Ψ PSI – Parallel Seismic Instrument

USER MANUAL

V2.0

PILETEST
Take a Deeper Look

Description

The PSI is used to find the depth of test all types of foundation elements, either stand-alone or topped by an existing structure. The PSI can determine the length of the foundation element as well as the wave speed of it's material.

WARNING

Although PSI itself contains no dangerous components, working on construction sites in general and close to rigs, cranes and open boreholes in particular might be a dangerous activity.
You should participate in safety training
Always obey local safety rules.

System components (Fig. 1)

1. PSI 2 instrument
2. Hammer with trigger switch
3. Depth meter
4. Hydrophone on cable rolled on cable drum
5. USB cable connecting computer

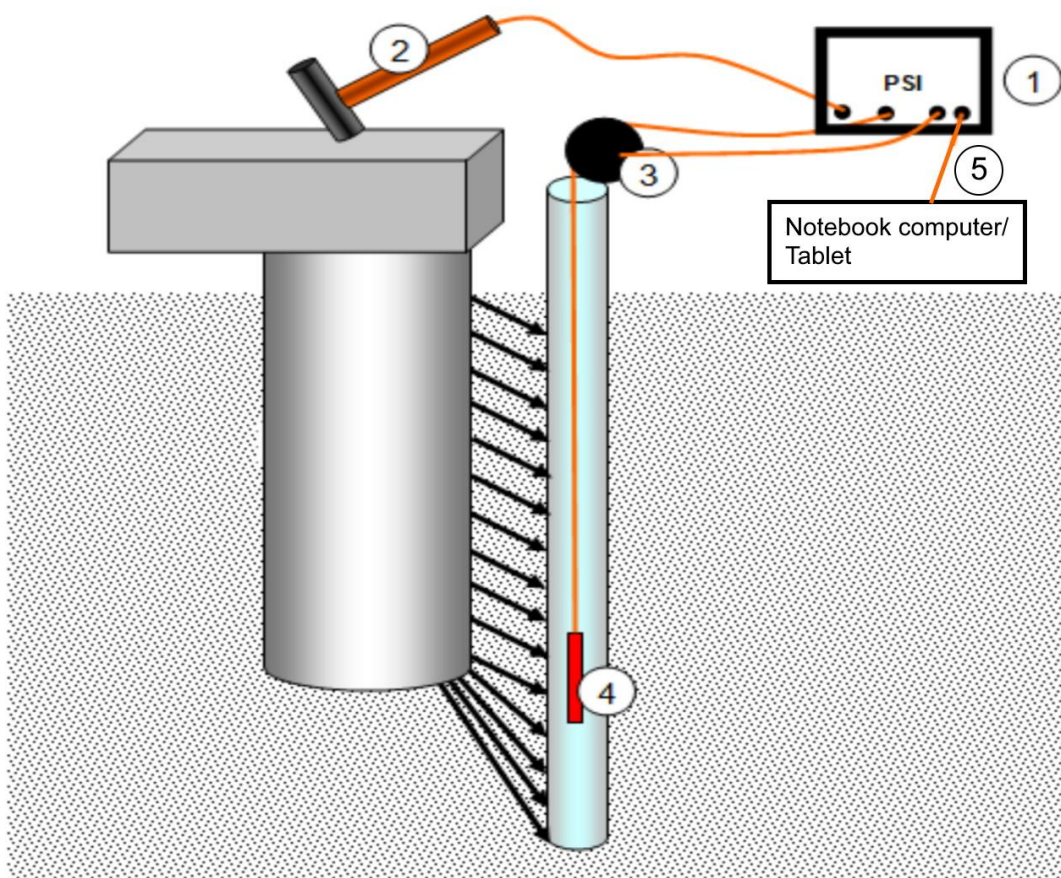Items 2, 3 and 4 are all connected via dedicated cables to the instrument

Fig. 1: PSI system components

Principle of the test method

Test setting

Before performing the test, a vertical plastic tube should be inserted into a suitable hole drilled in the ground, parallel and as close as possible to the tested foundation element.   The parallel tube, with a watertight cap at the bottom, should have an inside diameter of not less than 40mm. It should be inserted at least 5m below the assumed toe depth of the tested foundation element.
In dry soil the annular space between the tube and the drilled hole should be filled with cement grout throughout its length.
The plastic tube should be filled with clear water to ensure acoustic coupling for the hydrophone.
A suitable dummy weight on a string in the length of the tube, should be used to test that the tube is free of obstacles.

