓

Mid Plane Pore Suction Probe

Pressure ranges

-400 to 1500kPa ✓
-400 to 700kPa ✓

Air entry values

1500kPa ✓
500kPa ✓

Mid Plane Pore Pressure and Mid Plane Suction Probes

What is it?

The GDS Mid Plane Pore Pressure probe provides a direct measurement of the specimen pore pressure at the mid height of the sample. The GDS Mid Plane Suction Probe is a similar device but uses a high air entry porous disk in the tip to enable suction measurements to be made for unsaturated soil testing.

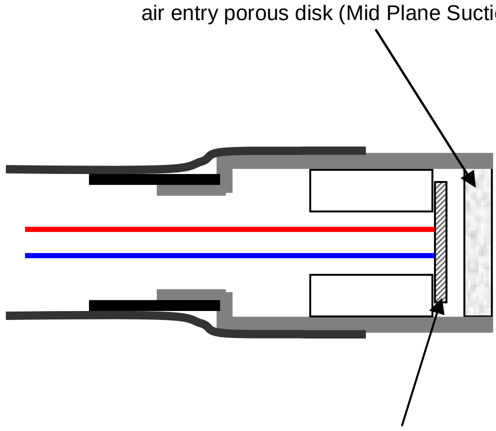
Why use it?

Mid-plane pore pressure measurement is preferred to measurements made in the area of the base pedestal. The reason for this is due to the minimal volume change of pore fluid required to activate the transducer diaphragm compared to that in a base pedestal transducer.

Measurement of matric suction in unsaturated soil

One of the two stress state variables for unsaturated soils is matric suction. The GDS suction probe provides a direct measurement of pore water pressure for the measurement of matric suction. This type of direct measurement is preferred in unsaturated soil tests as measured values of pore water pressures are more rapidly reflected. When the tip is fully saturated, the response of the time of the suction probe is generally less than 3 seconds, even for relatively large changes in pore water pressure.

The principal of making suction measurements using a suction probe is based on the equilibrium between the pore water pressure in the soil and the pore water pressure in the water compartment of the transducer behind the porous tip. Before equilibrium is attained, water flows from the water compartment into the soil, or vice versa. In an unsaturated soil specimen, negative pore water pressure causes the flow of water from the water compartment into the soil. On the other hand, in a saturated soil specimen, positive pore water pressure causes the flow of water from the soil into the water compartment.



Technical specification

- **Pressure ranges (standard)**: 700, 1500kPa,
- **Pressure ranges (suction)**: -400 to 1500, -400 to 700kPa
- **Combined Non-linearity and hysteresis**: +/- 0.2% BSL
- **Temperature range**: -20 to +120 degrees C
- **Thermal zero shift**: +/-0.05% FS/degrees C
- **Thermal sensitivity shift**: +/-0.2% of reading/degrees C
- **Output:** linear DC volts output of approx. 0 to 200mV

Why buy a Mid Plane Probe?

- Response speed of pore pressure measurement.
- Measurement of pore pressures (and hence effective stress) in the middle third of the specimen where end effects are not present.
- Measurement of pore pressure distribution and equalization throughout the specimen length.
- Direct measurement of suction (suction probe only).

Options available for GDS ND

Chamber capacities

6litre ✓

8litre ✓

Nold DeAerator™ (GDSND)

What is it?

The GDS Nold DeAerator™ (GDSND) is designed for the rapid degassing/deairing of water by means of cavitation and nucleation. This unit operates by violently agitating the liquid while it is held under a vacuum. The agitation is produced by means of an impeller coupled by a magnetic clutch to an electric motor. Cavitation occurs behind the blades of the rapidly rotating impeller causing the liquid to vaporize into a fine mist-like spray, (nucleation). Gases released from this spray are hurled outwards by centrifugal forces and bubble upwards into the evacuated space above the liquid from where they are removed.

How is it used?

The GDSND can quickly (within 3 to 5 minutes) produce de-aired water with a purity of less than 1ppm dissolved air without the need for application of heat.

Vacuums must exceed 29.5ins Hg (12Torr) for the GDSND to be effective. Belt driven, two stage, oil filled vacuum pumps of 25litre per minute capacity are preferred. Where the water aspirator is used, the water pressure must exceed 450kPa and approximately 12litres of water is required.

Technical specification

- **Capacities**: 6litre or 8litre.
- **Degassing purity**: 0.6ppm
- **Vacuum requirements:** 750mm Hg (12Torr) or better
- **Power consumption:** 14 Watts
- **Unit size (mm):** 6 litre: L=190, W=190, H=510, 8 litre: L=190, W=190, H=600
- **Unit weight:** 9kg

Why buy GDSND?

- Quick to use (de-aired water to 1ppm within 3 to 5 minutes)
- Extracts the air without the use of heat
- GDS worldwide technical support for peace of mind (see testimonials at www.gdsinstruments.com)

Due to continued development specifications may change without notice

HAVCD summary:

- **1 MPa pressure** ✓
- **Upgradeable maximum pressure** ✓
- **Alternative volume change ranges / resolutions available** ✓
- **Fully supported by GDSLAB** ✓

High Accuracy Volume Change Device (HAVCD)

What is it?

The High Accuracy Volume Change Device (HAVCD) provides a simple, high resolution, high accuracy alternative to traditional volume change devices. The device is used to measure volume change along a pressure line. The most common application for the use of the HAVCD is during unsaturated testing where accurate measurement of both small and large pore volume change is critical.

How does it work?

The basic principle of the HAVCD is to record the change in the height of the water column inside a vertically orientated tube connected to the drainage line. The pressure head in the tube is measured using a low range, high-accuracy differential pressure transducer.

The water volume change is equal to the change in the water level multiplied by the cross section of the tube. The accuracy and resolution of the water volume indicator depends on the cross-section area of the tube connecting to the drainage line.

Three tubes with inner cross-sectional areas of 28sq mm, 63sq mm and 196sq mm are installed as standard in the apparatus (see Fig. 1). Through a series of valves, the user can choose one or two of the three tubes according to the expected water volume change.

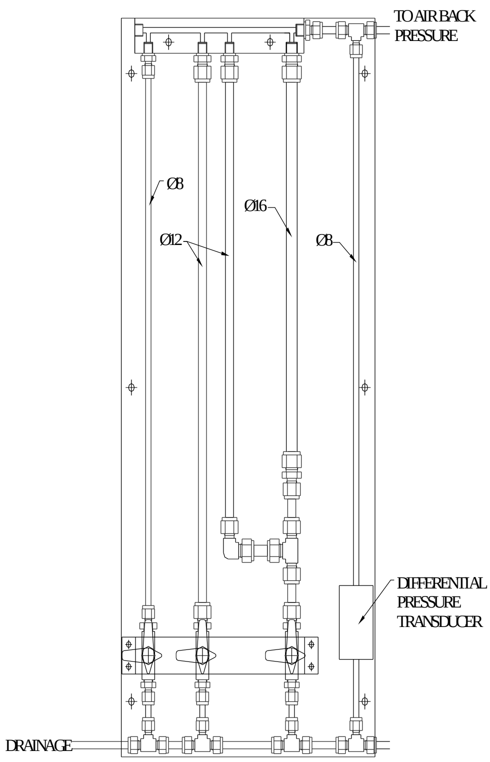


Fig. 1 Schematic of the GDS High Accuracy Volume Change Device (HAVCD)

Why buy the GDS High Accuracy Volume Change Device (HAVCD)?

