ZBL-P8000

Wireless Pile Dynamic Testers

Instruction Manual

NOVATEST®
TESTING - CONSULTING - TRAINING

Contents

Conventions in this manual

1. Word with gray background and black box is a button on the interface, e.g OK.
2. The keys on the instrument panel are represented by 【】, e.g. 【SAVE】.
3. Word with white background and black box represent software menu command in Windows, and "→"is a separator between different menu levels. e.g. File→Open means the command of selecting "Open" under the "File" menu.
4. Word with gray background but without box indicates the name of the control (choice box, input box, etc.) of the popup window on the screen, such as the input box of File Name in the open-file window.
5. The sign  means special attention is needed here.
6. Besides the descriptions in the manual, some prompt messages may show automatically in the use of the software. Please operate accordingly.
7. The software interfaces and photos in manual are only for reference. There will be changes with software upgrade and improvement of products. No further notice is provided.

Chapter 1 A General Introduction

1.1 Introduction

ZBL-P8000 Wireless Foundation Pile Dynamic Testers（hereinafter called "Wireless Dynamic Tester"）was produced by Beijing ZBL Science and Technology Co., Ltd. It is a kind of digital and portable dynamic tester using the low strain reflected wave method to test the integrality of concrete pile.

Wireless dynamic tester is used for Signal acquisition, and the mobile terminal with Android platform is used to receive data, the real-time acquisition data is transmitted to the receiver through the wireless communication for display, analysis and storage.

1.2 Main Functions and Features

1.2.1 Main Functions

1. Low strain reflected wave method is used to test the integrality of concrete pile;

Referred test specifications and verification regulations：

1） Technical Code for Testing of Building Foundation Piles, JGJ106

2） Technical Specification for Dynamic Pile Tests of Highway Engineering, JTG/TF81-01

3） Technical Specification for Non-destructive Testing of Railway Piles, TB10218

4） *Code for Testing of Building Foundation in Guangdong Province（DBJ 15-60）*

5） *Technical Specification for Quality Testing of Building Foundation Piles in Shenzhen（SJG 09）*

6）Verification Norms for Dynamic Pile Tester（JJG930-1998）

7） *Foundation Pile Dynamic Tester JG/T 3055-1999*

1.2.2 Main Features

1. Wide dynamic range, low noise amplifier system, 24 bit A / D sampling, signal has good stability, so the defect and pile bottom can be identified easily.
2. Built-in WIFI module can help access the LAN through the wireless router to enable more convenient and faster data transfer.
3. Real time on-site processing such as smoothing, differential, filtering, exponent and linear amplification can be given to tested wave form.
4. Brand-new wavelet processing can exceed international standards.
5. The signal noise can be eliminated by taking average superposition of multiple signals. Superposition signals can be checked at any time, poor-quality signals to be rejected.
6. The projects→ piles arrangement of files being clear and convenient, project/pile testing data can be easily accessed, edited, or deleted.
7. Wireless connection is suitable for any place, the transmission distance is more than 10 meters.
8. The simple operation of instrument, proceeding from the

requirement of project testing, is easy to learn and master in a few minutes.

9. It is small in dimension and light in weight, thus convenient for carrying. Rechargeable lithium battery inside , it has long standby time and can be recharged at any time.
10. It is convenient enough to use hand or touch pen to operate in the touch screen directly.
11. Check for updates automatically and install updates online.
12. Professional Windows OS-based analysis software is sound in functions, with user-friendly interfaces. Flexible print settings makes possible print preview and processed result output. Detailed test reports can also be produced.

1.3 Main Technical Parameters

Table 1.1 Main Technical Specifications

Item	Specifications
Dynamic range (dB)	≥180
Amplifier frequency band (Hz)	1～10k
A/D resolution	24 bit A/D
Sampling time intervals	6.4μs～1638.4μs
Maximum length of sampling	≥2048
Amplitude nonlinear degree	≤10%
Error of time indication	≤1%
Gain error	≤1 dB
Fixed point magnification	1, 2, 4, 8, 16, 32,64
Acceleration transducer sensitivity (mV/g)	≥100 mV/g
Frequency range of Acceleration transducer	0.5~9000 Hz
Continuous operating hours	>5 hours

Power-supply mode	Rechargeable lithium battery inside; DC: +5V
Total weight(kg)	About 0.34
Total volume(mm)	φ5×120

1.4 Signs and Terms

1.4.1 Terms

1. Foundation pile

   Single pile of foundation

2. Pi1e integrity

   The comprehensive qualitative index used to reflect the relative change of pile section size, density and continuity of pile material.

3. Pile defects

   The umbrella name of phenomena such as fracture, crack, necking, mud (debris), cavity, honeycomb, loose, which deteriorate the pile integrity and to a certain extent reduce the strength and durability of pile structure.

4. Low strain integrity testing

   The detection method which uses low energy transient or steady-state excitation mode at the top of the pile to test the time-history curve or velocity admittance curve and employs the analysis of wave theory and frequency domain to determine pile integrity.

1.4.2 Signs

c——Pile longitudinal stress wave propagation velocity（Pile

wave velocity for short，m/s）；

D——diameter of pile（external diameter，mm）；

L——length of pile（m）；

T——the transfer time of stress wave along the pile，ms；

F——frequency，Hz；

1.5 Announcements

1. In order to make better use of the tester, please carefully read the instructions before using the equipment。
2. Working environment:

   Temperature：0℃～40℃

   Relative Humidity：<90%RH

   No long time direct sunlight

   Corrosion Protection: necessary protective measures should be taken in damp, dust, and corrosive gaseous environment.
3. Storage environment:

   Temperature：-20℃～+60℃

   Relative Humidity：<90%RH

   When it is not in use, preserve it in the packing box in ventilated, cool, and dry environment and avoid long time direct sunlight.

   If it is not to be used for a long time, periodical power-on inspection is necessary.
4. Avoid water.
5. Avoid magnet: No usage in strongly magnetic environment, such as large electromagnet, transformers.
6. Avoid quake: No severe vibration and shock during the process of operation and transfer.

1.6 Instrument Maintenance

1. Power source: The instrument adopts a special built-in rechargeable lithium-ion battery; it can work continuously for 5 hours when charged full. Please pay attention to the battery indicator in operation. When electricity is insufficient, external power source (AC power or external rechargeable battery) should be adopted as soon as possible. Otherwise, a sudden power failure may happen, which may cause data loss or even damage to the test system; if the AC power supply is used, please ensure the instrument is connected with the power of AC220±10%V, otherwise, damage will be caused to the AC-DC power modules and even the instrument . Other batteries and power supply for this instrument is prohibited.

2. Charging: When charged with the equipped AC-DC power supply module for the internal batteries, just put the attaching plug into the AC220 ± 10%V socket and connect the DC output terminal to the power socket of tester. When the charging indicator light is on, it means charging is on-going for the built-in battery; when the light turns green, it means the battery is charging with low current.

NOTE: To ensure full charge, please charge continuously for 6~8 hours, and avoid charging the instrument in environment where the temperature exceeds 30℃.

If the instrument is unused for a long time, the rechargeable battery will discharge naturally, resulting in reduction of power quantity, so that it should be recharged before reuse. In the process of charging the instrument, the AC-DC power supply will be heated in some degree, which is a normal phenomenon. The instrument, AC-DC power or charger should be maintained in good ventilation for easy heat dissipation.

NOTE: Avoid other power adapters for charging, or

damages may be caused to the equipment.

3. Rechargeable battery: The service life of the rechargeable battery is about 500 times for charging and discharging. When the battery life is going to end, if it can't work properly (charging failure, failure to full-charge or short time usage after getting fully charged), it is possible that the battery is damaged or reaches the end of its service life. Please contact our company for a new battery. Short-circuit or closeness to high temperature heat source is prohibited.

4. Sensor: A strong impact or vibration will cause performance decline or damage of the sensor; therefore you should prevent the sensor from falling from a high position or being pressed with weight.

5. Each time after using the instrument, host, sensors and some other parts should be cleaned appropriately, so that the connector or instrument is free from water, mud, etc. causing the decline of performance or damage to the instrument.