The test procedure

A hydrophone, sensitive to audio frequencies, is lowered into the tube in predetermined stages of half a meter or less.
At each stage, the top of the foundation element or an appropriate spot on the superstructure is hit with the hammer several times. The location of this point should be kept constant during the whole test. The hammer blows create longitudinal waves that travel down the foundation element and through the soil to the hydrophone inside the tube. The waves that arrive at the hydrophone are transmitted to the PSI and recorded in the connected computer.
Upon completion of the test, the recorded waves are plotted at the respective hydrophone depths. When the first arrival times (FAT) of the recorded waves, are connected, the resulting line clearly shows three distinctive zones (Fig. 2):
   - In the top zone, the FAT values form a straight line with a slope S_1
   - In the bottom zone, the FAT values form a straight line with a slope S_2
   - In the intermediate transition line, the FAT values form a curve.
The intersection between the top and bottom lines indicates the toe level of the foundation element (or, alternatively, a total discontinuity).
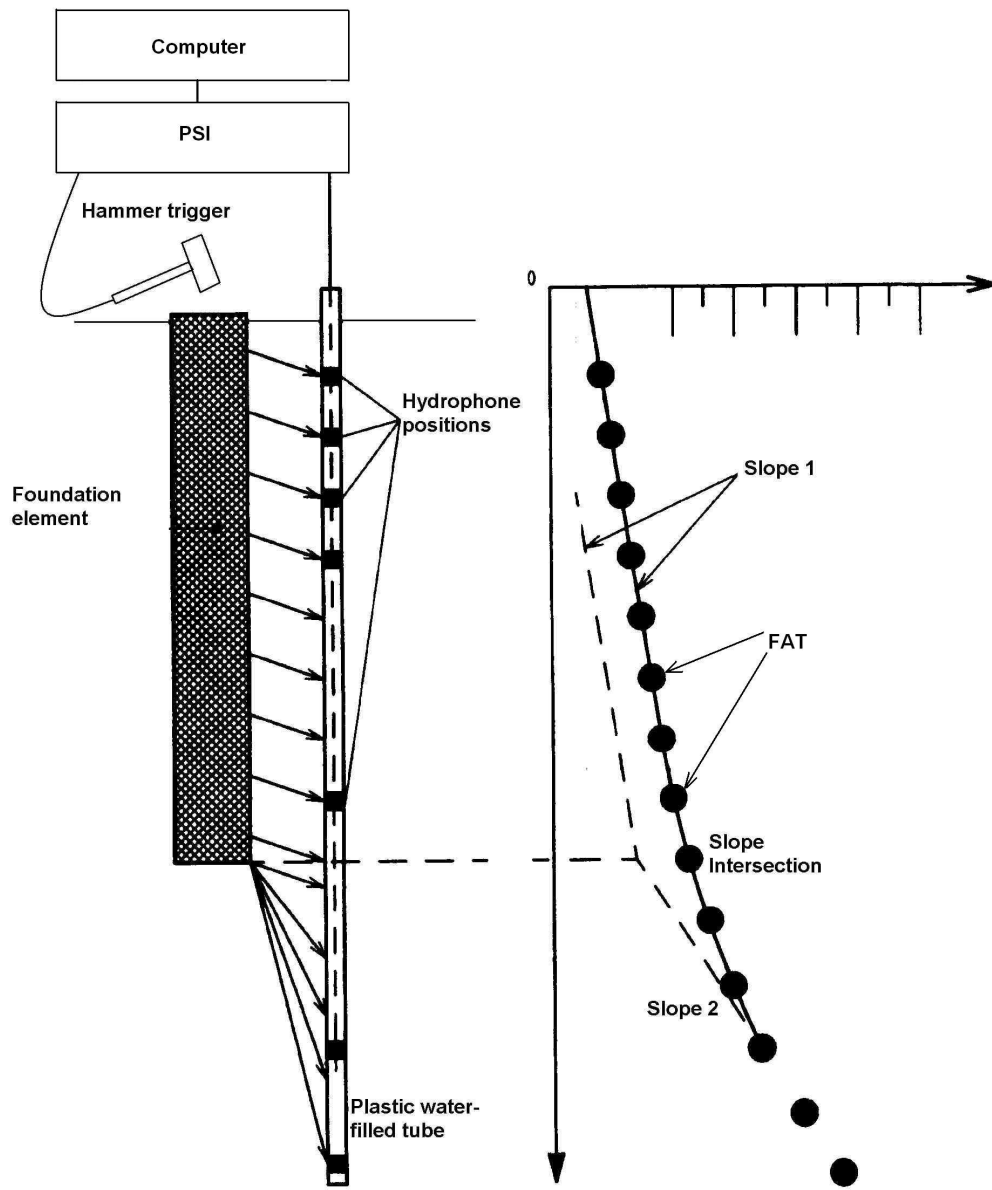The slope S_1 indicates the wave speed in the foundation element material.

