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	✓

Radial Stress (Cell Pressure)

200/100/60mm = 2MPa
400/200/160mm = 1MPa

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).

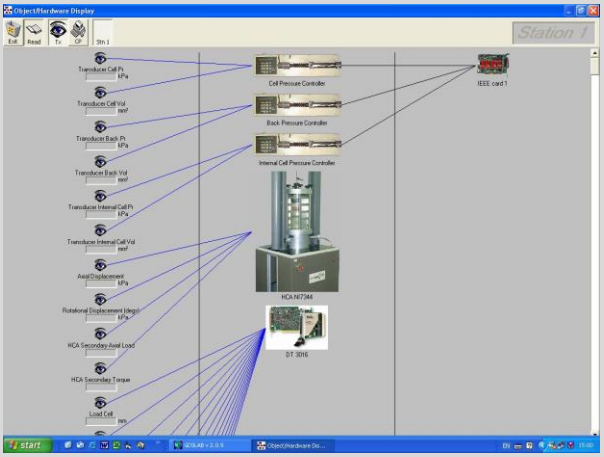


Fig. 1 Object display showing a GDS SS-HCA arrangement

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)

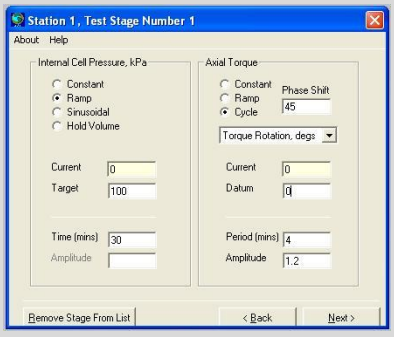


Fig. 2 HCA static test setup module

SS-HCA d (Dynamic version)

The 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 Digital Control System (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.

Adaptive Control Firmware – As Standard on Dynamic HCA

Adaptive Control

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

The GDS Adaptive Control firmware algorithm automatically adjusts the control gain values based on the observed specimen stiffness, removing the need for the user to enter a specimen stiffness value prior to the test. This has the additional advantage of ensuring specimen stiffness changes during a test are also dealt with correctly. An example of this is observed during liquefaction testing, in which the specimen stiffness reduces considerably as the soil liquefies. When testing using an apparatus running GDS Adaptive Control, the firmware automatically optimises the control gains' values based on variations in soil stiffness as a cyclic test stage progresses, enabling a consistent loading amplitude to be applied to the test specimen.

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.

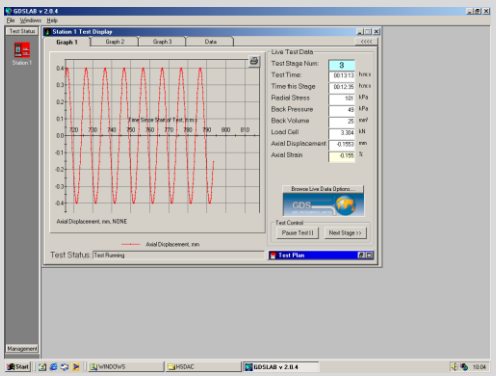


Fig. 3 GDSLAB test display showing dynamic cyclic test in progress

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).

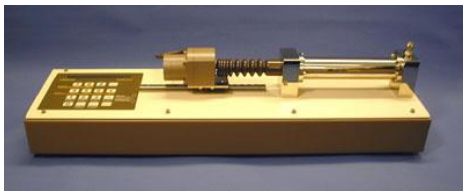


Fig. 5 The ADVDPC

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).

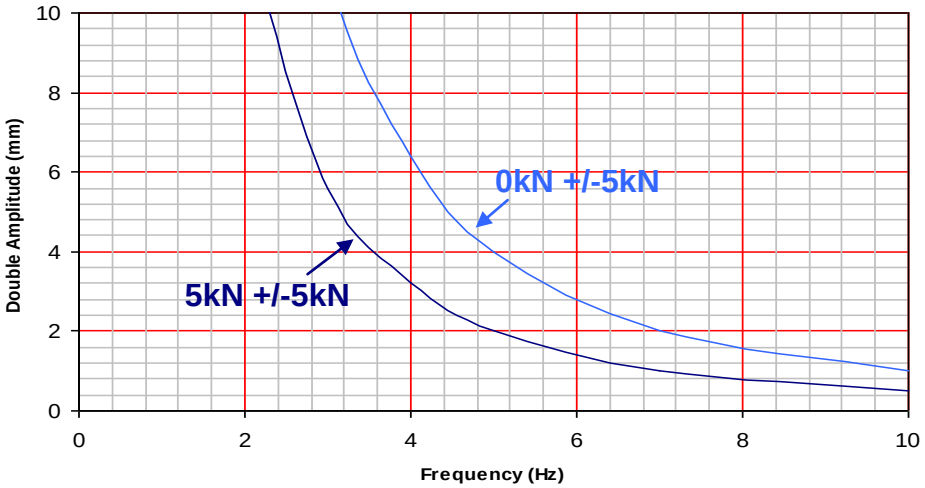
The manual soil lathe is suitable for all available sample sizes up to 400/200/160. The correct platens then need to be fixed to the lathe in order to prepare the required sample size. Platens for specific sample sizes are purchased separately to the lathe.

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.

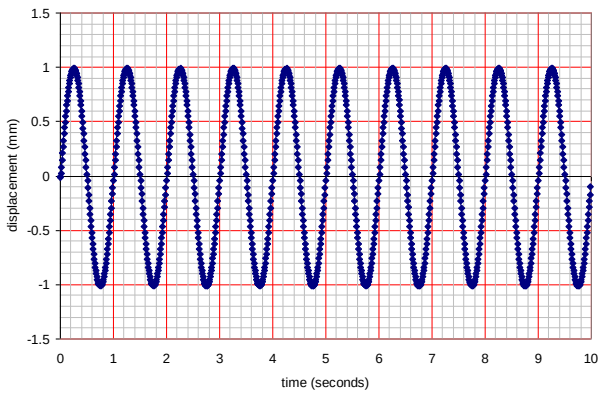
SS-HCA d, Example dynamic system performance for axial axis based on a 5Hz machine. Note: performance will vary for machines other than 5Hz.

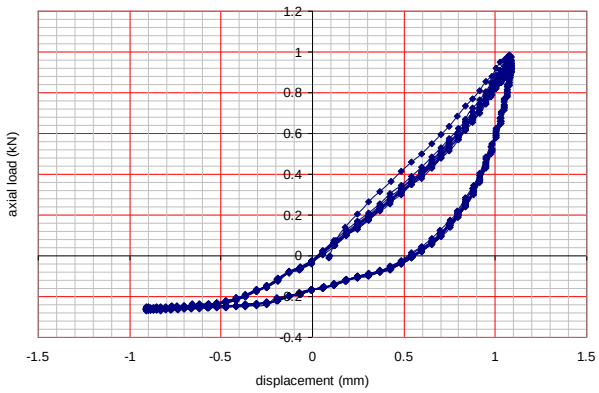


Frequency (Hz)	with 5kN force datum		with zero kN force datum	
	Amplitude (mm)	Double amplitude (mm)	Amplitude (mm)	Double amplitude (mm)
0.1	50	100	50	100
0.2	50	100	50	100
0.5	26.5	53	26.5	53
1	13.3	26.6	13.3	26.6
2	6	12	6	12
3	2.8	5.6	4.4	8.8
4	1.6	3.2	3.2	6.4
5	1	2	2	4
7	0.5	1	1	2
10	0.25	0.5	0.5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

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.