NOTE: Do not put the instrument and accessories into the water or scrub them with wet cloth!

NOTE: Do not use organic solvent to clean the instrument and accessories!

Please use soft dry cloth to clean the host.

Please clean the socket with a clean soft brush.

6. Storage: when unused, the instrument should be preserved in the packing box in ventilated, cool, and dry environment. If it is not to be used for a long time, periodical power-on inspection is necessary.

1.7 Responsibilities

The instrument is for precision testing, so in case of the following

actions or other man-made damages, ZBL Company will not bear relevant responsibilities.

1. Violating the mentioned requirements for working environment or storage environment.
2. Improper operation.
3. Opening the case and removing any parts without permission.
4. Serious damage caused by acts of man or accidents.

Chapter 2 Instrument Description

2.1 Instrument Composition

Wireless dynamic tester is mainly composed of the host, the PAD, excitation equipment and fittings (including power adapter, wire for charging, etc.).

2.1.1 Host

ICP sensor, data acquisition circuit, power management circuit, wireless transmission module and lithium battery are all enclosed into the Wireless dynamic tester host, as shown in Figure 2.1.

Figure 2.1 Appearance diagram of P8000 host

The sensor is coupled to the measured pile directly, the mechanical vibration is changed into electrical signals, acquisition circuit collects the signal received by the sensor, and then the signal

will be transmitted in real time to the pad through the wireless transmission module for display, analysis, storage. The operation is convenient and rapid, no need of any wire connection, it is applicable to any place.

2.1.1.1 Power switch

It is used to turn on / off the instrument. Pressed once, power is on; pressed again, power off.

2.1.1.2 Power socket

Connect the input plug of the power supply adapter (equipped with the instrument) with 200~240V AC power, the output plug with this nozzle, to supply power for the instrument, as well as to charge the internal battery.

2.1.1.3 Protective cover

Power socket of the P8000 is equipped with protective covers. It will be closed when not in use so as to protect the above socket.

2.1.1.4 Charging Indicator

It is used to indicate the battery charging state. Upon being connected with the power supply adaptor, the lamp lights up, which means a charging state. When the light turns green, it means the battery is charging with low current.

2.1.1.5 Working indicator

It is used to indicate the working state. The red light means the

power is low, need to charge in time, or the tester can't work normally. The green light means that the tester is working properly. Red and green light flashes to indicate that the tester is waiting for the match.

NOTE: When the light turns red, it means the power is low. You must charge in time, otherwise it will affect the normal operation of equipment.

2.1.1.6 Receiving Senor

Vibration sensor is one of the most important basic test elements for reflected wave dynamic testing; it is connected directly with the tested pile and changes the mechanical vibration parameter into electrical signal. Its performance parameters directly affect whether the data of electric signals could truly reflect the pile's reflection information. Now people all tend to choose a built-in type (ICP) acceleration sensor (as shown in Figure 2.2), because this kind of sensor is not limited to charge amplifier so that the frequency response is wider. As it has become the amount of voltage and low resistance output, and the line requirement is low, it is more suitable for the outdoor use.

2.1.2 Panel Computer

The P8000 wireless dynamic tester can work with panel computer of Samsung, ASUS and other major brands, as shown in Figure 2.2, the panel computer is used to receive the data collected by the dynamic tester, and then to display, analyze and store.

Figure 2.2 Panel computer

NOTE: The actual PAD may vary with the schematic, refer to the actual product.

2.1.3 Excitation Equipment

Figure 2.3 Hammers and Force Stick

Excitation was designed to make a disturbance at the top of pile, thereby causing an elastic stress wave along the pile. Stress waves with different frequency have different attenuation characteristics. Qualitatively speaking, high-frequency components are sensitive to

tiny interface and aggregate, but attenuate quickly; low-frequency components are easy to produce diffraction in small interface, but attenuate slowly and propagation relatively deep. Therefore, in practical application, knocking tests is often applied on site, such as changing the hammer's weight or shape of excitation rod, material hardness and adding pile cushion of different materials on pile head, so as to produce stress waves with different frequency components, which can meet the needs to judge the defects of pile's shallow and deep section.

When testing the piles through reflected wave, do not always use the same kind of hammer; several kinds of hammer and cushion should be prepared and selected according to different detection purposes. For testing of long big pile, generally we choose the excitation mode with high energy, wide pulse and low frequency, such as force sticks, nylon hammer which apply to the detection of defects in pile bottom, but it is also likely to cause mis-judgment about shallow and tiny defects. To avoid this, we can judge the defects and position in the shallow part by using the excitation mode with low energy, narrow pulse and high frequency. In some complicated cases, we can use the combination of high frequency and low frequency method to get the integrity signal of pile, which means using low frequency pulse wave to obtain the reflection from the pile bottom, and the high frequency pulse wave to detect defects of the top pile. To this end, we designed a variety of knocking devices of different weights and different materials, as shown in Figure 2.3.

2.1.4 Fittings

2.1.4.1 Power adapter

The input plug of the power adapter should connect 200~ 240V

AC power and the output plug should connect the host to supply power as well as to charge its internal battery.

2.1.4.2 Other accessories

Please refer to the packing list for details.

2.2 Low Strain (Reflected Wave) Detection Principle

The reflected wave method use low energy transient excitation mode to vibrate at the top of the pile to test the speed time-history curve, and determinate the pile integrity through wave theory analysis and frequency domain analysis.

Reflected wave method could test the integrity of pile concrete, identifying the defect position. Combined with the geological survey report, construction technology and construction records, it can also presume the properties of internal defects of the pile.

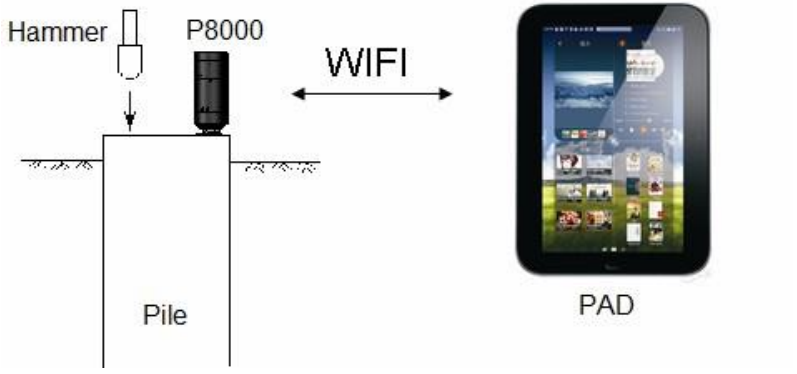


Figure 2.4 Schematic Diagram of Reflected Wave Detection

The Reflected Wave Detection is shown as Figure 2.4. Its basic principle is: use hammer or force stick to vibrate the pile head, the

stress thus produced will propagate downward along the pile. In the process, if it encounters wave impedance interface, the reflection and transmission of sound wave will be produced. The amount of reflection and transmission energy depends on the magnitude of the two medium wave impedance. According to the wave theory, when the stress wave meets breaking, segregation, necking and expanding in bottom, as the wave impedance declines, the reflected wave has the same phase with the incident wave; when the stress wave meets an expansion of top or bottom, as the wave impedance increases, the reflex wave has the opposite phase with the incident wave. A comprehensive judgment could be made about the pile integrity, defect degree, location, etc. by integrating amplitude, wave height, and arrival time of reflected wave.