Fig. 2: Interpretation of the results

Using the PSI

Setting up

Make sure the access tube is filled with clean fresh water.
In order to release enough hydrophone cable before connecting it to the PSI unit:

- place the depth wheel on the access tube
- pass the hydrophone with the connected Orange cable above the wheel.
- Lower the hydrophone to the bottom of the tube
- take a few meters extra
- connect the hydrophone to the PSI box

Now, also connect the depth meter cable and hammer trigger connectors to the PSI panel.
Plug the PSI USB plug into the computer. The green LED on the PSI panel will blink ten times.

Depth meter Calibration

Before your first test you must calibrate the depth meter.

Install the depth meter at the top of the parallel tube.
Pass the hydrophone with the connected orange cable above the wheel.
Using an adhesive tape, mark two lines on the cable, 10m apart (Exactly)
Suggestion: You can use the "Piletest.com" markings on the cable which are printed at 1m separation, to mark the two lines 10m apart.
If necessary, calibration can be done off the tube or even in the office, provided the cable is kept in good contact with the wheel.

Feed the cable in until the bottom marker (the marker closer to the hydrophone) reaches a suitable reference point on the depth meter.

Start PSI software.
Select [Tools] [Depth Calibration] and follow closely the instructions of the calibration wizard. If this is the first depth meter calibration, the displayed depth values may be very different from the actual ones and also carry a negative sign. Disregarding this, follow the prescribed procedure and save the calibration.
Repeat the calibration process for verification.
This time the calculated and actual length values should match
Press [Next] to return to the main page

Note: Depth meter calibration should by repeated every time the Depth meter or computer are replaced.

Test Settings

Select Tools-Options to open the settings form

- in the [General] tab, select Meters/English units.
- In the [Hardware] tab, select USB (make sure [Demo] is **NOT** selected)
- Select the nominal spacing between samples. This is only indicative and you can collect impacts at any depth by simply hitting with the hammer.
- The [Advanced] tab is mainly for visual tweaks and you may leave it with the default values.
- In the [Signal] Tab select ☑ remove random peaks - to clean obvious high-freq noise from the signal
- Band Pass filter may be used to filter unwanted frequencies from the signal, however, it may also distort the signal and give wrong FAT picking. Leave this unchecked for now.
- The "Threshold ratio" (TR) is used to find the First Arrival Time (FAT) of the impact. It is done by finding the signal maximal point, dividing it by the TR to get the threshold T and finding the first time at the impact where the voltage is T or more.
  Start with a threshold ratio of 10, if you obtain clean signals, raise the value, and if the S/N ratio you get isn't great, you may need to use lower values.
- Select ☑ Use stacking - in that mode the software will automatically stack and average impacts taken at the same depth stage (within 2cm gap)

Testing

Start PSI software. The PSI main screen (Fig. 3) will appear.

