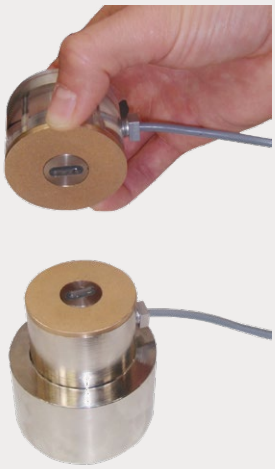


Bender Element System (GDSBES)

The GDS Bender Element system enables easy measurement of the maximum shear modulus Gmax of a soil.

Measurement of soil stiffness at very small strains in the laboratory using traditional load and displacement gauges is difficult due to resolution and accuracy limitations of the measuring devices. While local strain transducers improve this and may typically reach 0.0001% they are more complicated to setup compared to using bender elements which enable observations to 0.00001% or lower strain levels.

The addition of Bender Elements to a triaxial testing system makes the routine measurement of Gmax simple and cost effective. To date GDS have installed bender elements in triaxial, consolidation, simple shear, resonant column, core holders and many other systems manufactured by GDS and other suppliers.

Key Features:	Benefits to the User:
USB interface:	Plug and play connection easily connected to any modern PC.
Titanium element inserts:	Titanium is used for high corrosion resistance and low-weight.
Wide Compatibility:	Pedestals and top-caps can be manufactured for 3rd party as well as GDS cells. Our longstanding experience in designing or assisting with upgrades makes upgrading simple.
Standard insert design:	Reduces the cost and makes the bender element a modular device that can be easily fitted into a suitably modified pedestal/top-cap. Should an element be damaged, it is straightforward for the insert to be replaced by the customer.
High speed sampling rates:	User selectable rates from 500kHz to 125MHz provide ample temporal resolution for determining wave speeds.
Multiple gain ranges with auto ranging:	11 User selectable gain ranges from ±1mV up to ±2V allow input adjustment to match the signal level observed. Auto ranging ensures this happens without user inputs.
Bender Extender Type Elements:	Determining both S & P wave velocities allows additional specimen parameters to be calculated, such as Young's Modulus, E.
Vertical and horizontal elements are available:	Specimen anisotropy can be studied, with the use of both vertical and horizontal (H_h & H_v) elements on the same sample.
Unsat compatibility:	Bender elements can be fitted to unsat as well as saturated pedestals and topcaps.

Technical Specification:

Data acquisition speed:	Selectable up to 125MHz (125,000,000 samples/second), with simultaneous sampling of both source and received signals.
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:	±1mV to ±2V
Operating Temperature:	-10°C to 50°C
Sample Sizes:	Up to 300mm
Standards:	ASTM D8295-19

Tests that can be Performed:

Determination of Shear Wave Velocity and determination of P-Wave Velocity in the following planes:

- Vertically propagating horizontally polarised (vertical elements),
- Horizontally propagating horizontally polarised (horizontal elements),
- Horizontally propagating vertically polarised (horizontal elements).

GDSBES Hardware

The full GDSBES system is typically made up of the following; bender element inserts, adapted pedestal & topcap, access ring, external USB control box and GDSBES Software.

Each Bender Element is encapsulated and mounted into a titanium insert. As well as its high axial rigidity and corrosion resistance, titanium is used for its low weight to minimize the imposed axial load when fitted to a sample top-cap.

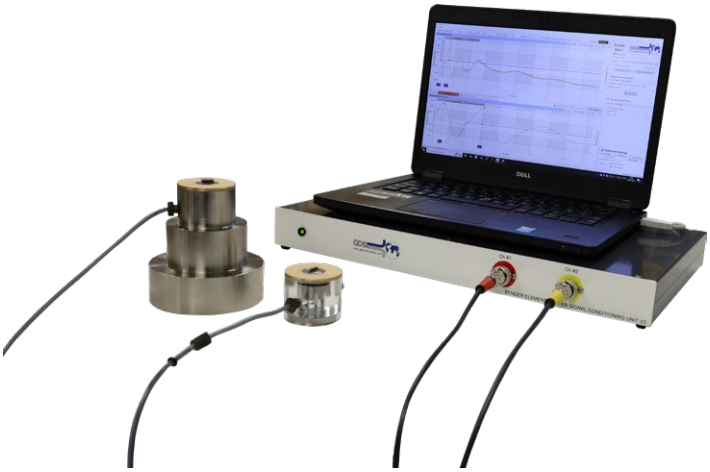


Fig 1. GDSBES System

S & P wave transmitting elements are subtly different to improve signal strength compared to using a common design for both ends of the sample. As such, different part numbers are required for fitting to the topcap or pedestal.

If bender element inserts are to be fitted to another manufacturers' equipment that has not previously been designed by GDS, full mounting information must be provided to enable quoting against your specific equipment

Bender elements for Horizontally Propagating Waves

Use of horizontally propagating elements, in addition to axial elements, allows the user to quantify the degree of stiffness anisotropy present in the soil specimen. As with the standard GDS inserts, the horizontal element casings 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 and silicone sealant.

These elements may be orientated on the sample either horizontally or vertically to produce two different polarisations (Hh & Hv), in the horizontal plane.

The common "full" bender element setup consists of a single vertical pair of elements, and two pairs of horizontal elements.

Fig 2. Horizontal elements mounted to specimen

The GDS encapsulated element and insert

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.