Chapter 3 Detection Software with Reflected Wave Method

3.1 Software Description

Click the icon which is the link of P8000 wireless pile dynamic tester application program in the application list interface, you will enter the software interface of reflection wave detection (as shown in Figure 3.1.). The interface consists of the following 5 sections: **Title bar**, **Function Button Section, Waveform Section, Pile chart and Analysis Parameter Section, Pile's Information Section.**

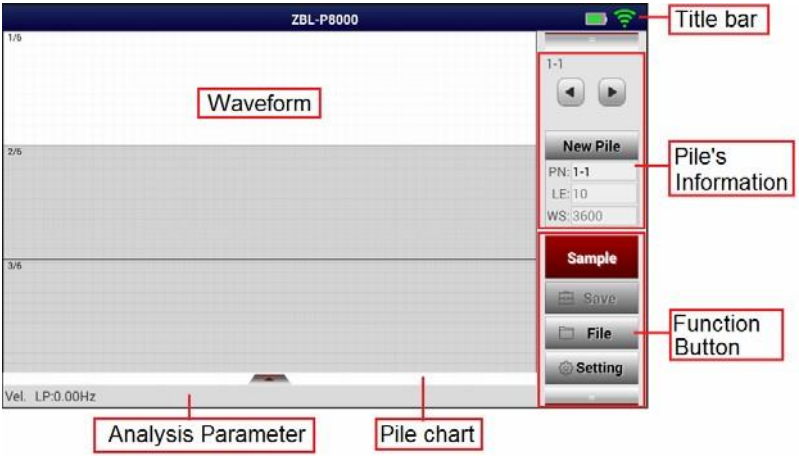


Figure 3.1 Software Interface of Reflected Wave Detection

1. Title bar

Title bar located at the interface of the top, the company logo and name are shown on the left, and the interface name is shown in the

middle of the title bar, the right side shows the sensor connection status and residual energy.

When the sensor is not connected, the wireless icon flashing, waiting for the connection, then click on the icon can enter the network settings interface, manually select the network to connect. After a successful connection, the WiFi icon stop flashing, and the work indicating lamp of the dynamic tester turns green by flashing red light.

2. Pile's Information section

This section is at the right-top corner of the main interface, shows the number, length and wave velocity of the current pile as well as a button New Pile.

There are two auxiliary buttons, € and €, in the top of this section, you can click them to move the cursor left or right. A point is shifted when pressed for a short time and the cursor is moved in an accelerated way if pressed for a long time.

The filename of current data is shown on the top of this section, press the filename for a long time, a list box will pop up to show all the files under current project, and then you can open one file to display by clicking one of the file in the list box.

3. Function button section

This section is in the right of the interface including many function buttons, such as File, Settings, Sample, etc. as shown in Figure 3.1. Every button represents one common function. When the button is grayed out, it means its function is invalid at current state.

Click the button  on top of this section and the button  on the bottom of this section, you can switch function buttons of the function button section. Besides, you can slide up or down in the function button area to achieve switching.

4. Waveform Section

The section used to display the waveform of current pile is in the left part of the main interface, as shown in figure 3.2. The intermediate fine black line of each waveform is the baseline, with scales marked below the waveform, and the scale value being time or length. Every waveform has two vertical green lines, representing the position of pile's top and bottom; the dark red vertical dotted line is set to be the defect location, on the right side the location of the defect is marked. On the left corner of every waveform displays the number of current waveform and the amount of total waveforms. The current waveform is displayed with white background while the other with gray background.

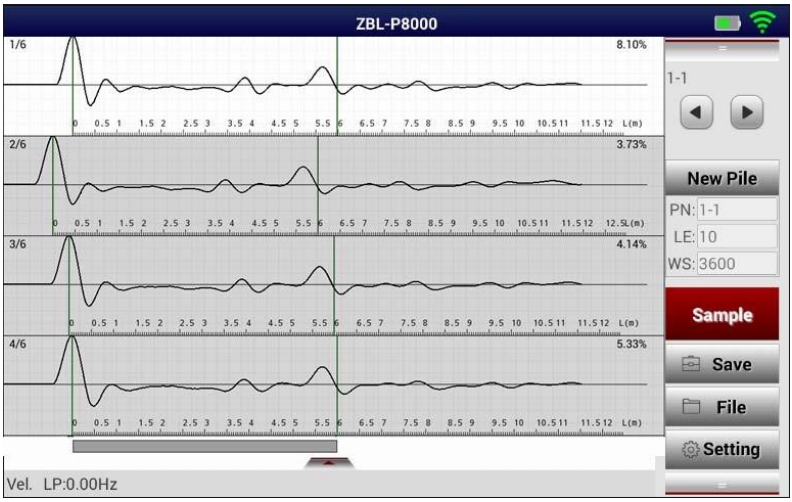


Figure 3.2 Waveform section

The waveform area can be interactive as follows:

1) Click a channel waveform in the waveform area, the channel will be regarded as the current channel and a vertical cursor appears at the click position; meanwhile parameters of the cursor position show in the cursor parameters area;

2) Click the € and € buttons in the pile's information area, to move the cursor to the left and right; a point is shifted when pressed for a short time and the cursor is moved in an accelerated way if pressed for a long time;

3) When the waveforms exceed a full screen, you can scroll the screen by sliding up or down on the touch screen.

5. Pile chart and analysis parameter section

This section is below the waveform section, consisting by 2 parts :

1) Pile chart section: show the chart of current pile; 2) Analysis parameters section: display the parameter used for analyze the current data. The section is usually retracted, only show the used analysis parameters. If you need to adjust the parameters, click any position of the area, it will be expanded to display all the analysis parameters. Please refer section 3.2.4.2 for details.

3.2 An Introduction to Software Functions

This software mainly has function of file management, parameter setting, data acquisition, data analysis and so on, in this chapter we will carry on the detailed introduction.

3.2.1 File Management

Click button File in the main interface of the software, the file management interface which include File, FTP Upload and Upload Log property sheets, as shown in Figure 3.3, will pops up, you can view or upload files of measured projects and piles.

3.2.1.1 File List

Click button File in the file management interface, the interface shown in Figure 3.3 will pops up, the left of which is the project list while the right shows the list of all the files in the current project, the lower part is the function button area.

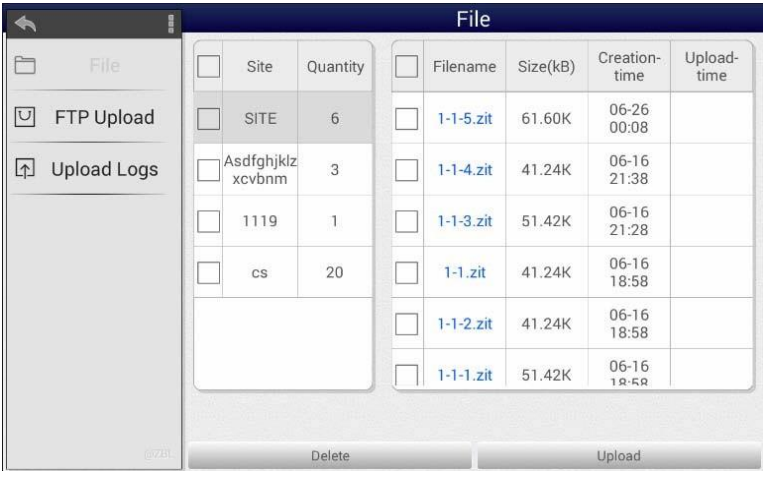


Figure 3.3 File List

1. Operation methods

1） Click a project in the list of projects, on the right displays all the files in the project; Click a file in the list of files, the file will be selected.

2） Click the list header to sort different columns; names will be listed in alphabetical order, the time column will be in chronological order and the file size column can be sorted according to file sizes, sorted either in ascending and descending order by multiple clicks.

3） Click the 1st column of the list header of project or file list, you can select all the projects or files.

4） Click the check box before a project or a file in the project or

file list, the project or file will be selected. You can select more than one project or file in the list box by clicking on the project or file needed to be selected.

5） When the projects or files exceed a full screen, you can scroll the screen by sliding up or down on the touch screen.

2. Opening file

Click on the filename in list of files，the selected file open and return to the main interface, showing the waves stored here.