- Developed in conjunction with Zhejiang University, China
- Simple to use, low cost design
- Very high resolution in addition to large overall volume change capability
- Flexible specification
- Available in two versions: standard = plastic connectors, high accuracy = stainless steel connectors

Technical specification

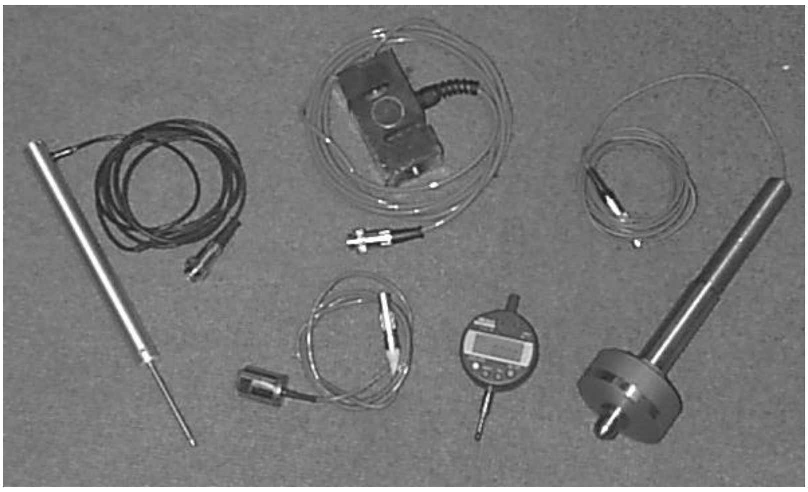
Overall dimensions: H = 800mm, L = 375mm, W = 75mm
Theoretical resolution (a function of tube size): 8mm = 0.43cu mm, 12mm = 0.97cu mm, 12+16 = 2.996cu mm. Alternative tube sizes available on request
Total nominal volume change = 150000cu mm = 150cu cm (150cc)
Differential pressure transducer accuracy: standard = 0.25% FSO
high accuracy = 0.1% FSO

Due to continued development, specifications may change without notice.

DATA

GDS INSTRUMENTS LIMITED

World Leaders in Software Based Geotechnical Testing Systems for Laboratory and Field



GDS

Triaxial Accessories

Overview

GDS Triaxial accessories are a complimentary range of transducers to enhance any triaxial system.

The accessories range is made up from transducers from three classes:

- Load Measurement
- Displacement Measurement
- Pressure Measurement

Load Measurement

The load measurement class contains internal submersible load cells, external load cells and analogue or digital proving rings.

The internal and external load cells are available with the following standard ranges 1, 2, 4, 8, 16, 32 and 64kN. Other ranges available on request.

All load cells have an accuracy of 0.1% of Full Range.

Proving rings are available with ratings up to 250kN.

Displacement Measurement

Displacement measurements may be made using a variety of transducers including:

- Axial and Radial Hall Effect local strain devices.
- Digital transducers with ranges of between 10 and 50mm (resolutions up to 0.001mm, typical accuracy 0.003mm).
- Rectilinear potentiometers 25 and 50mm ranges with accuracies of 0.25% of the full range.
- Axial and Radial LVDT local strain devices:
  - Low Pressure (up to 3.5MPa) for use in water or oil.
  - High Pressure (up to 200 MPa) for use in non-conducting oil only.

Pressure Measurement

A full range of pressure measurement transducers is available including: Gauge, Absolute, Mid-Plane and Wet-Wet differential transducers.

GDS Instruments Ltd

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London Road, Hook, Hampshire
RG27 9GR, U.K.
Telephone +44 1256 382450
Facsimile +44 1256 382451
e-mail: info@gdsinst.demon.co.uk
web: http://www.gdsinstruments.com

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.

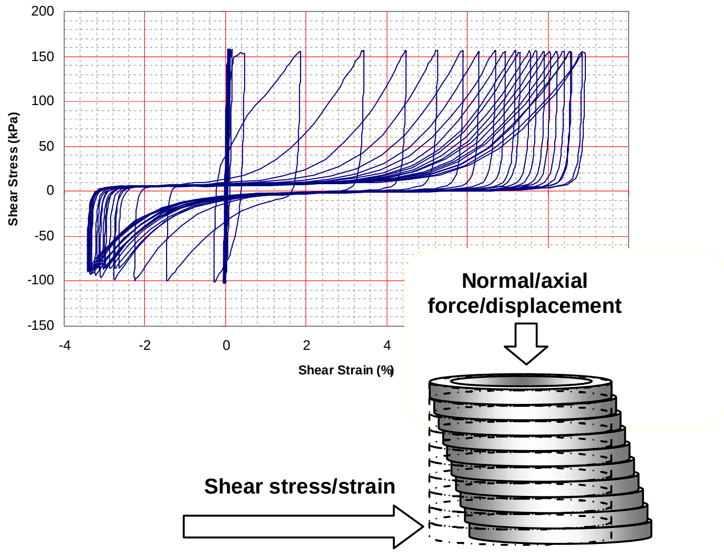


Fig. 1 Typical Graph shear stress (kPa) v shear Strain (%) and sample schematic during simple shear

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.

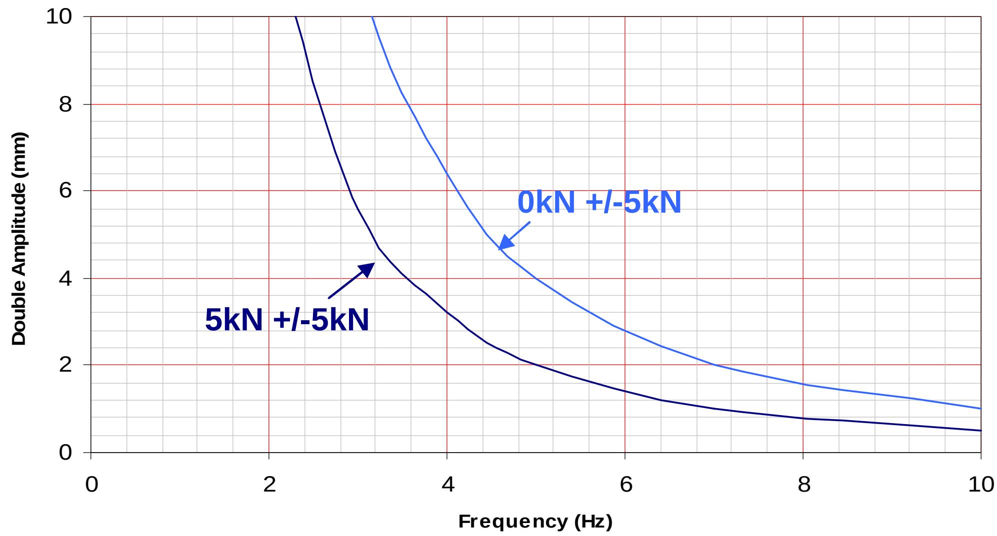
Constant volume conditions may be maintained by the system controlling the height of the sample via feedback from the localised axial transducer. This is called Active Height Control. This ensures system compliance is removed which would exist if the axial ram was simply ‘locked off’.

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



	with 5kN force datum		with zero kN force datum	
Frequency (Hz)	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.

