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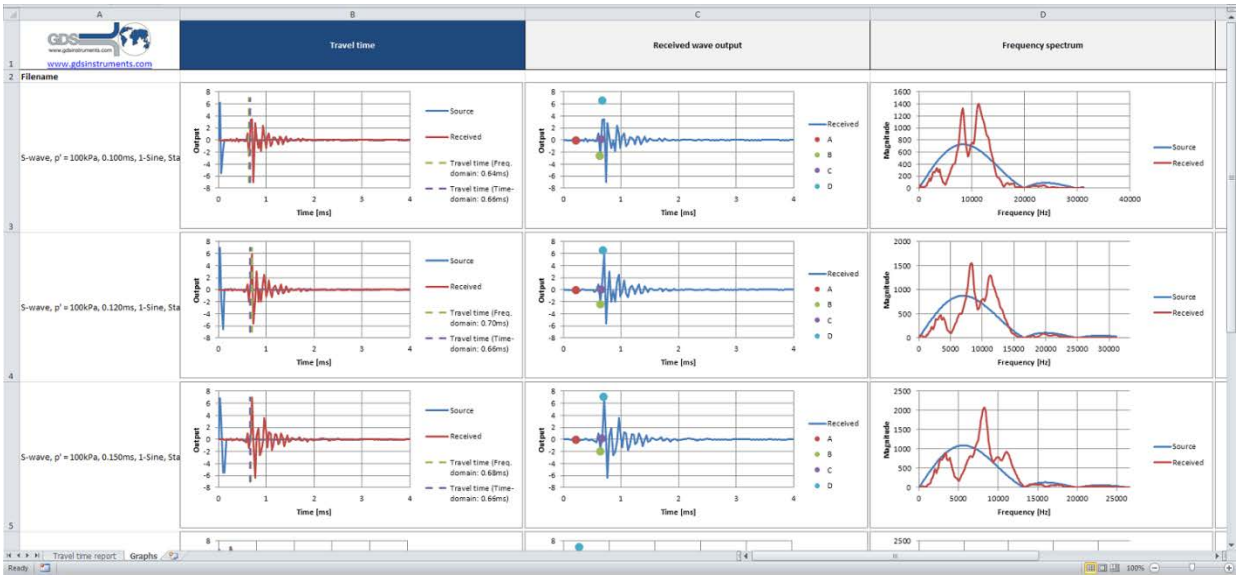
GDS BEAT – FAQ

The GDS Bender Element Analysis Tool – Frequently Asked Questions



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1 Frequently Asked Questions (FAQ)

This document provides answers to a set of frequently asked questions relating to the GDS Bender Element Analysis Tool (GDS BEAT). For any questions not listed here please contact GDS Instruments directly by emailing support@gdsinstruments.com.

1.1 General Questions

1.1.1 What is GDS BEAT?

The GDS Bender Element Analysis Tool (GDS BEAT) is a free-to-download set of Add-Ins for Microsoft Excel 2007 and 2010 that allow shear wave travel times to be estimated from bender element test data via automated analysis methods.

1.1.2 Why did GDS Instruments develop and share the tool?

The tool was developed due to the subjectivity and current lack of satisfactory standards for interpreting shear wave travel times from bender element test data. GDS Instruments hope that sharing the tool with the geotechnical community will help the progression towards accepted standards being created for these tests.

1.1.3 Where can I obtain GDS BEAT?

The tool can be downloaded for a limited time without charge from the following address: https://drive.google.com/uc?export=download&id=0B3H9EUpNg2zxQWxqVGl0dVoxYTA

1.1.4 How do I start using GDS BEAT?

Microsoft Excel 2007 or 2010 should be opened after GDS BEAT installation to access GDS BEAT through the Add-In tab. Clicking on either GDS Beat Add-In (Interactive analysis or Batch analysis) will then open the GDS BEAT registration window, requiring the user to input their details and email address. Following this, an activation code will be emailed to the user, allowing the tool to be activated until the 1st of January, 2018.

1.1.5 Will GDS BEAT run on my operating system?

GDS BEAT can be installed and used on PCs running Windows XP SP3 or higher. Note Microsoft Excel 2007 or 2010 must also be installed.

1.1.6 What are the terms of using GDS BEAT?

GDS BEAT is available free-of-charge, comes without warranty or technical support, and cannot be re-sold by a third party.

1.1.7 Why do I receive an error when registering GDS BEAT?

GDS BEAT sends user details to a registration server after the 'Register' button is clicked, allowing a user-specific registration code to be automatically generated and emailed to the user. An error will however be displayed if GDS BEAT cannot correctly send these details to the registration server – note this may be due to a network firewall or similar. GDS therefore recommend users speak with their IT department to ensure firewalls, antivirus software etc. is switched off while GDS BEAT registration takes place.

1.2 Analysis Methods Used

1.2.1 What methods does GDS BEAT use to estimate the shear wave travel times?

GDS Beat primarily uses three common methods to estimate the shear wave travel times from bender element test data: (1) observation of points of interest within the received element signal (see Figure 1); (2) cross-correlation of the source and received signals; (3) cross-power spectrums of the source and received signals.

1.2.2 How does observation of the received signal work?

Observation of the received signal is designed to semi-automate the travel time estimation process often performed subjectively by the user. An algorithm within the tool attempts to identify the times at which Point A, B, C and D occur, as shown in Figure 1. This then allows the user to calculate travel times using any observational method of their choice, such as 'start-to-start' or 'peak-to-peak'.