3. Deleting projects and files

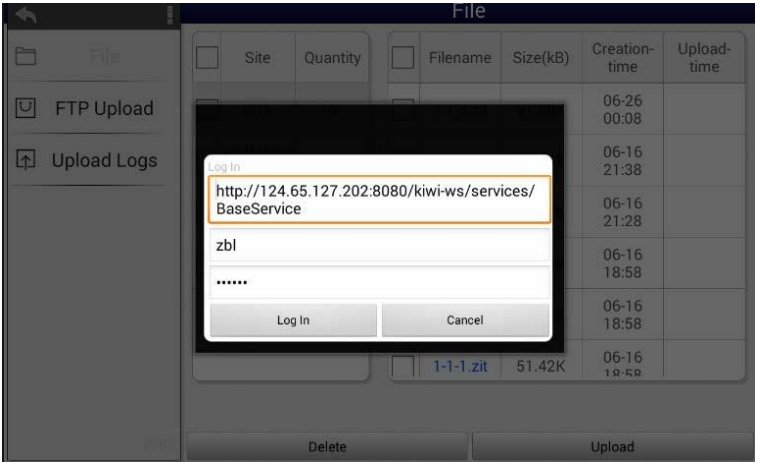
Click button Delete when select one or some projects，then the projects and their files can be deleted；click button Delete when select one or some files，then the files can be deleted. If no file or project be selected, the button Delete is ineffective.

Before delete project or file, there will be question "Sure to delete the selected sites or files?" click button Yes to delete, click button No delete not。

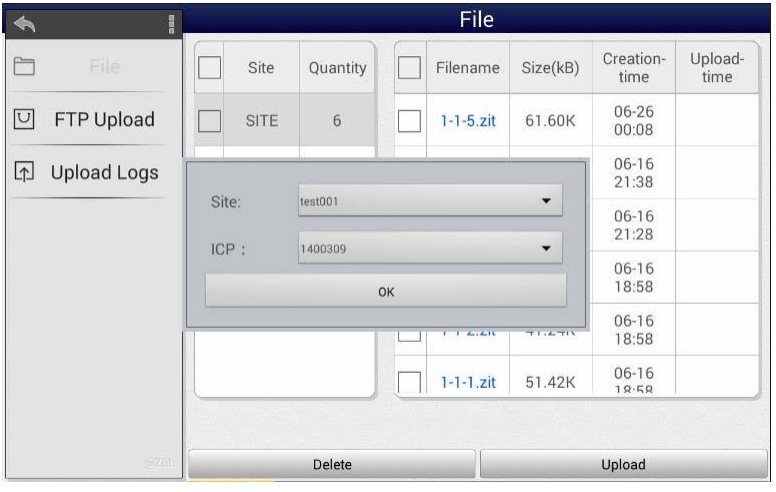
NOTE: Deleted data will not be able to recover! Before delete please ensure that the data has been backed up to the computer.

4. Uploading files

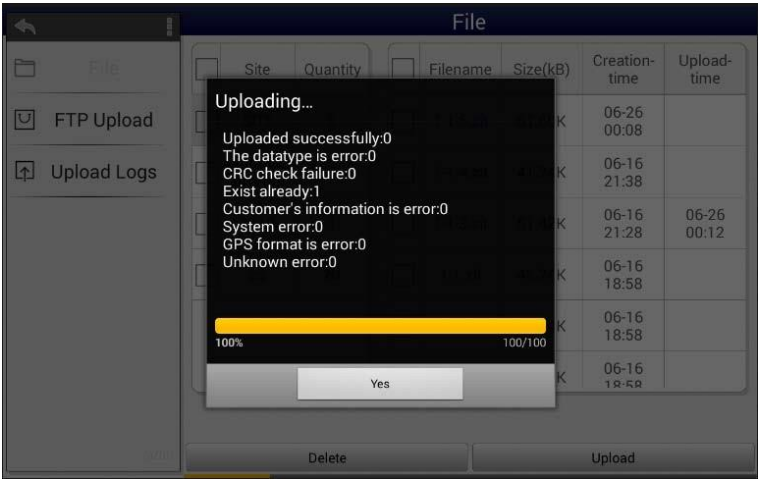
Click button Upload after selecting one project, a dialogue box as shown in Figure 3.4a will popup, click button Log In after setting all the login information, a dialogue box as shown in Figure 3.4b will popup, click the OK button after selecting the project and record No., then the files of the project can be uploaded to the NDT Management System, a message box as shown in Figure 3.4c pops up to display uploading progress information.



a) Log in



b) Select Record No.



c) Uploading Message

Figure 3.4 Uploading files

Click button Upload when select one or some files , then these files can be uploaded to the NDT Management System; If no file or project be selected, the button Upload is ineffective.

NOTE: The NDT Management System is developed by Beijing ZBL Information Technology Co., Ltd which is used to manage the overall process of NDT. Only the customer who have purchased this system can upload the testing data. For details, please refer to the manual of the system.

5. Exit

Click button  on the top corner, you can exit the file management and back to the main interface.

3.2.1.2 FTP upload

This function is used to upload the project and files to the PC.

Click the FTP Upload button on the left of the file management

interface, then display the interface as shown in Figure 3.5 to set Username and Password in Local Area Network (LAN).

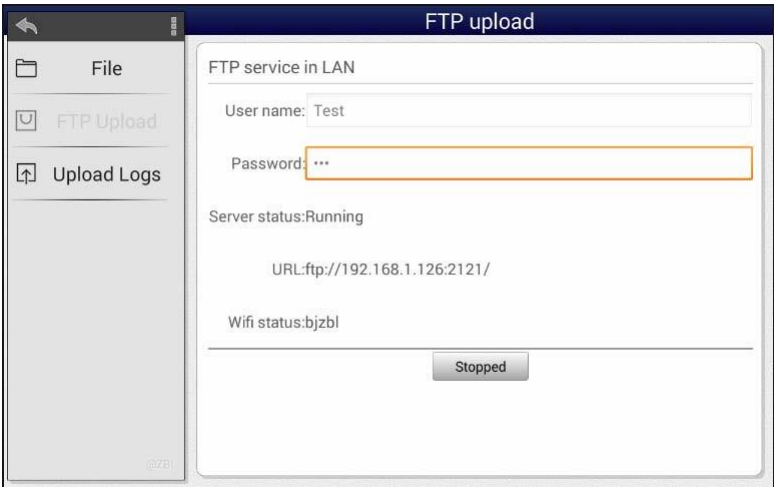


Figure 3.5 FTP Upload Interface

1. Username and password

Set username and password for client (computer in LAN) to access data in PAD, this item is mandatory since when FTP client logs on, it is required to verify whether this user has right to access data.

2. Service status

When FTP service in LAN is disabled, service status displays as "stop"; when FTP service is enabled, it displays as "running".

3. Access address

PC client accesses the address through link to view and download test data.

When FTP in LAN is disabled, the access dress is shown as "--"; when FTP service is enabled, the access address is shown as ftp://xxx.xxx.xxx.xxx:xxx/, such as ftp://192.168.1.126:2121/。

4. WiFi status

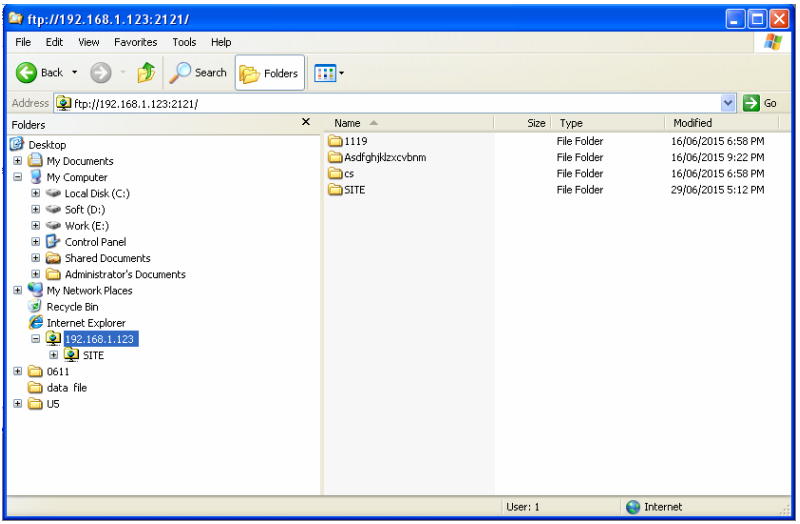
WIFI status displays the name of current connection, "Not available" will be shown when there is no connection. Click the

name of connected network, such as "zbl-1", then enter into the network setting interface to select the network to be used.