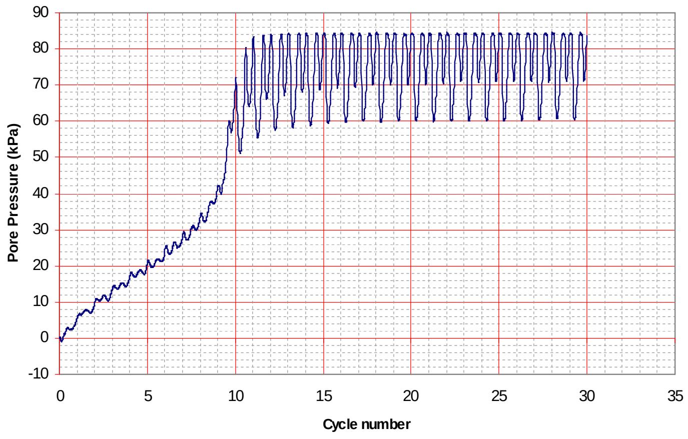


Fig. 2 Pore water pressure build up to failure

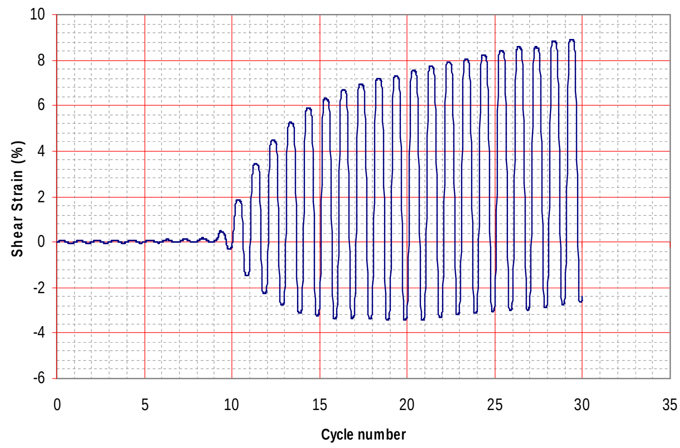


Fig. 3 Shear strain build up to failure

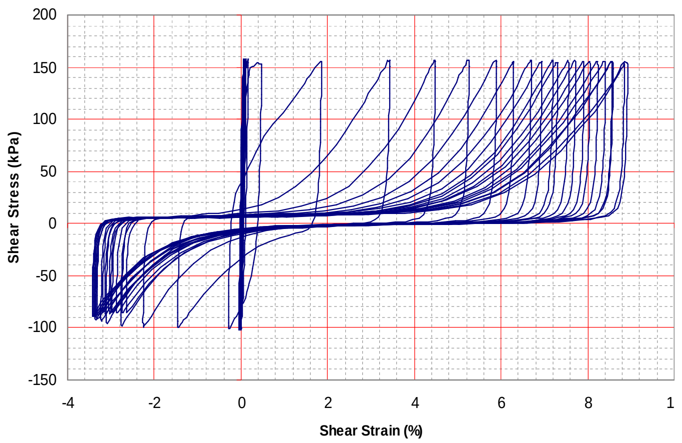


Fig. 4 Shear stress v shear strain

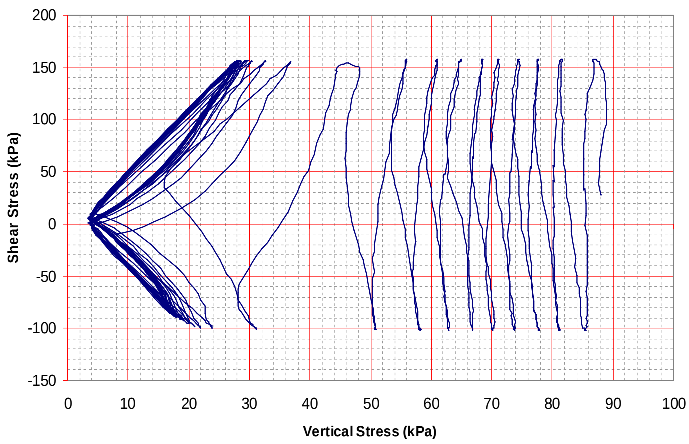


Fig. 5 Shear stress v vertical stress

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).

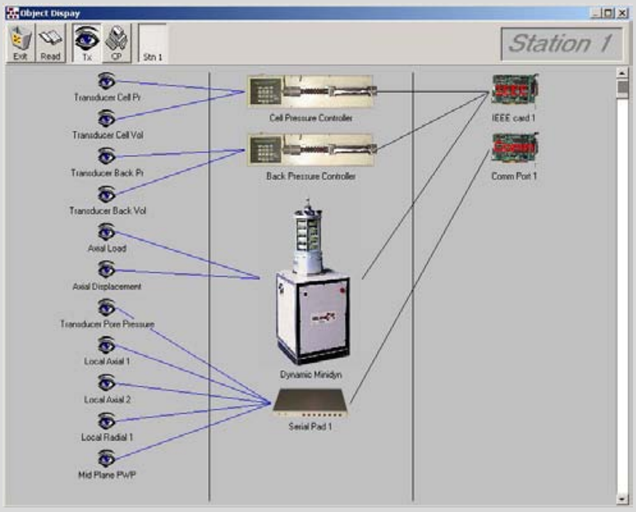


Fig.6 GDSLAB object display showing a GDS Advanced Triaxial Testing System (DYNTTS) setup

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.

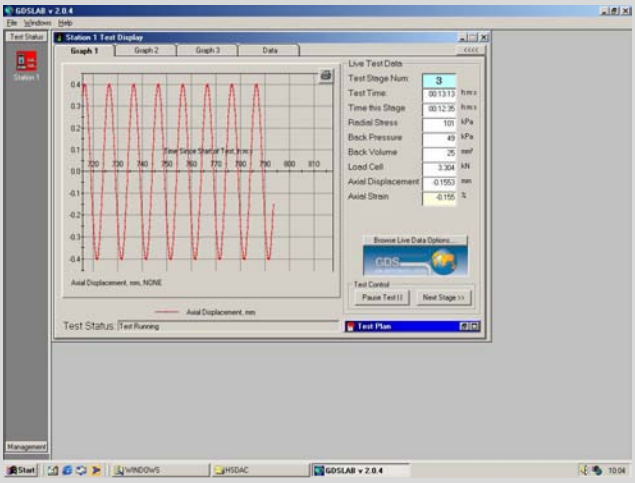


Fig.7 Test display showing a dynamic test in progress

Suitable for ASTM D6528

Actuator System:

Electro-mechanical ✓

Available Load ranges:

Axial Load: 5kN ✓

Shear Load: 5kN ✓

Software

Fully automated ✓

Control Parameters:
Axial Load/ Displacement
Shear Load/Displacement

Active Height Control ✓

Available options

10kN Upgrade ✓

Bender Elements ✓

Local Strain ✓

GDS Standard Simple Shear System (STDSS)

What is it?

The GDS Standard Simple Shear (STDSS) testing system is a stand alone simple shear device with no requirements for compressed air or hanging weights. The STDSS device can also be used to perform direct shear tests with the addition of optional direct shear platens and so is a combined machine.

The STDSS has been developed based on the experience we have achieved with our dynamic simple shear device, the EMDCSS which is a state of the art system for simple shear testing.

A cylindrical soil specimen is laterally confined by Teflon impregnated low friction retaining rings, ensuring a constant cross sectional area. A shear force loading is then applied. Vertical displacement is prevented using active height control (via the axial force actuator), therefore constant volume conditions are enforced (i.e. Simple Shear).

Features

Axial and shear loads (or displacements) are provided by proven GDS electro-mechanical force actuators. Axial and shear load readings are controlled under closed-loop feedback.

Topcap fixity is assured through a system of crossed roller linear guides to minimise topcap rocking during shearing.

The STDSS is a benchtop unit with a very small foot print of approximately 750mm x 200mm. This allows the system to fit into most laboratories. The only laboratory service required for the STDSS is mains electricity (110Vac – 240Vac).

Sample preparation and insertion into the system is made easy by using the included sample preparation and topcap support apparatus. This ensures that no load is applied to the sample during preparation and insertion.

Technical Specifications

- Accurate electro-mechanical actuators
- Available sample sizes (one size supplied with system):
  - Φ50mm
  - Φ70mm
  - Other sizes available on request
- Built in data logging for axial and shear loadcells
- Low friction sample slip rings
- High quality, low friction linear guides used to ensure strength and alignment in normal and shear directions.
- Available control parameters:
  - Axial Load / Stress
  - Axial Strain / displacement
  - Shear Load / Stress
  - Shear Strain
- Available control modes for each control parameter:
  - Ramp (monotonic), Cycle (slow speed) and hold.

- The STDSS uses the steps of the stepper motor to report axial and shear displacement. Additional accuracy can be achieved with the addition of an external GDS 16-bit Data logger and separate axial and shear displacement transducers for a more direct reading of the sample movement.
- The system can be upgraded by the addition of bender elements to measure small strain stiffness, please see below for further details.
- System designed to conform to and above the requirements of ASTM D6528.

