110 GDS Helpsheet

World Leaders in Computer Controlled Testing Systems for Geotechnical Engineers and Geologists

Hardware
Triaxial Testing Systems
Advanced and Standard products explained and compared

1. History

GDS Instruments Ltd. was formed in 1978 by Dr Bruce Menzies a researcher at the University of Surrey, UK. The aim of the company was to take the technologies enabled by the emerging microcomputer and to apply these to the development of a range of intelligent soil and rock testing systems. The most well known of these systems are the GDS advanced (ADV) intelligent pressure/volume controller and the computer controlled stress path system. These original systems were designed without compromise to satisfy the requirements of advanced research in both soil and rock mechanics.

In 1994 it became clear that the computer controlled technology developed by GDS was now required at all levels of soil/rock testing from production based commercial testing to the most advanced research. We therefore developed a new range of pressure controllers, the Standard (STD) range, to enable us to meet the price expectations of this enlarged marketplace. The STD controller was designed to a price and therefore could not be expected to have the uncompromising performance of the advanced controller. For a detailed comparison of the two ranges of controller please see our helpsheet No. 60 "Advanced and Standard Controllers - Comparison".

Following the development of the STD controller we enhanced our range of products by including a range of industry standard products (test cells and loading frames) and system engineering these products to be compatible with the GDS Systems and software. This allows us to provide complete automated soil and rock testing solutions to the industry at prices suited to the application.

For the start of the new millennium we have developed a new general purpose software (GDSLAB) which allows us to support all GDS hardware, and other manufacturer's hardware, on a common software base. GDSLAB offers a range of capabilities from simple data acquisition through to complex test control using the hardware of your choice. This means that the quality of test control and test parameter measurement and therefore the quality of results, depends on the quality of hardware only.

The different ranges of GDS hardware are described more fully below. Some example system comparisons are also shown.

2. The Advanced (ADV) Range of GDS Soil and Rock Testing Equipment

The advanced range of products includes actuators (pressure, volume, force, displacement), data acquisition and communications and test cells. All of these devices are designed and manufactured by GDS to a set of uncompromising standards to ensure the products are fit for use in all soil and rock mechanics up to the highest level of research

Advanced Actuators

All of these actuators feature control and measurement of at least two parameters (either pressure/volume or force/displacement) and for those pressure controllers equipped with remote feedback capability (RFM) a third parameter may also be controlled and measured. All of these actuators are designed for high accuracy long-term use (given a stable power supply) and in fact there have been some tests done of over six months duration.

Pressure/Volume Controllers

- ADV pressure/volume controllers 200 cc / 1,2,3,4,5 MPa
- ADV pressure/volume controllers 1000 cc /1,2 MPa
- ADV air pressure/volume controller 1000 cc / 1,2 MPa
- ADV high pressure/volume controllers 200 cc / 8,16,32,64,128,150 MPa

Force/Displacement Actuators

- 7 kN / 50 mm quasi static actuator with in-built advanced triaxial cell for 38/50 mm test specimens.
- 40 kN / 100 mm quasi-static actuator with in-built triaxial cell for 38/50/70/100 mm test specimens.
- 10, 16, 40 kN / 100 mm 2 Hz dynamic actuator with in-built triaxial cell for 38/50/70/100 mm test specimens.
- 20 kN / 50 mm 10 Hz dynamic actuator with in-built triaxial cell for 38/50/70/100 mm test specimens.
- 10 kN / 100 mm, 100 Nm / 120 degrees 2 Hz dynamic Hollow Cylinder actuator with in-built cell for 100 / 60 mm hollow cylinder test specimens and 38/50/70/100 mm solid cylinder triaxial test specimens.
- General purpose force actuator 5, 10, 25, 50 kN / 100 mm available for customer to build into apparatus.
- VIS calibrated loading frames with 100 mm displacement and maximum forces in the ranges 100, 250, 500, 750 kN. These loading frames have 0.1 mm resolution of displacement.

Test Cells

These advanced triaxial cells are designed for high pressure use with hard soils and rocks. Typically they allow application of back pressure and measurement of pore pressure and volume change and in many cases there is provision of internal transducers as well.