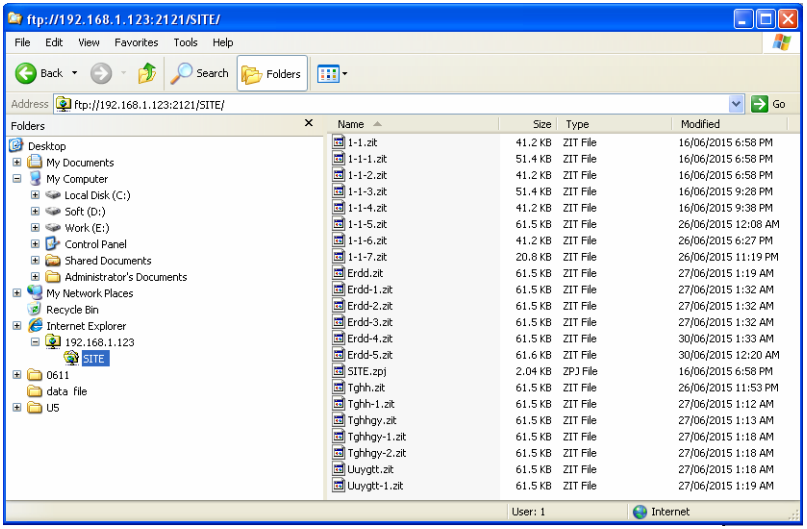
NOTE: FTP is used for file transmission on Internet, the common tools include FTP software, IE browser and explorer; LAN must be used when enable FTP service, otherwise access address cannot be generated.

5. Copying the data

Click Start button after settings, then the system will generate PC access address in this LAN automatically, the service status is shown as "running"; open explorer in any PC within the LAN and input access address in address field (such as ftp://192.168.1.161:2121/) and press the Enter key, dialog box will pop up to require enter username and password (which are set in Figure 3.5); after correct username and password have been entered, click OK button to view the projects folders and files in storage card, as shown in Figure 3.6.



a) Folder list



b）File list

Figure 3.6 FTP Access

Copy data from the instrument to computer through copying and pasting the selected projects (folder) or pile files in explorer.

3.2.1.3 Data upload log

Click the button of Upload Logs at the left side of file management interface, the log of test management system for data file upload will be shown at the right side of interface, including operator, record number, file name and upload time etc. as shown in Figure 3.7.

Select and keep pressing one log, the Delete button will pop up, click OK to manually delete the selected log.

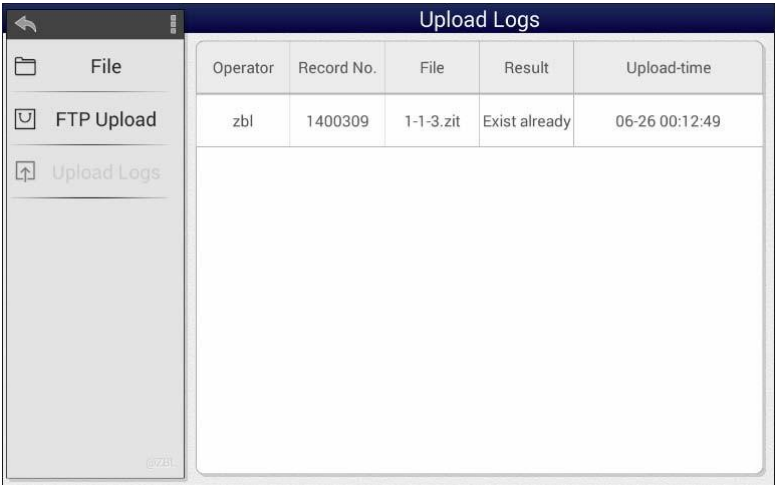


Figure 3.7 Data upload log

3.2.2 Parameter Setting

Parameter setting function is mainly used to set pile information, sampling parameters, etc.

Click button Setting in the main interface of the soft，the interface shown in Figure 3.8 will come out. This dialog box include 7 page, Pile Param., Sampling Param., and Display Param.. The default values of each parameter are values saved last time.

After setting the parameter, it will work immediately. If all the parameters are set, you can return to the main interface of reflected wave measuring to start testing.

3.2.2.1 Pile Parameters

Click Pile Param.， then switch to this attribute page as shown in figure 3.8, the project name, the information of pile could be set.

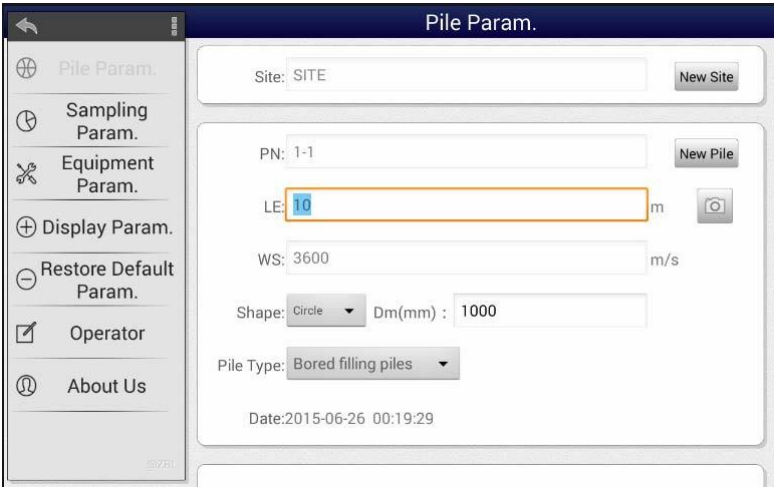


Figure 3.8 Pile parameters

1. Create a new site

Click the button New Site after the Site edit box, the character input soft keyboard will come out, after the site name input, a new folder with site name will be created, the data of all subsequent testing pile are stored in this folder. If the folder name already exists, there will be a prompt: "the site exists already, overwrite?" click the button Yes to overwrite, click the button No, the site name input box pop-up to input a new name of project.

2. Create New piles

When ready for the test of the next pile, click the New Pile button. The data of the current pile will be cleared and a new file will be created for the test of the new pile. Before emptying the data, the system will check whether the data has been saved "Save or not?" Select Yes, the file will be saved; select No, then it is not saved.

After the creation of the new pile, the character soft keyboard will automatically pop up, and the user may enter the name of the foundation pile to be tested.

3. On-site photograph

The purpose of this function is to photograph the piles to be tested. Click the camera icon below the button of New pile to enter into the photograph program; picture will be saved in the works folder automatically after photograph, its name is as same as the name of pile number.

4. Pile length and wave speed

Click the edit box after the LE, a numeric soft keyboard pops up, enter the designed (or actual) pile length (unit: m). Pile length should be as accurate as possible. After the input, the instrument will automatically set the sampling interval, as the exact pile length will be conducive to the pile shape analysis. The range of the pile length should be greater than 0 and less than 200.

Click the edit box after the WS, a numeric soft keyboard pops up, enter the designed (or actual) wave velocity (unit: m / s). Wave velocity should be as accurate as possible. After the input, the instrument will automatically set the sampling interval, as the accurate wave velocity will be conducive to the pile shape analysis. The range of the wave velocity should be greater than 100 and less than 10000.

Wave velocity value is generally based on the design strength of the pile concrete and experienced estimation, whose reasonable range is generally between 3000m/s and 4500m/s. Wave velocity of other types of piles is generally ranged as follows:

- precast piles: 3600 to 4200 m/s
- steel piles: 5100 to 5400 m/s
- filling piles: 3400 to 4000 m/s
- DJM: 1400 to 2100 m/s

For concrete piles, the correspondence between different strength levels and wave velocity is shown in the following table:

Concrete strength grade	C15	C20	C25	C30	C35	C40
wave velocity	2500	2800	3300	3600	3800	4100

Range (m/s)	3000	3500	3800	4000	4200	4400

5. Pile Cross-section Information

The shape of a pile cross-section can be of a Circle or a Rectangle. When a Rectangle is selected, the Diameter becomes the Length of the pile cross-section, and an edit box related to the pile cross-section Width will appear below.