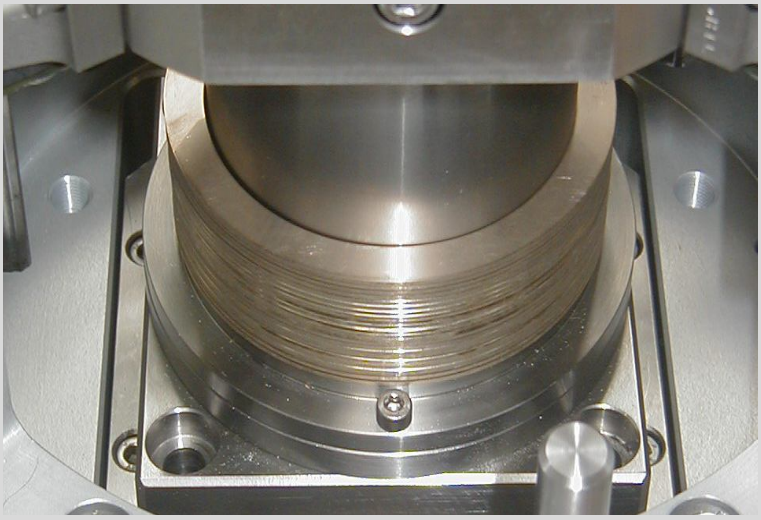


Fig. 1 An STDSS Sample under test.

Upgrade to bender element testing

Any STDSS system may be upgraded to perform P and S wave bender element testing with the addition of the following items (see Fig. 2):

- Bender element pedestal with *new* inserted element
- Bender element top cap with *new* inserted element
- High-speed data acquisition card

Signal conditioning unit, amplification of source and received signals (P and S wave) with user-controlled gain levels (via software).

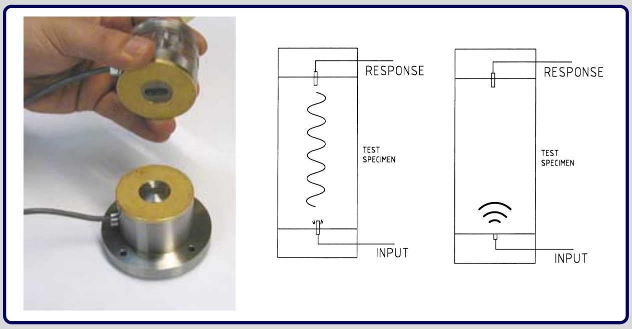


Fig. 2 P and S wave elements

For further information on bender element testing, please refer to the dedicated Bender Element Testing datasheet.

GDSLAB control software

The GDSLAB control and acquisition software from GDS 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 available are as follows:

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

GDSLAB has the ability to be configured to your hardware 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, as in Fig. 3.

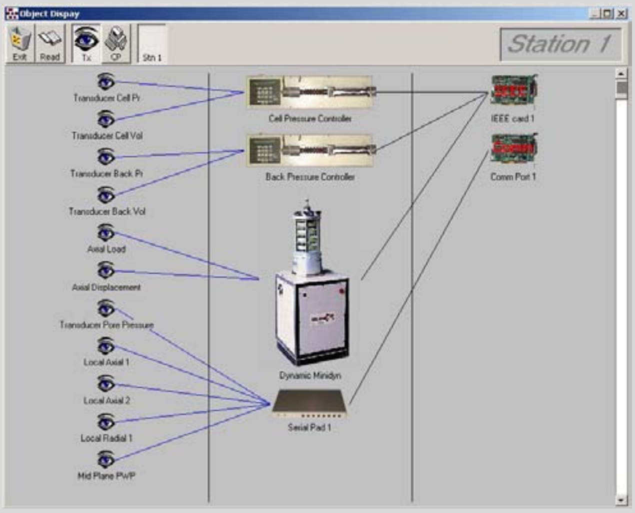


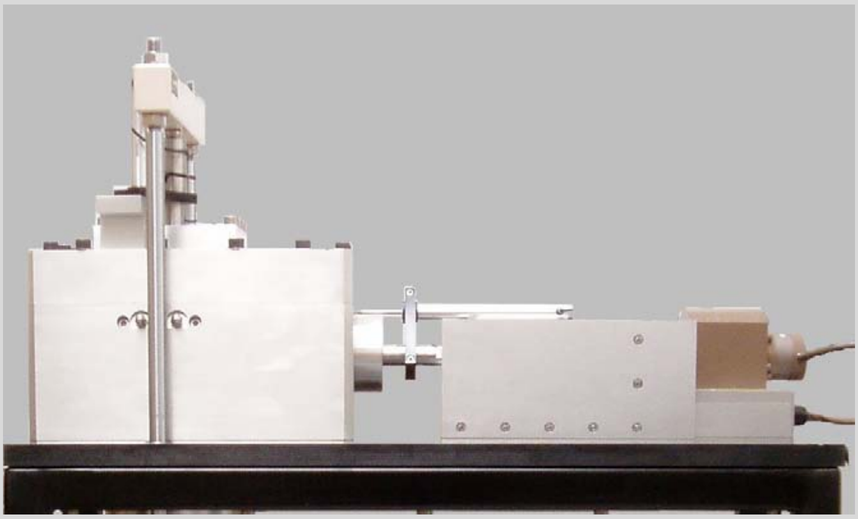
Fig. 3 GDSLAB object display showing a DYNTTS setup

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

BPS features:

- *Fully supported by GDSLAB* ✓
- *1MPa pore air pressure* ✓
- *1MPa back pressure (water)* ✓
- *5kN shear load* ✓
- *5kN axial (normal) load* ✓
- *Internal shear and axial loadcells* ✓
- *Maximum pressures and loads may be custom specified* ✓
- *Optional bender elements* ✓
- *Optional high air entry porous disk in base pedestal. Standard ranges:*
- *300, 500 or 1500kPa* ✓

Saturated/Unsaturated Back Pressured Shearbox (GDSBPS)



What is it?

The GDS Back Pressured Shearbox (GDSBPS) is used for direct shear testing on soil specimens with varying degrees of saturation by controlling the pore water and pore air pressures of the specimen. The GDSBPS is based on a standard direct shear device, modified to allow the measurement and control of matric suction (the difference between the pore air and water pressures). The complete system runs using GDSLAB control and data acquisition software. This allows standard direct shear tests to be carried out as well as advanced unsaturated tests under computer control. Control parameters include:

- Shear force and displacement
- Effective stress control
- Total stress control
- Pore air and water pressures
- Axial (normal) force and displacement (with optional axial actuator)

Features

- Low-cost version uses hanging weights for axial load
- Internal loadcells for both shear and normal force
- Closed-loop control of shear force/displacement and normal force/displacement (if axial actuator upgrade is ordered)
- Shear gap manually adjustable from outside the pressure vessel whilst under pressure
- Rigid aluminium cell body to reduce system compliance
- Optional bender elements

Control of matric suction

Matric suction is applied to the soil specimen by maintaining air pressure in the air pressure chamber and a water pressure below the high-air-entry porous disk (unsaturated version only). The measurement and control of matric suction during shearing is critical for simulating the behavior of partially saturated soils. As such the GDSBPS provides a realistic model of many real-world geotechnical problems, such as slope stability in semi-saturated conditions.

Technical specification

- **Overall dimensions:** L= 875mm x W = 350mm
- **Standard specimen size =** 75mm x 75mm (alternative sizes available on request)
- **Displacement range:** axial = +/- 15mm, shear = +/- 25mm
- **Displacement accuracy =** <0.1% FSO
- **Displacement resolution of measurement =** 16 bit with optional external transducers (± 25mm = ± 0.7µm(shear), ±10mm = ±0.3µm (axial))
- **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 (control) =** 1.25N for 5kN load cell
- **Force resolution (measurement) =** 0.5N for 5kN load cell
- **Data acquisition =** 8 channel, 16 bit with, serial interface and 8 user definable gain ranges from 10mV to 10V input.
- **Control modules =** closed-loop control feedback system integrated with each independent actuator control unit (shear and axial).
- **Electrical specification =** 240V or 110V 50/60Hz single phase

System overview

The standard GDSBPS apparatus uses a standard 75mm x 75mm square test specimen, although alternative sizes are available on request. The sample is placed into the shearbox sample chamber, as is usual for a shearbox. The chamber is then placed into the pressure vessel and connected to the shear actuator and the shear loadcell (see Fig. 1). The top of the pressure vessel is closed and the back pressures can be applied. A GDS pressure controller is used to apply the water back pressure through a high air entry porous stone set in the base of the shear box (HAEPD in unsaturated version only). This controller also records measurement of pore water volume change. A GDS pneumatic controller is used to apply pore air pressure, where air volume change is measured using the new GDS High Accuracy Volume Change Device (HAVCD) - please see the separate datasheet for this device. Consolidation is carried out using either the manual weight hanger or the optional feedback controlled actuator. Once the specimen is consolidated and the required degree of saturation is achieved, the shearing stage can begin. All of the system and tests are controlled by GDSLAB software.

