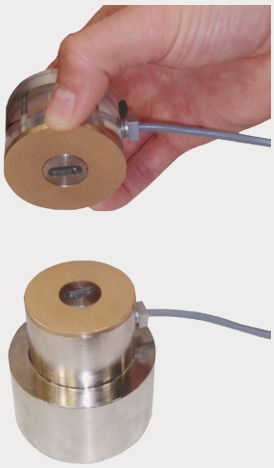


Bender Element System (BES)

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.

Key Features:	Benefits to the User:
USB interface:	Allows the system to be swapped to any PC in the lab with a USB interface.
Titanium element inserts:	Reduces the weight of the top-cap.
Utilising existing products:	Pedestals and top-caps can be made for other manufacturers' cells as well as GDS cells, so upgrading is potentially simple.
The GDS Bender elements are bonded into a standard insert:	This 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 for the complete insert to be replaced by the customer
2 Mega Samples/Second, 16bit Data Acquisition:	High speed data acquisition is essential as the sample interval provides the resolution for determining wave speeds.
Elements are manufactured to allow S and P wave testing to be performed:	Determining both S & P wave velocities allows additional specimen parameters to be calculated, such as Youngs Molulus, E.
Vertical and horizontal elements are available:	Specimen anisotropy can be studied with the use of both vertical and horizontal elements on the sample.

Tests that can be Performed:

Determination of Shear Wave Velocity, determination of P-Wave Velocity, vertically propogating horizontally polarised (vertical elements), horizontally propogating horizontally polarised (horizontal elements), horizontally propogating vertically polarised (horizontal elements).

Upgrade Options:

- Combined pedestals for unsaturated testing and bender elements (ie with bonded high air entry porous disc).

Technical Specification:

Data acquisition speed:	2,000,000 samples/second, simultaneous sampling of both source and received signals.
Resolution of data acquisition (bits):	16
Operating Pressure Range:	Up to 3.5MPa. Above 3.5MPa Acoustic Velocity transducers are required for P&S waves.
Computer Interface:	USB
Available gain ranges for data acquisition:	From x10 to x500
Operating Temperature:	-10°C to 50°C
Sample Sizes:	Up to 300mm

GDSBES Hardware

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

The Bender Element is 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 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.

Fig 1. GDS BES System

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 automatically 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 signal. 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 (see also GDS BEAT Analysis Tool on the following page).

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. 2). The installation procedure requires the membranes to be cut, then the inserts to be sealed using an o-ring.

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.

Fig 2. Horizontal elements mounted to specimen

The GDS encapsulated element and insert

The GDS Bender element is bonded into a standard insert (see Fig.3). 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.

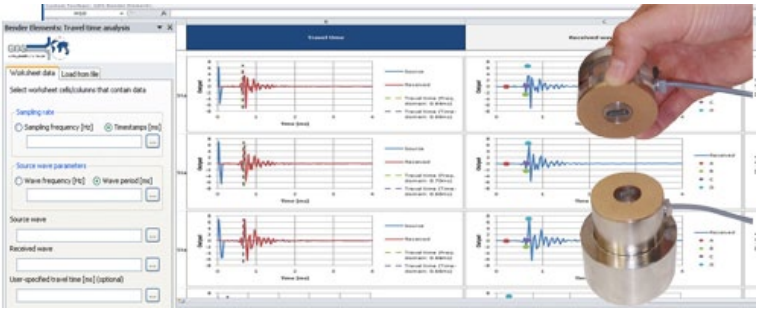
The Bender Element system connects directly into a master control box (see Fig. 4) which, in turn connects to a PC running through the GDS bender element control software.

Fig 3. GDS Titanium Bender Element Insert

Fig 4. The Bender Element System connects directly into a master control box.

Bender Element Analysis Tool

The subjectivity and lack of satisfactory standards for interpreting shear wave travel times across the industry from bender element test data, has led GDS to develop a bender element analysis tool. The tool allows the rapid, automated analysis of bender element tests to objectively estimate the shear wave travel time.