6. Types of Foundation Piles

Main types of foundation piles include Bored filling piles, Manual digging piles, Precast concrete piles, Prestressed pipe pile, Immersed tube piles, Rammed expanded piles and CFG piles.

7. Test date and time

Test date and time is marked by the date and time for testing currently piles, which can't be modified. As for new piles, the test date and time is the system date and time; as for the measured piled, it is the date and time when it was tested.

8. GPS information and time

Global Positioning system (GPS) is used to display the coordinates of current test data for authenticity investigation of data. For new pile, GPS information and time is position information of the current pile; for tested pile, it displays the position information of test data.

3.2.2.2 Sampling Parameters

Click Sampling Param., then switch to this attribute page as shown in figure 3.9, advanced parameters for sampling could be set. These parameters should not regularly set, once set up can be constant.

Figure 3.9 Sampling parameters

1. The sampling interval

The sampling interval is the time difference between every two sampling signal, you can select one of the 9 intervals, 6.4μs, 12.8μs, 25.6μs, 51.2μs, 102.4μs, 204.8μs, 409.6μs, 819.2μs and 1638.4μs. This value can be set or not , but pile length and velocity must be set before sampling so that it will automatically calculate the sampling interval value.

2. Sampling points

Sampling points is quantity of signal sampling points, usually it is set to 1024.The same pile length, bigger the points of the sample , smaller the sampling interval, which means the sampling frequency is higher, more conform with the sampling principle , smaller the signal distortion is.

3. Blow number

Blow number refers to the total number waveform that every channel to collect, there are multiple options, minimum is 1, maximum is 12.

4. Gain

Gain is the amplification of the electrical signal received by sensor of instrument, it's designated fixed magnification, 1, 2, 4, 8, 16, 32, and 64 can be chose, generally it is set to 8. Gain value should be adjusted according to the length of pile, condition of pile top surface, vibration equipment and so on. When the signal is so weak that it's not easy to trigger, increase the gain value; when the signal is too strong, decreases the gain value.

5. Trigger level

Trigger level is the level of signal collected when starting the instrument, there are three levels: Low, Medium, and High. Higher the set is, stronger the receiving signal be required. In pile testing, average gain is no greater than 10 in case of "low ", gain greater than 50 in case of "high". If the interference signal in scene is so strong that signal produced without knocking after sensor be set, set to "high level".

6. Sampling method

There are two methods, Single collection and Continuous collection. Single collection means according to the parameter setting only one waveform can be collected once; continuous collection means according to the same parameter set, continuous multiple waveform can be collected, until the acquisition be stopped.

7. Quality of hammer in each channel

You can choose a number between 1 and 6.If the quality is bigger than 1, then it is a overlapping sample, which means all the sample collected in the same channel will be plus and then average.

8. Acceptance mode

When test in scene, percussion will influence the quality of signal, if knocking force is too large, then the signal will be distorted, while knocking over light, the bottom signal of pile may not found, so the knocking force must be moderate. According to signal strength, we

can determine the strength of the force.

Three modes are accepted, Automatic, Manual, and All. In automatic mode, if the strike is too heavy or light, the dynamic tester will automatically abandon the signal, while show corresponding message, only when the percussion is moderate will the collected signal to be a useful one. In manual mode, if the strike is too heavy or light, dynamic tester will give the appropriate message and ask whether to retain the signal or not, click buttonYes, and the signal is a useful signal, click buttonNo, the button will be abandoned. When the All mode be selected, if the strike is too heavy or light, dynamic tester will be given the corresponding message and keep the signal.

3.2.2.3 Instrument parameter

Click on the Equipment Param. tag and it then switches to the Properties page, shown in Figure 3.10, you can get the instrument information.

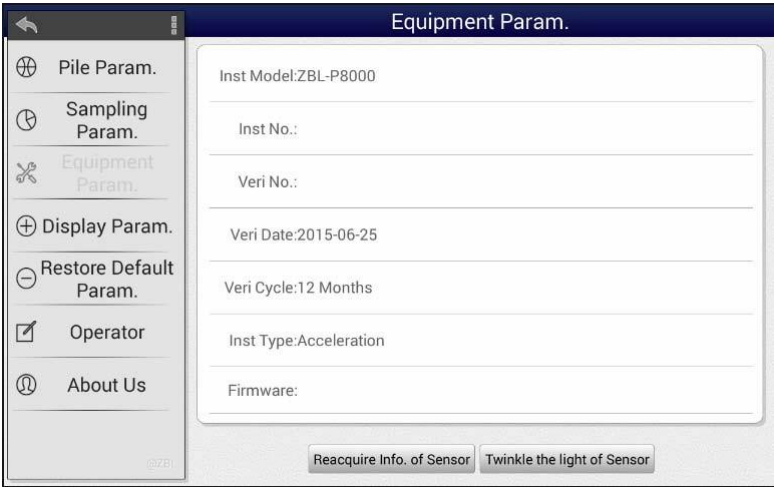


Figure 3.10 Equipment parameters

1. Verify date and cycle

Verify date refers to the most recent test date of the instrument; verify cycle refers to the time interval for each test, generally about one year. Judged according to the verify date and cycle, one month before the expiration of the certification date, each boot will remind the user of the inspection to be made.

1. Regain sensor information

The page of Equipment parameters displays the instrument information used in the last time according to the default setting; click Reacquire Info. of Sensor to update the information of currently binding instrument to here.

2. Instrument indicator flash

If there are several instruments in operation and have no idea about which instrument is bound, this function may be used to find out the instrument. Click Twinkle the light of Sensor, the indicator of bound wireless dynamic testing instrument for foundation pile will flash.

NOTE: Before click two buttons above mentioned, make sure the instrument has been turned on and the connection with PAD has been established.

3.2.2.4 Display Parameters

Click the Display Param. tab and it will switch to the Properties page, shown in Figure 3.11, you can set the Pen width, X Axis and can preview the effect of setting on the bottom.

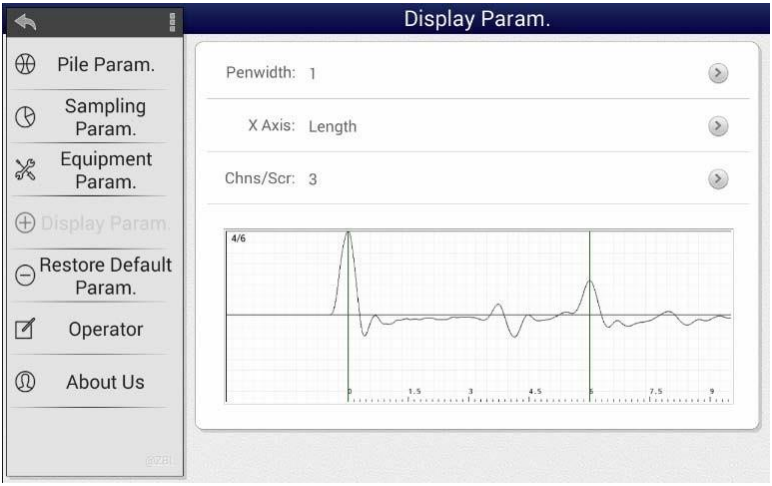


Figure 3.11 Display parameters

1. Waveform line width

The scope of the single-channel waveform line width is around 1 to 5, with the default as 1.

2. Abscissa axis

For select Time or Length, the unit and the scale value of every waveform abscissa can be changed; default is on behalf of Length.

3. Chns/Scr

Chns/Scr refers to the amount of waveform displayed in every screen; option is 1, 2, 3 or 4. Number in every panel can't be bigger than the sampling number.

3.2.2.5 Restore Default Param.

Click the label of Restore Default Param. to switch to its property page as shown in Figure 3.12 and recover pile parameter, display parameter and sampling parameter, etc. to Restore default parameter.