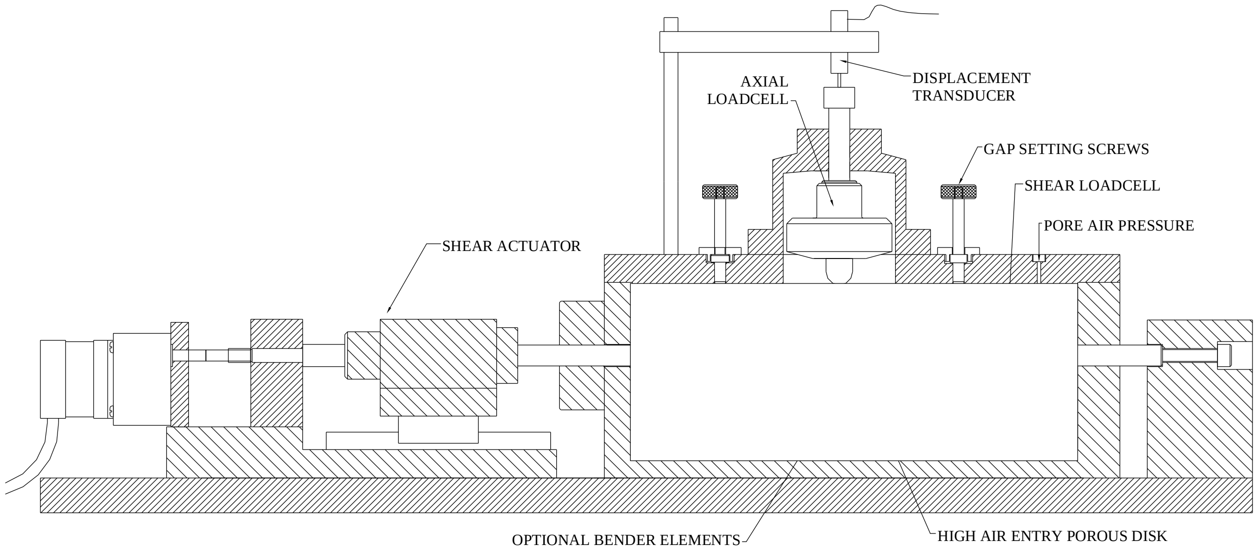


Fig. 1 Schematic of the GDS Back Pressured Shearbox (BPS) with full unsaturated options

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:

- direct shear (with or without back pressure)
- 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' (see Fig. 2). This makes setting up the devices and checking the connectivity extremely simple.

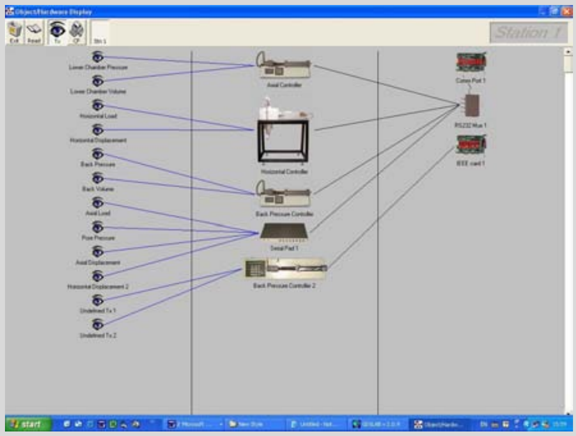


Fig. 2 GDSLAB object display showing a GDS BPS

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

Further options

The GDSBPS apparatus can be specified with many different options, some are listed below but many more are available. Please contact GDS if the required specification is not listed here or if higher pressures / forces are required.

- **maximum back pressure:**
  - 1MPa basic
  - option to 10MPa as part of standard range
- **maximum axial and shear load:**
  - 5kN basic
  - options to 100kN as part of standard range
- **normal (axial) load upgrade to electro mechanical actuator**
- **bender elements**

High-air-entry porous disk

When testing unsaturated soils it is necessary to separate the pore-air and the pore-water so that differential pressures (known as matric suctions) can be maintained. This separation is achieved by the use of high-air-entry porous discs (HAEPD).

When a HAEPD is properly saturated it has the ability to maintain an air pressure on one side higher than the water pressure on the other side, without the air passing through the material. The maximum difference that can be held between these pressures is known as the 'air-entry value'. In a GDS system, the HAEPD is bonded into the base pedestal (see Fig. 3). Other 'special' pedestals are available such as a HAEPD bonded into a bender element pedestal (see Fig. 4).

Fig. 3 HAEPD bonded into a standard triaxial pedestal

Fig. 4 HAEPD bonded into a bender element triaxial pedestal

Other shearing systems available from GDS include:

- **saturated back pressured shearbox**
  - **2MPa** back pressure
  - **25kN** axial (normal) force
  - **5kN** shear force
- **high pressure back-pressured shearbox**
  - **10MPa** back pressure
  - **100kN** axial (normal) force
  - **100kN** shear force
- **Dynamic Dyclic Simple Shear (DCSS)**
  - **5** or **10kN** actuators available for axial and shear forces
  - **1MPa** cell pressure
  - **dynamic triaxial upgrade available**

Other unsaturated systems available from GDS Instruments include:

- unsaturated consolidation testing system
- HKUST volume change measurement system
- all GDS triaxial systems can be supplied in unsaturated versions

Why buy GDSBPS?

- Developed in conjunction with the University of Durham, UK (saturated version) and Zhejiang University, China (unsaturated version).
- The GDSBPS is unique to GDS.
- The system can be supplied as a complete, ready-to-test system.
- The GDSBPS is fully integrated into and supported by GDSLAB.
- GDS can customise most products to match the required specification
- Flexible data output which can be imported directly into Microsoft® Excel.
- Each system produced by GDS is tested as a complete system before dispatch to ensure the system is complete and fully functional.
- GDS is an ISO9001:2000 accredited company.

Due to continued development specifications may change without notice

Suitable for ASTM D6528

Test Types:

Dynamic Simple Shear ✓

Dynamic Triaxial ✓

Available Load ranges:

Axial Load: 5kN ✓

Axial Load: 10kN ✓

Shear Load: 5kN ✓

Shear Load: 10kN ✓

Software

Fully automated ✓

Control Parameters:
Axial Load/Displacement
Shear Load/Displacement

Active Height Control ✓

GDS Combined Advanced Dynamic Cyclic Simple Shear (ADVDCSS)

What is it?

The GDS Combined Advanced Dynamic Cyclic Simple Shear (ADVDCSS) testing system is a new innovation by GDS in that it combines Simple shear and Triaxial testing without the use of a separate loadframe. The ADVDCSS uses our established technology of Electro-Mechanical actuators which are designed for long life and highly accurate position control. Unlike pneumatic actuators this type of actuator is even suitable for carrying out small strain testing, long term creep tests and dynamic tests up to 5Hz. The system converts from a simple shear test to triaxial test in about 15 minutes by replacing the cell wall with a shorter one and raising the position of the lower platen using the built in lift system to allow for the shorter sample length of simple shear tests

Features

Axial and shear loads or displacements are provided by proven GDS electro-mechanical force actuators. Axial and shear load readings are controlled under closed-loop feedback.

During shearing the constant axial strain for the specimen is maintained using active height control via the axial force actuator. Topcap fixity is assured through a system of linear guides to minimise topcap rocking during shearing.

During simple shear tests constant volume conditions are ensured in the sample by use of PTFE coated low friction slip rings around the sample. These rings are finely machined for smoothness and flatness to ensure minimum friction. Optionally wire reinforced membranes can be used in the GDS system. Height control of the specimen is active and readings are taken from a very small range LVDT to ensure accurate control of the topcap position.

Triaxial tests such as stress paths, K-zero and permeability can all be carried out in the ADVDCSS subject to the correct test modules being present.