In the informational part fill-in the following (optional) data:
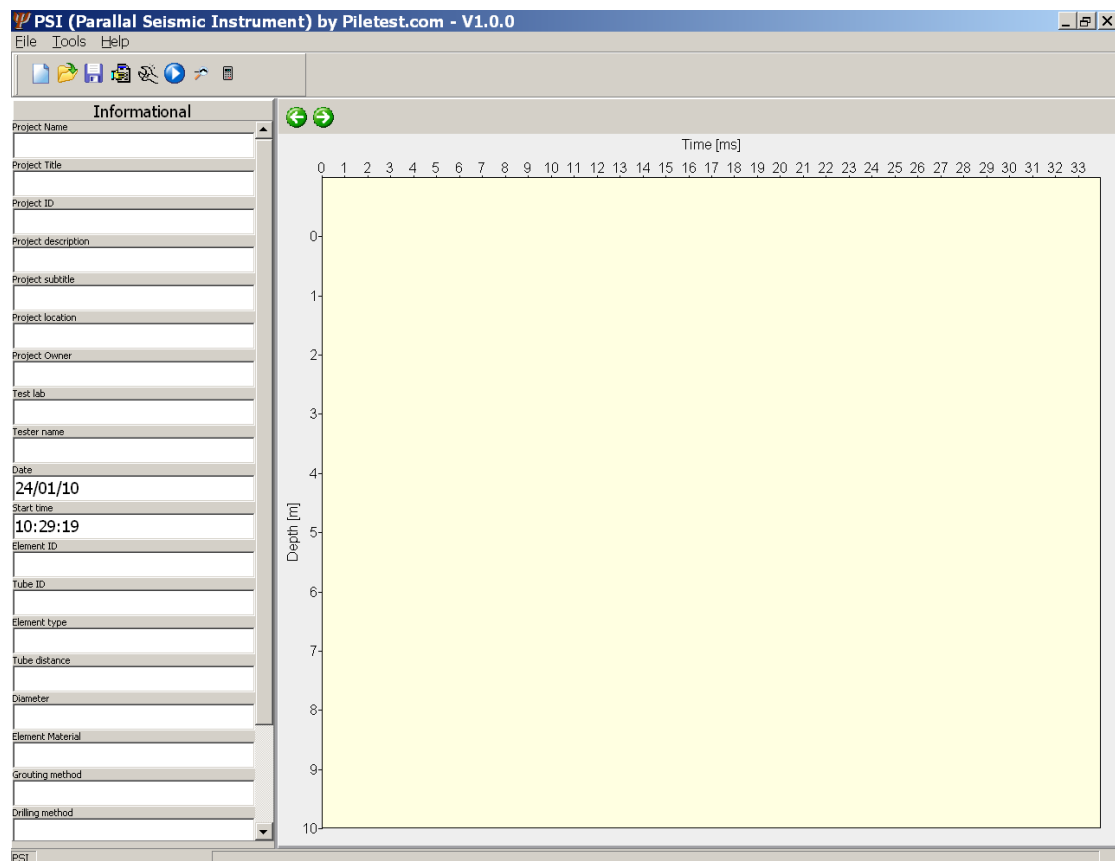

Fig. 3: PSI main screen

- Project name, title, ID, description, subtitle, location, owner
- Test lab and testers identification
- Element ID
- Element type
- Element material
- Tube ID
- Drilling method
- Grouting method
- Tube distance from element
- Element material

Testing Steps

1. Connect all cables (see setting up)
2. Place the depth wheel on top of the access tube
3. Place the hydrophone through the depth wheel at depth=0.0
4. On the PSI screen, press ▶ Start Test (blue button with the white triangle)
5. Keep the hydrophone motionless and with the trigger hammer hit sharply the top of the element (or a suitable spot on the superstructure).
6. Hit several (1-20) times on the same depth. The software will automatically stack impact traces of the same depth to improve the signal quality.
7. With the Orange cable in good contact with the depth meter wheel, lower slowly the hydrophone until the green band on top of the screen turns red.
8. Wait a few seconds for all water movement to end.
9. Hit again, several times to collect the impact(s) at the current depth stage.
10. Repeat the procedure until the hydrophone rests at the bottom of the plastic tube.
11. Press [Stop Test] (blue button with the white square).
12. Save the file!

The software will readily plot the top and bottom slopes and calculate the following:

- Depth to the bottom of the foundation element
- Wave speed in the foundation element material
- Wave speed in soil below the foundation element toe.
- Correlation quality: this is the smaller coefficient of determination R^2 value of the linear fit of the lines above and below the crossing point. formally, if there are N points ($P_1...P_N$) and the match is calculated at i
  ```
  Correlation quality ::=
  100*min[R²(P₁...Pᵢ), R²(Pᵢ₊₁...Pₙ)]
  ```