The analysis tool is available to download from the GDS website, free of charge, for a limited period of time. The aim is to share our software with the geotechnical community and help the progression towards accepted standards for these tests. The GDS Bender Element Analysis Tool (GDSBEAT) itself is an easy-to-use set of Add-Ins accessible through Microsoft Excel, allowing any laboratory to participate in performing automated analysis of bender element data, without the prior requirement of software programming knowledge. Benefits of the tool include its ability to estimate travel times using both frequency and time domain analysis methods previously suggested in the geotechnical literature, and the flexibility to analyse data taken from any manufacturers bender element test system. Reporting of the analysis is both numerical and visual, allowing the validity of the results to be quickly assessed, as the tool still does require engineering judgement from the user.

GDSBES Control Software

The functionality of the GDSBES software (Fig. 5) 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

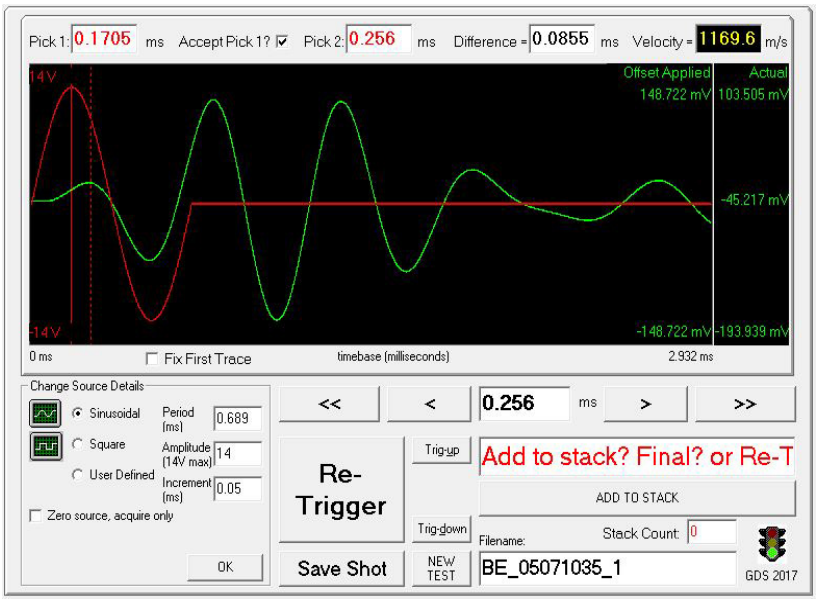
To cater for the many different approaches to bender element testing that have been developed around the world, the GDS Bender Element software allows the following source signal types to be used as follows:

- Sine wave
- Square wave
- User defined

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)



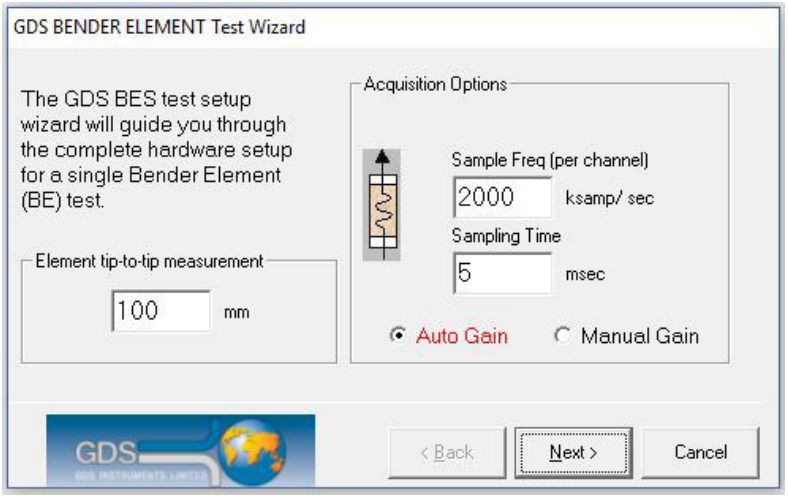


Fig 5. GDSBES software during testing

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.

Why Buy GDS?

GDS have supplied equipment to over 84% of the world's top 50 Universities:

GDS have supplied equipment to over 84% of the world's top 50 Universities who specialise in Civil & Structural Engineering, according to the "QS World University Ranking 2019" report.

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

TOP 50

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

100% of our customers answered "YES"

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

Made in the UK:

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

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

40 YEARS OF BRITISH INNOVATION

Extended Warranties:

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

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

GDS Training & Installation:

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

Technical Support:

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