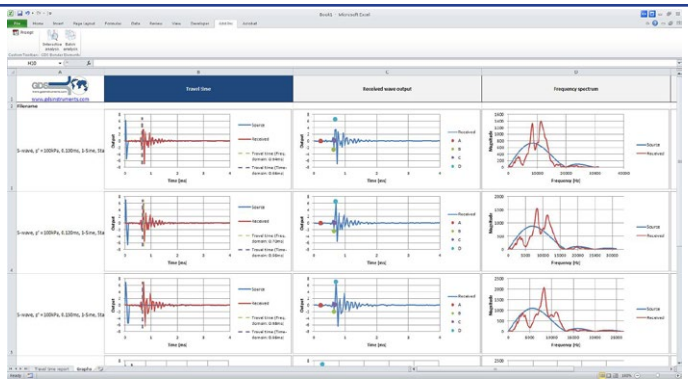
The Bender Element system connects directly into a master control box (see Fig. 4) which, in turn connects to a PC running through the GDS bender element control software.

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 GDSBESv3 software (Fig. 5) has been overhauled for simplicity and includes the following features:

- User friendly pulse triggering.
- Stacking of data (manually or automatic; used to overcome noise in weak signals).
- Tip-tip time delay function.
- Manual picking of timestamps.
- Calculation of shear wave velocity.
- Calculation of primary wave velocity.
- Easy adjustment over transmit pulse waveform amplitude and wavelength.
- Excitation wavelength adjustable from 0.01ms to 10s
- Selection of sinusoidal square or custom waveforms.
- Log only mode.
- Custom user defined waveforms as standard, loaded via csv file.
- Selection of 11 hardware gain levels.
- Automated optimal gain level selection.
- Signal reversal to allow easier picking of traces.
- Slave box control allowing selection between three pairs of elements.
- Automatic frequency scanning.

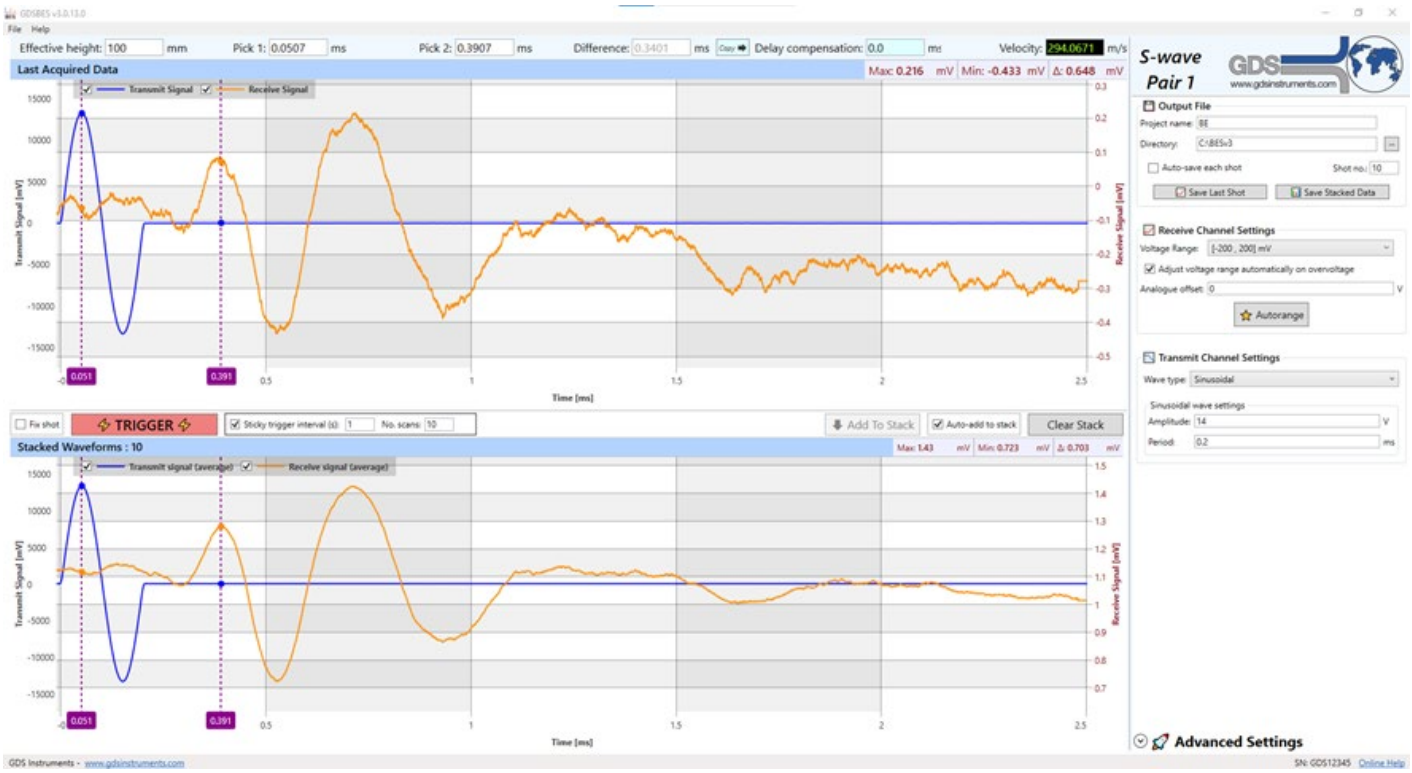


Fig 5. GDSBES software during testing

Why Buy GDS?

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

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

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

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.

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.