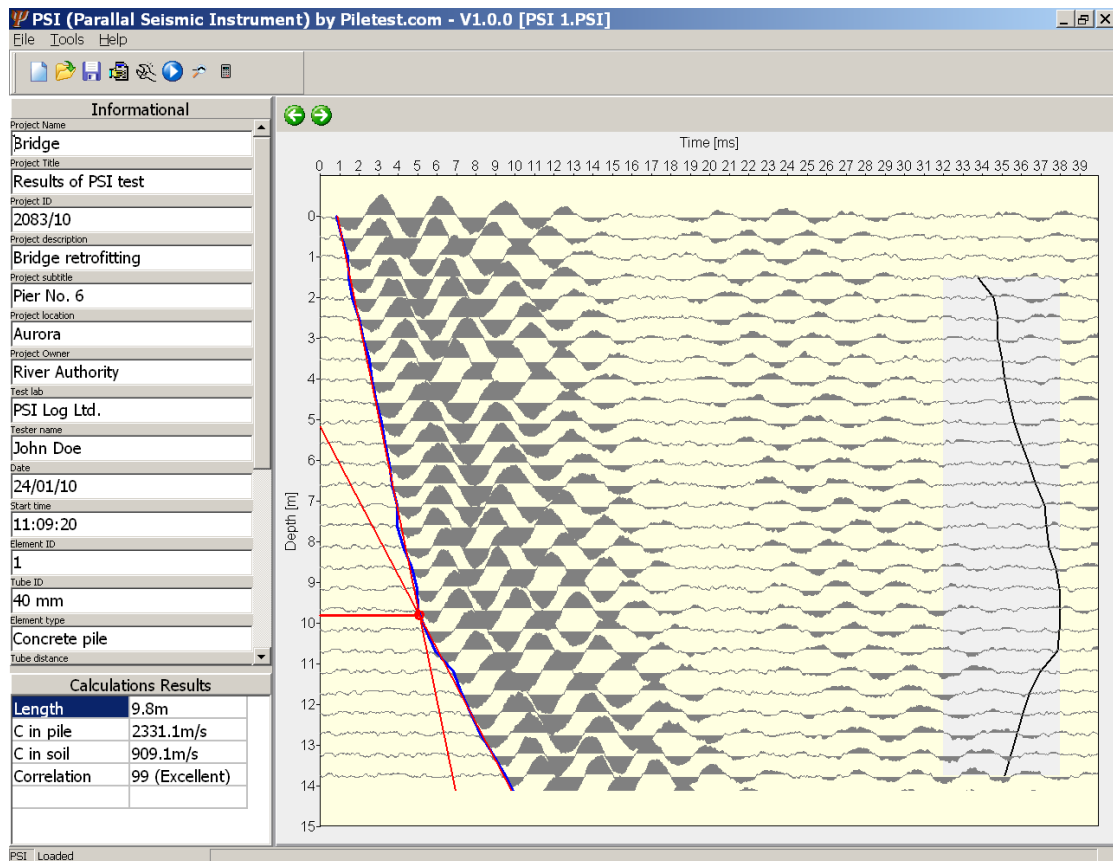You should examine the above results to see if they make any sense.

Fig. 4: PSI screen at the end of the test

Going over the results

Using PSI software you can go over the logged results and perform the following actions:

1. Zoom on any impact
2. Override the automatically-selected FAT (First Arrival Time) of each impact
3. Instruct the software to ignore any specific impact
4. Delete an impact permanently
5. Force the software to use any impact as the depth point and perform the linear regression calculations on impacts below and impacts under that point.