Technical Specifications

- Accurate electro-mechanical actuators
- Available sample sizes (one size supplied with system):
    - Φ50mm x 100mm
    - Φ70 x 140mm
    - Φ100 x 200mm
    - Other sizes available on request
- 8 Channel Dynamic 16 Bit data logger
- Low friction sample slip rings
- High quality, low friction linear guides used to ensure strength and alignment in normal and shear directions.
- Available control parameters:
    - Axial Load / Stress
    - Axial Strain / Displacement
    - Shear Load / Stress
    - Shear Strain
- Available control modes for each control parameter:
    - Ramp (monotonic), Cycle (slow speed) and hold.

Advantages of the GDS ADVDCSS

- The system can carry out Simple Shear and Triaxial testing (a cell shown in Fig. 2)
- The ADVDCSS can saturate Simple shear samples in a similar way to normal triaxial testing, using cell pressure and back pressure. This cannot be achieved in a normal simple shear system
- The ADVDCSS has been designed to be extremely stiff in the axial and shear directions, this leads to very low system compliance.
- Upgrades can be added to allow:
  - Bender element testing
  - Unsaturated Testing
  - Local strain measurement

Fig. 2 Both tests are interchangeable on one carriage

Upgrade to bender element testing

The ADVDCSS system may be upgraded to perform P and S wave bender element testing with the addition of the following items (see Fig. 3):

- Bender element pedestal with *new* inserted element
- Bender element top cap with *new* inserted element
- High-speed data acquisition card

Signal conditioning unit, amplification of source and received signals (P and S wave) with user-controlled gain levels (via software).

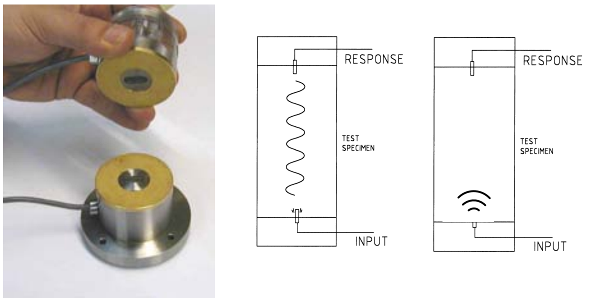


Fig. 3 P and S wave elements

For further information on bender element testing, please refer to the dedicated Bender Element Testing datasheet.

GDSLAB control software

The GDSLAB control and acquisition software from GDS 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 available are as follows:

- Simple Shear
- Dynamic Triaxial
- 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 choice, no matter how unique the arrangement. 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, as in Fig. 4.

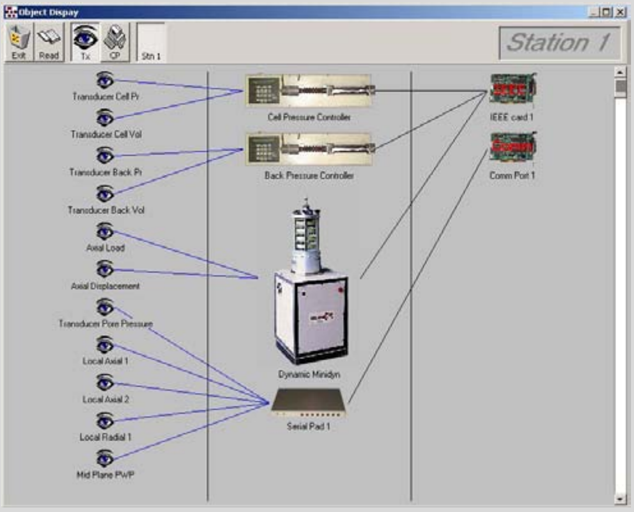


Fig. 4 GDSLAB object display showing a DYNTTS setup

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

International Standards

Compliant ✓

Test Option Modules:

Direct Shear ✓

Advanced Shear ✓

Software:

Fully automated ✓

"Future-proof" ✓

Upgrading:

With PC control ✓

Without PC control ✓

Options:

Complete system ✓

Individual Components ✓

Spot-verification ✓

GDS Automated Direct Shear System (ADS)

What is it?

The GDS Automated Direct Shear (ADS) testing system is a fully computer automated control and acquisition setup for direct and advanced shear tests.
ADS has been designed to comply with international standards of test execution and data presentation. The system is controlled by the user's PC (running Windows) and GDSLAB control and acquisition software.

Features

The system can be supplied complete or alternatively as individual components to upgrade an existing system to computer control. The system has interfaces to transducers and data loggers to give full computer control and data acquisition capability.

With the flexibility of GDS software (GDSLAB) it may be possible to use an existing data logger, even if it is from another manufacturer. Many GDSLAB drivers are available free of charge for existing data acquisition devices currently residing in soil laboratories throughout the world.

The Operator chooses the required type of test from a test menu be it a direct or advanced shear test (see technical specifications below).

The test proceeds automatically with all test data being saved to a file. On-line graphics are presented in Windows with up to three graphs displayed together with a block of current live test data. (Tests can proceed overnight and during weekends and holidays).

To enable spot-verification, all electronic measurements may be duplicated by mechanical gauges. In addition, well defined calibration procedures using Budenberg dead weight tester are used.

The test can run from a dedicated computer to each test station or using multiple stations per computer.

GDSLAB Reports for post-test processing and presentation to National/International Standards can be generated.

Technical Specification

- **Direct Shear Test Module Controls:**
  - Simple rate of displacement (forward and reverse)
  - Continuous reversal cyclic displacement (constant velocity)
- **Advanced Shear Test Module Controls**:
  - Shear Load
  - Shear Stress
  - Displacement
- **Available control modes for each control parameter**:
  - Constant, Ramp and Cyclic*.
    *available Cyclic waveforms: triangular and sinusoidal
- **Transducer resolution** = 16 bit
- **Computer automated control of testing** – not just data logging
- **MS Windows Windows® software (GDSLAB)** for test control and post test processing

Upgrading machines <u>WITH</u> PC control

If your shear box machine has inbuilt computer control via an RS232 port (for example), then it is extremely simple to 'plug-and-play' for control and acquisition by connecting the shear machine either directly to the COM port of the PC, or through a serial mux. Attach your data acquisition device with a displacement transducer, and strain control is available. Attach your data acquisition device with a load cell, and load or stress control is available.

The system elements are shown in Fig. 1

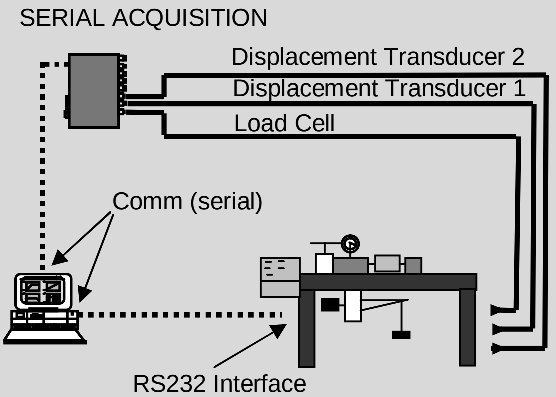


Fig. 1 System Schematic (with RS232 interface).

Upgrading machines <u>WITHOUT</u> PC control

If your shear box machine does not have inbuilt computer control via an RS232 port, then it may still possible to have complete PC control. Many direct shear or simple shear machines have manual control of start, stop and direction. The velocity is set via the machine's gears. In this type of machine we can provide our "GDS DIO control box". This box can be wired into your system, allowing the PC to then control the start, stop and direction (Fig. 2). With this box in place you can turn an existing 'manual' machine into a complete PC controlled system with the ability to:

- run tests up to particular strains set by the user
- continuous reversal for residual strength tests
- user safety limits (on load for example) to protect equipment or specimens

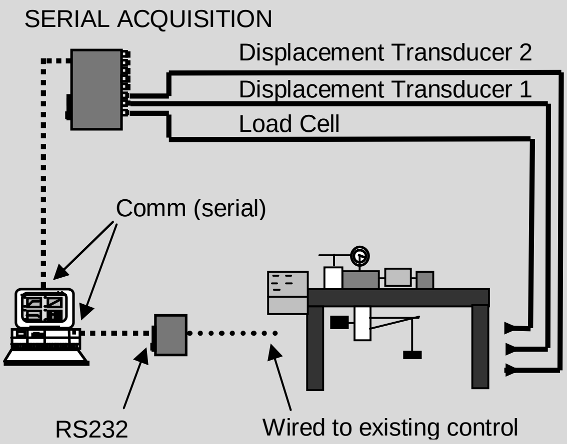


Fig. 2 System Schematic (without RS232 interface).