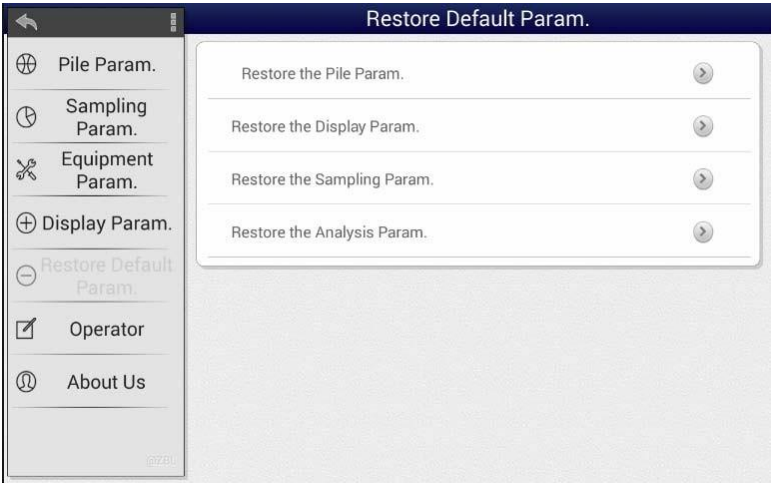


Figure 3.12 Factory parameters recovery

1. Restore the pile parameter

Modified pile parameter may be recovered to factory setting through this function. Click Restore the pile parameter, the dialog box of "Sure to restore the pile parameters?" will pop up; clicking Yes button will recover the pile parameter to factory setting and clicking No button will not recover it.

2. Restore the display parameter

Modified display parameter may be recovered to factory setting through this function. Click Restore the display parameter, the dialog box of "Sure to restore the display parameters?" will pop up; clicking Yes button will recover the display parameter to factory setting and clicking No button will not recover it.

3. Restore the sampling parameter

Modified acquisition parameter may be recovered to factory setting through this function. Click Restore the sampling parameter, the dialog box of "Sure to restore the sampling parameters?" will pop up; clicking Yes button will recover the sampling parameter to factory

setting, clicking No button will not recover it.

4. Restore the analysis parameter

Modified analysis parameter may be recovered to factory setting through this function. Click Restore the analysis parameter, the dialog box of "Sure to restore the analysis parameters?" Click Yes button to recovery the analysis parameter to factor setting, clicking No button will not recover it.

NOTE: If test data exists, all buttons for parameter recovery is invalid and parameters cannot be recovered.

3.2.2.6 Operator

Click the Operator tab and it will switch to the Properties page, shown in Figure 3.13, you can check or modify the information of testers.

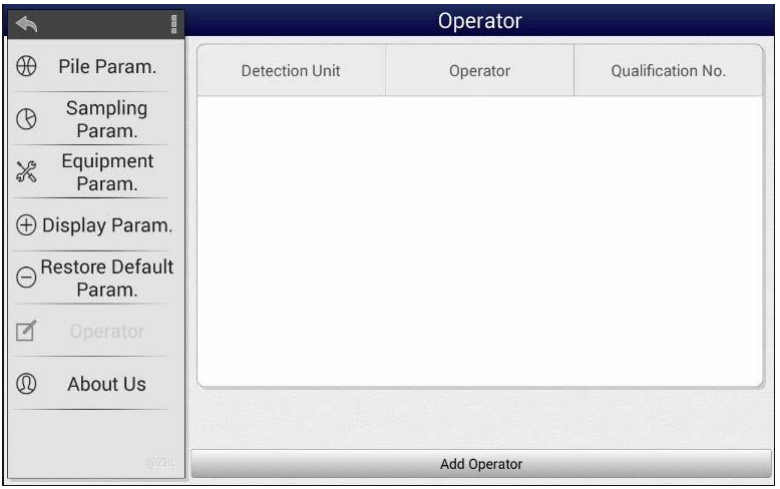


Figure 3.13 Operator

1. Add a new tester

Click the Add Operator button, a dialog box will pop up, users

can input the information of testers, after that, click OK button, the tester will display in the list; click Cancel button, the information of the tester will be canceled.

2. Edit tester

Press the tester list area for a long time, a menu will popup, click Edit button, you can modify the information of the selected tester, after finishing modification, click OK button, the information of the tester will be updated; If click Cancel button, the modified information will be canceled.

3. Delete tester

Press the tester list area for a long time, a menu will popup, click Delete button, a message box will pop up for you to confirm to delete the selected tester, click OK button, the tester will be deleted from the list; If click Cancel button, the tester will not be deleted.

3.2.2.7 About us

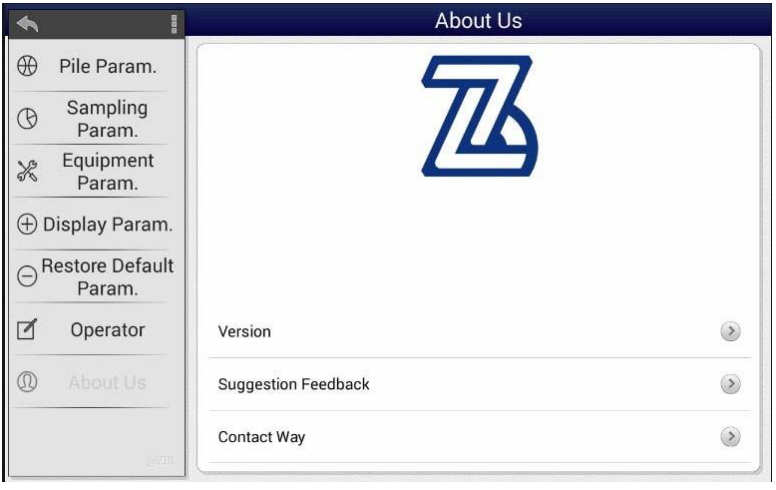


Figure 3.14 About us

Click About us label to switch to its property page as shown in Figure 3.14 about brief introduction of our company, version information of this software, contact way and suggestion feedback.

1. Version information

Click Version to enter into the interface as shown in Figure 3.15, the Version bar displays version number of the software.

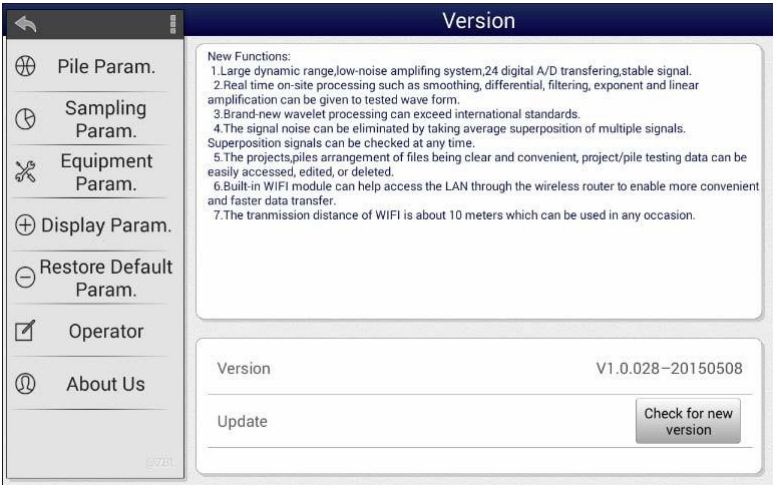


Figure 3.15 Version information

Click Check for new version button to detect update version. If so, new functions and version information will be shown on the top information box and user will be suggested to update the software, the Check for new version button will change to Update button; if no, information box will display that current version it the latest version. Click Update button when new version is available, the software will be closed and updated to the latest version automatically.

NOTE: Before detect new version or update software, make sure PAD is connected with Internet.

2. Feedback

During the service period of our products, if you find out any problems or have some suggestions, please click Feedback button and

enter into the interface as shown in Figure 3.16, fill your suggestions and relevant information, click Feed back to us button to send them to us, we will reply to you after have received the suggestions.