To use those options, select the magnifying glass from the top toolbar. This will show the "Zoom pane" under the main window.
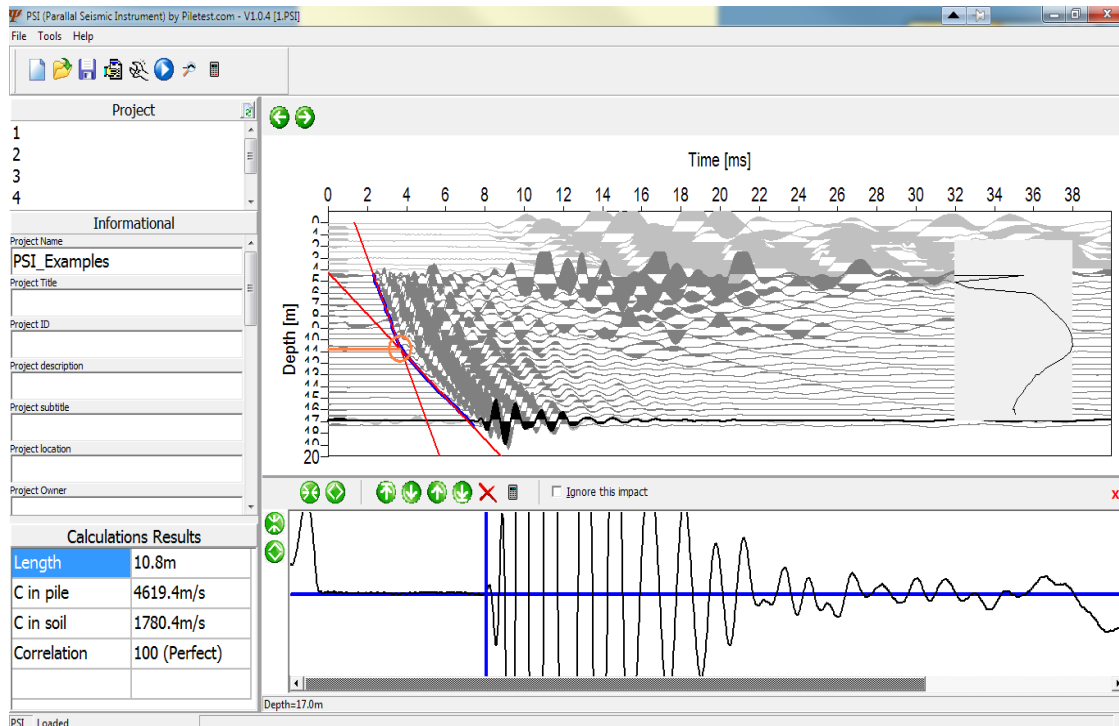
Left buttons:
- ↕ Enlarge or decrease vertical scale, A for automatic scale

Top buttons, from left to right
- ↔ Increase or decrease the horizontal scale.
  (Use the bottom scroll bar to scroll right and left)
- ↑↓ Select first, next, previous or last impact
  keyboard: arrows and home/end
- **X** delete the current blow (Permanently)
  Keyboard: [Del]
- Force calculations on current impact
- Ignore the current impact
  Keyboard: i

Click anywhere on the impulse to override the automatic FAT picking

After each change, click the calculate icon at the TOP toolbar to make the software try and calculate automatically.

Reporting

Select [File]-[Report] or click the report icon
Select a reporting template and click OK
The software will generate an HTML file (readable by all browsers)
The report will be generated in the same folder as the data file.

The report can also be loaded by many word processors such as MS™ Word and saved into other formats such as DOC, PDF, etc.

Customizing the report

You may create more templates by editing the Default.PSITemplate.HTM file and save it under a new name (with the same suffix) – for example "New.PSITemplate.HTM". HTML files can be edited by many editors, including MS™ Word.

When the report is produced, the chosen template file is copied and placeholder fields will be replaced with actual data. Placeholder fields are marked with #, for example #Pilename
Field names must be copied as-is. If an exact match is not found the PSI software cannot replace the field placeholder with the actual data

Field	Description
#TestDate	Date of the test
#TestTime	Time of the test
#ProjectName	The project name, as entered by you
#PileName	The pile's name
#TubeName	The access tube name
#CalculatedLength	The calculated length
#ProjectTitle	Title of the project
#ProjectOwner	Owner of the project
#ProjectID	ID of the project
#ProjectDescription	Description of the project
#ProjectSubTitle	Project sub-title
#ProjectLocation	Location of the project
#Lab	Testing laboratory
#Tester	Tester's name
#PileType	Type of foundation being tested
#TubeDist	Distance between tube and the foundation

#PileDiameter	Diameter of the foundation (if circular)
#PileMaterial	Material of the foundation
#Grouting	Was grouting performed (free text)
#DrillMethod	Drilling method (free text)
#Elevation	Ground elevation
#PileElevation	Pile elevation
#PipeElevation	Top of pipe elevation
#FirmwareVersion	Firmware version of the PSI2 box
#HardwareModel	Model of the PSI2 box
#PSIUnitSN	Serial number of the PSI2 box
#Graphics	The result graphics (Many graphics properties are set in tools-options-advanced)
#WaveVelocityInPile	The calculated wave velocity in the pile
#WaveVelocityInSoil	The calculated wave velocity in the soil
#CorrelationQuality	0-100 match correlation quantifier
#CorrelationQ_Words	wording of CorrelationQuality: 100: Perfect 96-99: Excellent 91-95: Very good 86-90: Good 81-85: OK 0-80: Poor

- End -