- High pressure hydraulically actuated triaxial cell 10 MPa confining pressure, 120 kN axial force 25 mm displacement for test specimens from 38 mm to 55 mm. This cell features internal load cell and internal displacement transducer.
- High pressure instrumented triaxial cell for use with traditional loading frame. 20 MPa confining pressure, 120 kN axial force 25 mm displacement for test specimens from 38 mm to 76 mm. This cell features internal load cell and internal local strain (LVDT) transducers (two axial, one radial).
- Very high pressure triaxial cell for use with traditional loading frame. Up to 150 MPa confining pressure, 250 kN axial force, 25 mm displacement for test specimens from 38 mm to 55 mm.

Data Acquisition and Communications

- 8 channel 16 bit data acquisition system with RS232 interface

- 16 channel 16 bit data acquisition system with IEE 488 and RS232 interfaces, also includes four channels of digital indicator input.
- 4 channel digital indicator input multiplexor
- 4 channel RS232 multiplexor to interface up to four RS232 devices to COM 1 or COM2

A typical advanced triaxial testing system (ADVTTS) will use components from the above range, normally a triaxial cell/ actuator and two or three advanced controllers of the appropriate pressure range.

3. The Standard Range of GDS Soil Testing Equipment

Products given the name Standard are based on the use of the standard pressure/volume controller in place of the advanced pressure/volume controller. The standard pressure/volume controller has a single capacity of 200 cc and can have maximum pressures in the range 1, 2, 3, 4 MPa.

Traditionally there are two systems considered as STD systems by GDS these are:

- STDTTS, a triaxial testing system based on the Bishop and Wesley hydraulic triaxial stress path cell with internal load cell and using three STD pressure controllers for control of axial stress, radial stress and back pressure.
- GDSTAS or Triaxial Automated System, a system based on the use of industry standard 50 kN loading frames and using traditional triaxial cells with external load cells. The system uses two STD pressure controllers for control of radial stress and back pressure.

4. Industry Standard Range of Components

Some of the components used in our STD range of systems are not designed and manufactured by GDS but are industry standard components which are bought in by GDS and systems engineered into our products and systems. These include the following components:

- 10 kN and 50 kN loading frames
- Traditional triaxial cells
- Bishop & Wesley hydraulic stress path cell
- Some transducers and small components

5. Comparison between Advanced and Standard Soil Testing Systems

Many systems with different specifications can be built using the GDS testing components. One of the main differences is the range of controllers being used. A comparison of the ADV and STD controllers can be found in helpsheet No. 60 "Advanced and Standard Controllers - Comparison". Table 1, below, shows a general comparison between ADV and STD systems designed for testing soils up to 1700 kPa confining pressure.

Feature	STD systems	ADV systems
Accuracy (pressure and volume)	Better than 0.25%	Better than 0.1%

Axial load range	0.7 ton (B&W stress path cell), 1, 3 and 5 ton (Load Frame)	0.7 ton (B&W stress path cell, GDS motorised cell), 4 ton (GDS)
Size of test specimen	38, 50, 70 and 100 mm by different cells	38, 50, 70 and 100 mm by different pedestals and top caps in the one cell
Pressure/volume controllers	Standard	Advanced
Transducer access	Transducer access ring extra	Transducer access ports included. Access ring extra with B&W cell
Static or dynamic	Static only	Static and dynamic options available
Cell pressure range	1700 kPa	1700 kPa

Table 1. Standard (STD) and Advanced (ADV) soil testing systems compared

Of the standard systems the STDTTS and GDSTAS systems use different approaches. With STDTTS the B&W hydraulic triaxial cell is used with three STD pressure/volume controllers. For GDSTAS a traditional loading frame and triaxial cell is used with two STD pressure/volume controllers. The different specifications of these two systems are summarised in table 2, below.