GDSLAB control software

Additional transducers may be easily configured at any time due to the flexible nature of the GDSLAB software. Spare channels may also be configured for use with an adjacent system, therefore enabling computer control and acquisition from multiple systems simultaneously from the same PC. This makes the system "future proof", as the software is expandable to include additional transducers, hardware or complete systems. GDSLAB has the ability to be configured to your hardware choice, no matter how unique the arrangement.

The GDSLAB control and acquisition software from GDS 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 available are as follows:

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

Depending on the module, 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, as in Fig. 3.

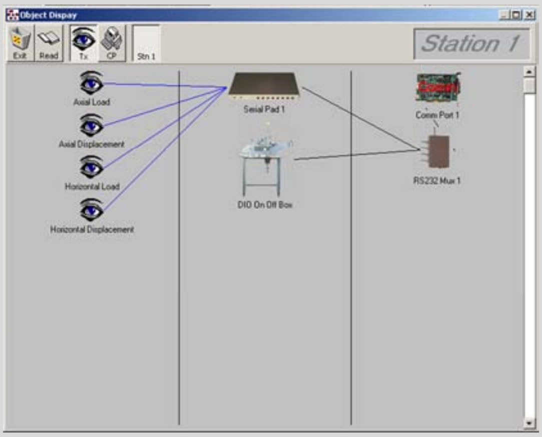


Fig. 3 GDSLAB object display

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

The CSWS provides:

- *Automated, computer-controlled test procedures* ✓
- *Easy-to-use, MS Windows®-based user interface* ✓
- **Cost-effective compared with alternative methods** ✓
- *Easy to use:* ✓
  - *set up in 5 minutes*
  - *portable equipment*
  - *non-invasive testing*
  - *USB port for data downloads*
- *Stiffness v depth available immediately in field* ✓
- *Time domain output* ✓
- *On-line Fast Fourier Transform (FFT)* ✓

Continuous Surface Wave System (CSWS)

What is it?

The Continuous Surface Wave System (CSWS) enables a shear stiffness-depth profile to be determined to depths between 10m (in clays) and 30m (in some granular soils and weak rocks) without the need to provide a borehole. It provides on-line data processing such that the stiffness-depth profile may be viewed as the test is in progress. This allows the operator to assess the quality of the data before moving to another location. These profiles enable geotechnical engineering predictions of surface settlement.

Recent developments in laboratory small strain stiffness measurements and the use of non-linear finite element analysis have closed the (perceived) gap between static and dynamic measurements of stiffness. Thus, stiffness parameters, determined from seismic velocity measurements, can be used in geotechnical design. Traditionally, geophysics has been used only as an indirect means of targeting and dimensioning sub-surface features. This application has its origins in oil and mineral exploration.

The CSWS is set up on the ground surface and propagates Rayleigh waves which are constrained within a zone which is, approximately, one wavelength in depth. In ground where the stiffness changes with depth, these elastic waves are dispersive in nature, which means that they travel at a velocity which is dependent upon frequency and wavelength.

The CSWS uses a frequency controlled vibrator to regulate the frequency of these surface waves, thus permitting a dispersion curve (velocity against frequency or wavelength) to be readily determined (see Fig. 1). By using the theory of elasticity, shear wave velocity and shear modulus G can be determined from these velocity measurements.

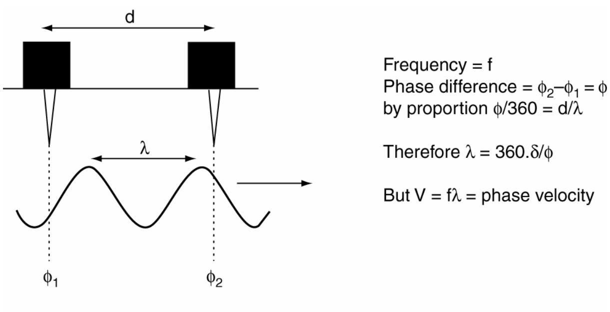


Fig. 1 By knowing the frequency, f, and the change in phase with distance from the vibrator, the phase velocity of the ground Rayleigh waves can be determined

Technical specification

- **Display**: 12.1" colour TFT touch screen
- **Resolution of measurement**: 16 bit data capture
- **Frequency of measurement**: up to 200,000 samples per second
- **Sensor number:** standard system for 2-6 geophones, upgradeable to a maximum of 12
- **Size of control unit**: 450mm x 350mm x 180mm
- **Weight of control unit**: 12kg
- **Power**: 92-265V AC, 48-440Hz, 65w maximum, single phase three wire earthed supply, 2A fuse x 2
- **Size of ground vibrator**: 450mm x 350mm x 180mm
- **Weight of ground vibrator**: 70kg (489N force)
- **Can be used as a Spectral Analysis of Surface Waves (SASW) test system using an impact source**

System set-up

The set-up is shown in Figs 2 and 3. A computer-controlled inertial vibrator applies a precisely regulated and measured continuous vertically polarized disturbance to the ground surface. This generates surface waves which are detected by a line of sensors (geophones) which are co-linear with the vibrator. The signals from the sensors are fed back to the computer which analyses the phase relationships between them and so computes the velocity of the surface wave. By changing the frequency of the continuous wave generated by the vibrator, velocity measurements can be made over a range of depths. The measured dispersion curve is inverted to produce a profile of surface wave velocity with depth. By entering the bulk density and its Poisson's ratio of the soil/rock, this profile is converted to that of shear modulus with depth. These parameters may be estimated on site with minimal errors in stiffness.

The plot of shear stiffness against depth may be viewed after each stiffness measurement is made. Typically a shear stiffness-depth profile will contain between 50 and 100 separate stiffness measurements at different depths. By using smaller frequency increments, even more stiffness measurements may be made. A typical profile will take about 45 minutes to produce. If the cost of each individual stiffness measurement is considered, the surface wave system works out cheaper than other direct methods of measurement such as the pressuremeter and the plate loading test.

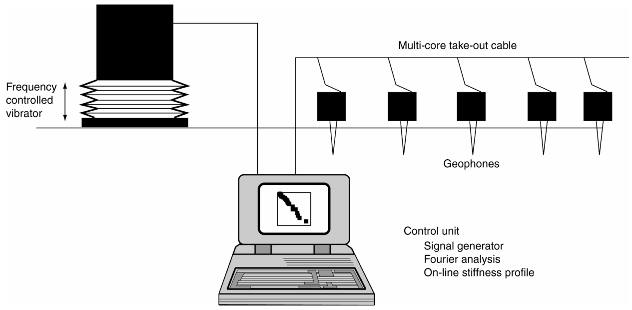
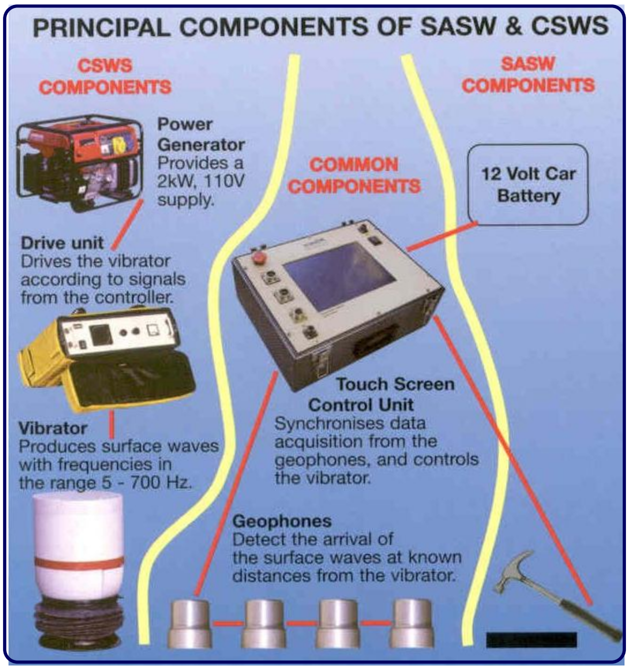


Fig 2. Diagrammatic layout of the CSWS

Fig 3. Photograph showing a six-geophone layout on one of our test sites



System features

- Provides on-line shear modulus with depth profile to depths of up to 30m depending on the type of soil or weak rock
- Enables rapid assessment of ground variability across a site in terms of stiffness
- Provides stiffness parameters for ground that is difficult or impossible to sample in a representative manner, eg granular soils and highly fractured rock
- Provides between 50 and 100 (or more) stiffness measurements per location
- Can be operated by two people in the field
- Enables predictions of settlement
- Verifies soil improvement, eg from dynamic compaction, vibrofloatation and classic consolidation
- Enables the measurement of Gmax which can provide a valuable benchmark for stiffness investigations in soils

Why buy CSWS?