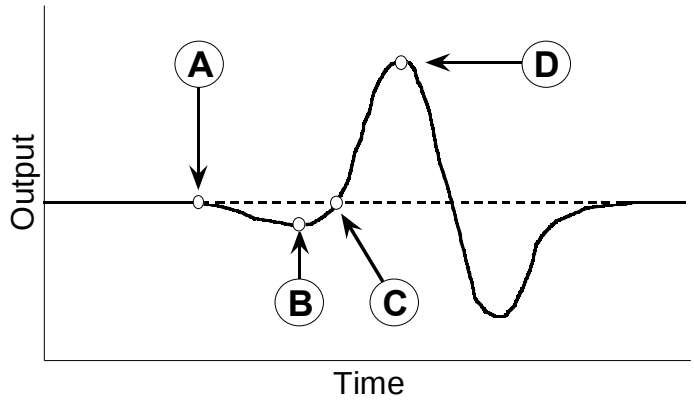

Figure 1 – Points of interest observed within the received element signal.

1.2.3 How does the cross-correlation work?

Cross-correlation values are calculated from the source and received element signals at each data time stamp. The time at which the maximum calculated cross-correlation value occurs is then used as an estimate of the shear wave travel time.

1.2.4 How does the cross-power spectrum calculation work?

The cross-power spectrums, obtained via a Fast Fourier Transform (FFT), are used to create a phase angle versus frequency plot. The slope of this plot is then used to estimate the shear wave travel time, based on a linear best fit across a defined frequency window. Note GDS BEAT automatically uses a frequency window of 0.8 to 1.2 times the specified source element frequency, however this can be manually altered by the user when running the Interactive Analysis.

1.2.5 Where can I find more general information on these analysis methods?

The cross-correlation and cross-power spectrum methods have been used to estimate the shear wave travel time for the past couple of decades, with Viggiani and Atkinson (1995) providing a good starting point. For recommendations based on an international parallel test of bender elements, there is the report from Technical Committee TC-29, authored by Yamashita et al. (2009).

1.3 Performing a Travel Time Analysis

1.3.1 When should I use the Interactive Analysis Add-In?

The Interactive Analysis Add-In is designed for use in analysing bender element test data taken from both GDS and non-GDS bender element systems. This is because all parameters required to perform the analysis can be manually selected from data loaded into an Excel spreadsheet. The Add-In is also useful in situations where the user may wish to alter the frequency window used in the cross-power spectrum analysis.

1.3.2 When should I use the Batch Analysis Add-In?

The Batch Analysis Add-In is designed for use in analysing multiple bender element tests primarily obtained from GDS bender element systems. Users can however re-format their test data into the GDS format (.bes) using the example data file provided on the GDS BEAT download page. Note the frequency window used in the cross-power spectrum analysis cannot currently be altered when using the Batch Analysis Add-In.

1.3.3 What does zero-padding the source and received element signals do?

Zero-padding is a technique sometimes used when performing spectral analyses, and therefore only affects the cross-power spectrum analysis within GDS BEAT. It simply adds a user-defined number of zeros to the end of both the source and received signals. This can enable information to be reported at specific frequencies by increasing the number of discrete data points in each signal, but is only recommended for users with prior experience in such analyses. Further useful information about zero-padding can be viewed at the following address: www.ni.com/white-paper/4880/en

1.3.4 What does checking the 'Output calculation worksheets' do?

Checking the 'Output calculation worksheet' box in the Interactive Analysis Add-In will display two extra tabs following completion of an analysis: 'Time domain calc' and 'Frequency domain calc'. The time domain calculation tab contains the calculated cross-correlation values at each time stamp of the bender element data, while the frequency domain tab contains numerous calculated parameters relating to the cross-spectrum analysis. Note these tabs cannot currently be output when running the Batch Analysis Add-In.

1.4 Analysis Reporting

1.4.1 What are the 'Frequency domain diagnostics'?

The frequency domain diagnostics simply provide numerical values of the frequency window used in the cross-spectrum analysis, and the R^2 value of the linear best fit curve used to determine the slope of the phase angle versus frequency plot.

1.4.2 How are the 'Peak-peak freq' values listed in the source and received wave metrics determined?

The peak-peak frequencies of the source and received signals simply provide an estimate of the waveform frequencies based on inspection of the recorded data. These are determined by identifying the time between the peak and trough of each waveform (the largest peak and trough amplitudes observed in the received waveform are used for this calculation), multiplying this time by a factor of two to estimate the waveform period, and then inverting to produce a frequency value.

1.4.3 How are the 'Additional travel time estimations' determined in the frequency domain analysis?

The additional travel time estimations are determined for the cross-spectrum analysis by calculating the slope of the phase angle versus frequency plot between the listed frequency (e.g., the spectral peak frequency) and the previous frequency step (i.e., by calculating the slope between two points only).

1.4.4 How are the 'Additional travel time estimations' determined in the time domain analysis?

Cross-correlation values are calculated using the received wave element signal and sinusoidal waveforms with frequency equal to the source and received 'Peak-peak freq'.

1.4.5 Why do the bender element signals displayed in the 'Graphs' tab appear incomplete?

The signal outputs displayed in the 'Graphs' tab are incomplete as some data points are removed during processing to increase the analysis speed (i.e., the plotted data is down-sampled). The outputs are therefore intended to help with rapid validation of the estimated travel times, rather than for final reporting purposes.

2 References

Viggiani, G. and J. H. Atkinson (1995). "Interpretation of bender element tests." Géotechnique **45**(1): 149-154.

Yamashita, S., T. Kawaguchi, Y. Nakata, T. Mikami, T. Fujiwara and S. Shibuya (2009). "Interpretation of international parallel test on the measurement of Gmax using bender elements." Soils and Foundations **49**(4): 631-650.