Feature	STDTTS	GDSTAS
Size of test specimen	38 mm and 50 mm only in the one (B&W stress path) cell	38, 50, 70, 76, 100 mm by different triaxial cells
Axial load range	7 kN but reduced by cell pressure	1, 5 and 10 ton by separate loading frames
Axial displacement range	In theory 50 mm but in practice about 40 mm	100 mm
Cell type	Special hydraulic (stress path) cell using Bellofram Rolling Diaphragm seals – no loading frame	Conventional cell using loading frame
Software	GDSLAB	GDSLAB
Cell pressure	STD pressure/volume controller	STD pressure/volume controller
Back pressure	STD pressure/volume controller	STD pressure/volume controller
Axial actuator	STD pressure/volume controller	Axial loading frame
Transducers	Axial force(internal), axial displacement, pore pressure	Axial force(normally external for convenience), axial displacement, pore pressure
Additional transducers	Via transducer access ring at extra cost	Via transducer access ring at extra cost

Table 2. STDTTS and GDSTAS compared

6. The impact of GDSLAB

In systems prior to January 2000 the GDS soil testing systems were differentiated by both hardware range (STD, ADV) and also by the software. ADVTTS and its derivatives is a software package that uses the advanced range of controllers with IEEE-488 communications interfaces and runs in an HTBASIC (DOS) environment. STDTTS and GDSTAS are written in Visual Basic

(VB) for Windows 3.1/95/98 environments and use STD controllers with RS232 communications interfaces.

From the start of 2000 all GDS systems are being transferred to the GDSLAB software environment in Windows 95/98/NT. This is a large undertaking. At the current time (April 2000) all systems based on the ADV and STD controllers using either a traditional loading frame or the B&W cell are supported by GDSLAB. By June 2000 all GDS quasi static systems will be supported by GDSLAB. By the end of 2000 all static and dynamic systems with the exception of the Hollow Cylinder Apparatus will be supported by GDSLAB.

For some advanced systems sold within the year 2000 you may be supplied with the HTBASIC version of ADVTTS, this will be replaced by a free of charge upgrade to GDSLAB as soon as it is available.

7. Choice of System

The choice of system is a compromise between price and performance. The information we have provided above will go some way to helping you with that choice.

Although we have indicated that generally an ADV system should be used for the highest quality research testing this is not exclusively true because the quality of your transducers and data acquisition can make up for the level of control provided by the actuators.

For example if you are using a B&W cell with local strain measurement and an internal load cell but using STD pressure controllers for pressure/volume change, you can achieve high quality results with the only compromises being slightly reduced accuracy of control of cell pressure and back pressure and the measurement of volume change. This approach is also good for the advanced tests of stress path, cyclic and K-zero.

At a different level if you are using a traditional velocity controlled loading frame with STD controllers you may get research quality results for simple monotonic loading tests (provided you have high quality transducers and data acquisition) but for the advanced tests of stress path, cyclic and K-zero the velocity controlled loading frame does not offer sufficient control of position to give high quality research results, however this arrangement is quite suitable for general commercial testing.

As a general rule, where high quality results are desired you need four things

- High quality data acquisition
- High quality transducers
- High quality control (as offered by the GDS ADV actuators and controllers)
- High quality reliable software

A total GDS ADV solution provides all of these requirements. In some cases, however, you can rely on high quality transducers to improve measurements made by the STD range of controllers and therefore in these cases you can substitute an STD controller for and ADV pressure/volume controller.

8. Summary

Generally, STD systems are suited to:

- commercial testing,
- production testing,
- under-graduate and post-graduate teaching,
- undergraduate and Masters students projects.

ADV systems, on the other hand, are suited to all forms of testing, including research at doctorate and post-doctoral level.

Generally, ADV controllers cost GDS about twice as much to manufacture as STD products. The price to the end-user is consequently in the same proportion.

These price differences between STD and ADV controllers arise from considerations of:

- accuracy (e.g. 0.25% compared with 0.1%),
- resolution,
- capability (e.g. ADV can be dynamic, high load/pressure, used in unsaturated testing, etc.),
- quality of materials, machining and components used in manufacture.

The new software (GDSLAB) is common to both STD and ADV hardware systems (but of course there are no dynamic or high pressure hardware components for STD systems). This means that the quality of test control and test parameter measurement and therefore the quality of results, depends on the quality of hardware only.

STD and ADV products can be mixed to achieve certain test goals e.g. an STD system plus an ADV air pressure controller (1000 cc) can be combined for unsaturated testing.

STD cells and loading frames are industry standard devices system engineered by GDS. ADV cells and loading means are of GDS design and manufacture. Some ADV cell components, however (e.g. chambers), are industry standard products system engineered by GDS to fit into the ADV systems.