- Automated test software - the user enters the required test frequencies and the software runs the complete test automatically.
- User friendly, easy-to-use software interface.
- Flexible data output which can be imported directly into Microsoft® Excel.
- Data output includes time domain, frequency domain (magnitude and phase), coherence and stiffness v depth using the Lambda/3 method.
- Future upgrade possibilities to CSWS system (with ground vibrator).

Due to continued development, specifications may change without notice.

The SASW system provides:

- *Cost-effective compared with alternative methods* ✓
- *Easy to use:*
  - set up in 5 minutes
  - user-friendly software
  - portable equipment
  - non-invasive testing ✓
- *USB connection to users Laptop for control and acquisition of data* ✓
- *Stiffness v depth available immediately in field* ✓
- *Time domain output* ✓
- *On-line Fast Fourier Transform (FFT)* ✓

Spectral Analysis of Surface Waves (SASW)

What is it?

The Spectral Analysis of Surface Waves (SASW) system provides compact, lightweight and easy-to-use equipment for the analysis of surface waves. It allows fast, non-invasive testing for all soil types, including residual soils and fractured soft rock. Typically used in site investigations for foundation engineering design and settlement prediction, SASW is also suited for the rapid sub-grade evaluation for roads, tracks and runways.

The system performs an on-line Fast Fourier Transform (FFT) on the acquired data with automatic stacking and trigger arming allowing for as many as 15 separate records per minute to be acquired for a single test.The stacked data can be manually or automatically 'picked' to create an on-line stiffness v depth plot.

The GDS SASW system uses impulse or transient energy sources to measure the seismic wave velocity. A variety of energy sources may be used, for example.

- Hammers or drop weights using the accurate remote triggering facility.
- Non-user controlled energy sources (eg dynamic compaction rig) may be triggered manually from the control unit.

The GDS SASW system is based on the GDS Surface Wave Control Unit which is also configured for use as the main control unit for the GDS Continuous Surface Wave System (CSWS). The CSWS uses a vibrating energy source run at single frequencies under the control of the unit.

New for version III

- Simultaneous sampling of all channels
- Designed to be more ruggedised/robust
- Smaller and lighter (version III weighs only 5.5kg).
- Greater power efficiency therefore a smaller battery required

Technical specification

- **Resolution of measurement**: 16 bit data capture
- **Frequency of measurement**: Hardware capable of up to 225,000 samples per channel per second
- **Connection**: USB connection to users laptop for control and acquisition
- **Sensor number:** Standard system for 2-6 geophones, upgradeable to a maximum of 12
- **Sampling type:** Each channel sampled simultaneously *(NEW feature for version III)*
- **Size of control unit**: 400mmx380mmx150mm (Nominal size including outer padded bag)
- **Weight of control unit**: 5.5kg (approximate weight)
- **Power**: 12-24V DC
- **Runs continuously for up to 8 hours with user supplied 12V battery**
- **Padded transport case with built in laptop weather hood**
- **Integral geophone amplification and signal conditioning**
- **Upgradeable to full continuous surface wave system (CSWS) with the addition of a ground vibrator and power drive amplifier**

SASW control software

- Remote (hardware) or local (software) triggering capabilities:
  - hardware triggering via switch contact on source of impulse (e.g. hammer)
  - manual triggering through software, i.e. the system can be triggered by the user touching the trigger button on screen.
  - time domain stacking or frequency domain stacking with automatic trigger re-arm
- On-line coherence calculation
- Instantaneous Fast Fourier Transform (FFT) after each data acquisition set
- Extremely simple 'wizard style' graphical user interface for test setup (see screen shots in Fig. 1)

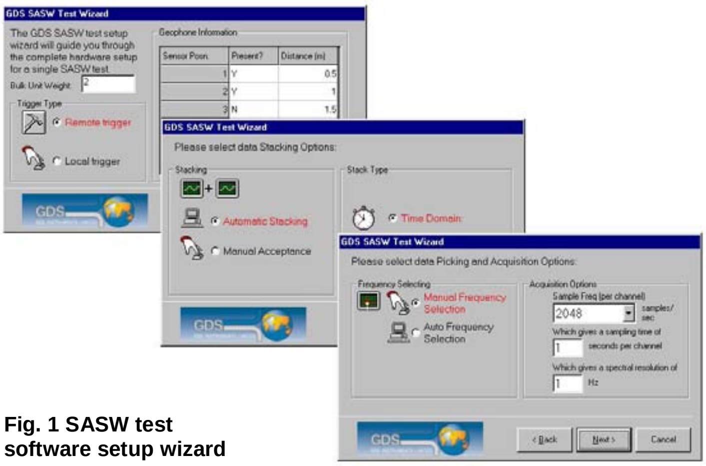


Fig. 1 SASW test software setup wizard

On-line test data stacking options

Time domain stacking. This means that multiple records can be added together in the time domain. This gives averaging of repeated pulses and effectively reduces random noise. This technique should only be used with automatic triggering.

Frequency domain stacking. Each set of time domain data is converted to frequency domain by means of the on-board FFT conversion. This data can then be averaged over a number of pulses to give signal enhancement.

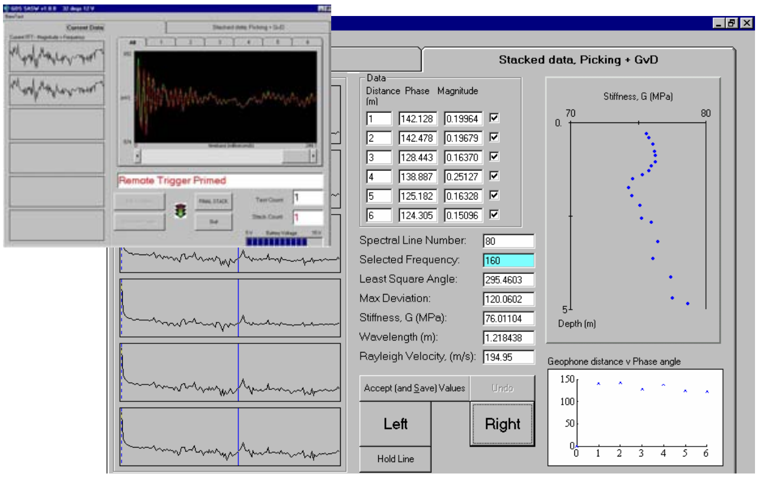


Fig. 2 Example of stacked data/final results screen

SASW portability

SASW system elements

1) Surface Wave System Control unit with padded transport case

2) Geophone Cable

3) 4.5 Hz Geophones or 2 Hz Geophones

4) Hammer and strike plate

5) Laptop controlling PC

Why buy GDS SASW?

- User friendly, easy-to-use software interface.
- Flexible data output which can be imported directly into Microsoft® Excel.
- Data output includes full time domain history, frequency domain (magnitude and phase), coherence and stiffness v depth using the Lambda/3 method.
- Easy upgrade path to CSWS system with addition of ground vibrator and CSWS software.

Due to continued development, specifications may change without notice.