**S and P -Wave velocity** ✓

**Dedicated software** ✓

**Sample sizes up to 300mm** ✓

***New Specification***

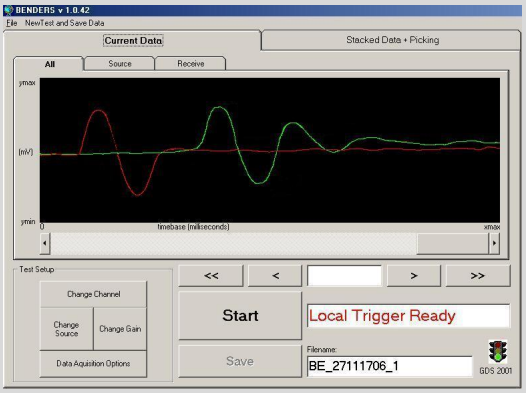
**2 Million Samples/Sec** ✓

**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.
- The Bender Elements systems connects directly into a master control box (see Fig. 2) which, in turn connects to a PC running bender elements control software.

**Fig. 1 GDS Titanium Bender Element and Insert**

**Fig. 2 The Bender Element system connects directly into a master control box.**

***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)**
- **Operating Temperature:** -20°C to 50°C

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## 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

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

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.


**Fig. 2 GDSBES software during testing**

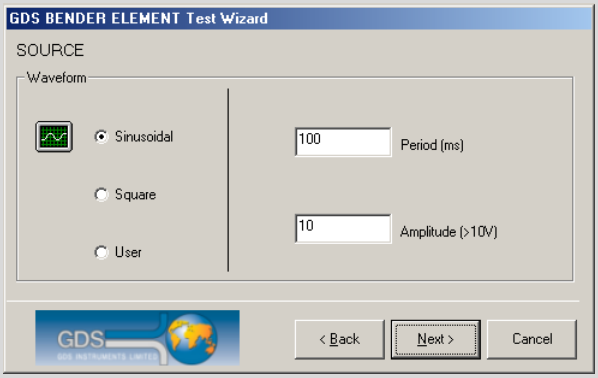



**Fig. 3 Example page from the GDSBES software test setup wizard**

## Bender elements for Horizontally Propagating Waves

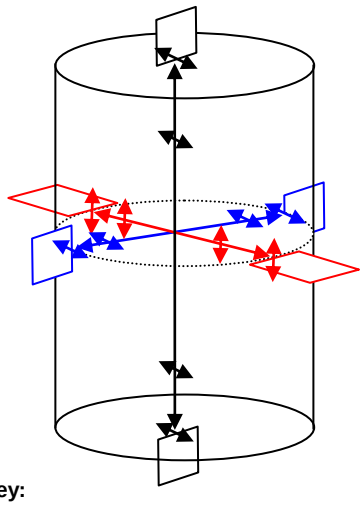
The development of the GDS horizontally propagating elements, when used in addition to the axial element inserts, allows the user to quantify the degree of stiffness anisotropy present in the soil specimen. As with the standard GDS inserts, the horizontal inserts are also manufactured from Titanium,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

**Option: Bender Elements Slave Box**

The slave signal conditioning unit is used in conjunction with master control box. It creates four more channels to enable two additional pairs of elements to be used (for example when using vertical and two horizontal pairs of elements together). The slave box allows the user to easily switch between up to three sets of elements using software control, in the same way as the end user currently switches between P and S waves in a single pair of elements he will be able to switch between S1, P1, S2 & P2.

***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**