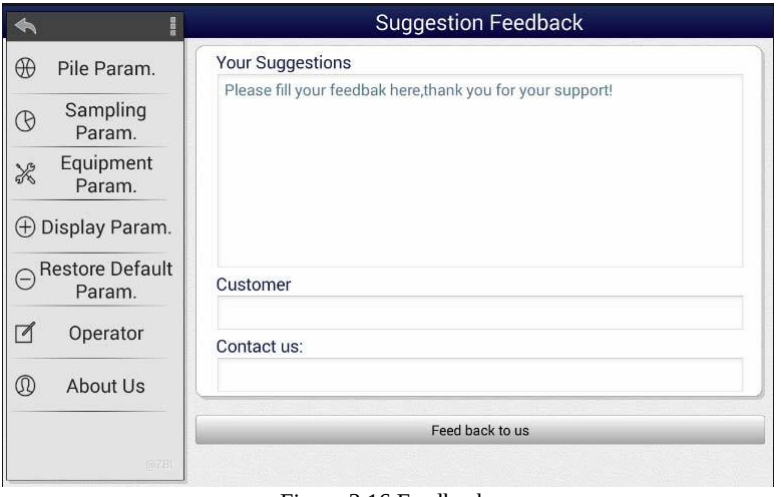


Figure 3.16 Feedback

NOTE: Before submit your suggestion, make sure PAD is connected with Internet.

3. Contact information

Click Contact way for the contact information of our company, including company name, website and customer service telephone number, etc.

3.2.3 Test Starting

3.2.3.1 Connection establishment

Before test, PAD must be connected with wireless dynamic tester: click the icon of  at the top right corner of interface to enter into the list of wireless network (as shown in Figure 3.17), select the wireless dynamic tester to be used (for example, ZBL-605D48), click Connect button and enter connection password in pop-up dialog box (for example, ZBL-P8000-605D48) to connect; after connection has succeed, return to acquisition interface, battery level and the icon of  are shown on the top right corner; if connection failed, the icon of  flashes continuously prompting the connection is not successful.

Figure 3.17 Wireless network

NOTE:

1）Data may be collected only after it is connected with wireless testing instrument, otherwise test cannot be implemented normally,

2）The name of wireless dynamic testing instrument in the list of wireless network is “ZBL-6-digit address code”(such as ZBL-001EEA),the connection password is ZBL-P8000-6-digit address code (such as

ZBL-P8000-001EEA）.

3）If connection has been established before, it will be established automatically during the software operation. 4）If the wireless connection icon at the right side of title bar keeps flashing, it means connection is not established yet. Please check whether the instrument is powered on, if automatic connection is not available when the instrument is powered on, please connect it manually according to the operation process above mentioned.

3.2.3.2 Signal acquisition and stop

1. Non overlapping sampling

Click the button Sample and wait for the start of the sampling, then there will be the information "sampling..." for users to knock. On waiting for sampling, button Sample turns to button Stop. If you want to stop sampling, then click the button Stop.

When use single sampling, every waveform sampled will be displayed in the waveform area, and automatically stops sampling. If users want to sample next waveform, they need to click the button Sample after chose next wave.

When use the continuous sampling, every waveform sampled will be displayed in the waveform area and automatically jump to the next one. In the sampling process, users can stop sampling at any time by click the button Stop.

When a sampling of signal has finished, judge whether the percussion force is appropriate according to the signal intensity, corresponding tips will be shown in the interface or dialog box if the signal is too heavy or light. According to different accepted mode, there will be some difference, refer to section 3.2.2.2.

2. Overlapping sampling

Click the button Sample and wait for the start of the sampling, then there will be information "sampling..." for user to knock. On waiting for sampling, button Sample turns to button Stop. If you want to stop sampling, then click the button Stop.

When use single sampling, every time when a waveform sampled it will automatically stop, and re-calculate the average waveform, displaying the average waveform in the current channel. If user want to collect a new waveform, then click the button Sample.

When use continuous sampling, every time when a waveform sampled it will automatically re-calculate the average waveform and add a new waveform for next sample. When the total number of overlapped waveform reaches the set value in "parameter setting", it will automatically turn to next channel and continue sampling

When a sampling of signal has finished, judge whether the percussion force is appropriate according to the signal intensity, corresponding tips will be shown in the interface or dialog box if the signal is too heavy or light. According to different accepted mode, there will be some difference, refer to section 3.2.2.3.

3.2.3.3 Overwrite the waveform

When signal collection finished and sampling stopped, if users find that the quality of signal in some channel is not good, it's necessary to re-collect and overwrite the existed ones. Click the button Sample after select the channel, then knock at the pile top for a second time, the new sample will automatically overwrite this channel.

3.2.3.4 Playback the waveform

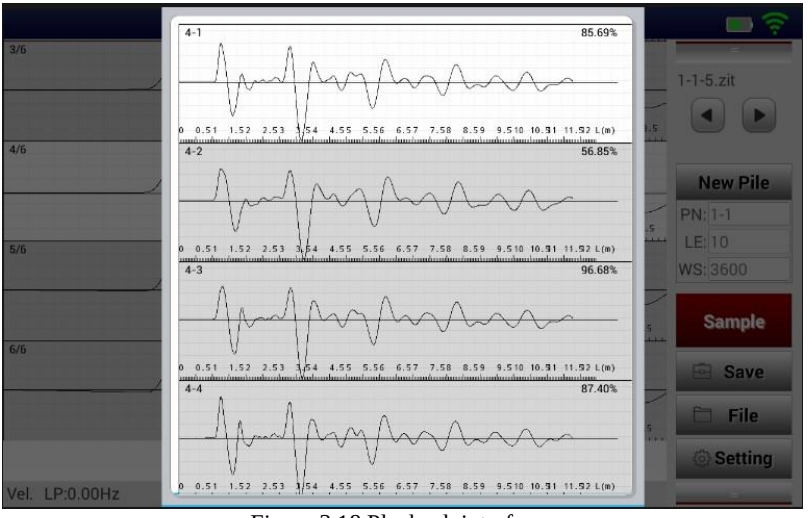


Figure 3.18 Playback interface

Press one waveform for a long time, click the button Playback in the pop-up menu, then enter the playback interface shown in Figure 3.18, where users can delete or retain the overlapping waveforms. In the left up corner of the waveform there shows "channel m-- hammer n", the current waveforms shown with white background while the others gray background.

NOTE: The button Playback is effective only in condition of overlapping sampling.

1. Delete or retain the waveform

Enter the interface of waveform playback, if users find that the quality of signal in some channel is not good, click the button Reject in the pop-up menu after pressing the channel for a long time, then the wave in this channel will be shown in dash line which means it has been deleted.

Select a rejected waveform, click the button Retain, then the

waveforms could be saved and shown in black solid line.

2. Exit playback

Click the buttonBack on the PAD panel or click the waveform area, then returned to the testing interface, and automatically calculate the average waveform (the rejected waveform will not be included in average) and refresh the display in waveform area.

3.2.3.5 Edit the waveform

Figure 3.19 Edit menu

When there's waveform in waveform area, user can stretch, compress or delete the waveform, click any position in waveform area for long time, the menu shown in Figure 3.19 will popup. If there's no waveform in waveform area, the menu cannot pop-up.

1. Playback the waveform

Please refer section 3.2.3.4 for details.

2. Inversion of waveform

Click the button Reverse, all the waveforms in the current pile will be displayed inversed.

3. Delete one waveform

As finish the collection of signal and sampling, if users find that the quality of signal in some channel is not good, click the button Delete One after the channel is selected, then the wave in this channel

will be deleted. The quantity of wave will reduce by one.

4. Delete all the waveform

As finish the collection of signal and sampling, if users want to delete all the signal in waveform, click the button Delete All, there will be a dialogue box "Delete wave in all channels, yes or no", click button Yes， wave in all channels will be deleted; click button No, no wave will be deleted.

5. Compression and tension of waveform

While separating or closing the two fingers horizontally in the waveform area, all the waveforms in the current pile will be compressed transverse (axis of time or length) or stretched. When compress or stretch to a certain extent, you can't compress or stretch the waveform again. After tension, you can slide left or right in the waveform area to realize waveform rolling.

3.2.3.6 Check the Waveform

When there are many lines of waveform in the waveform area, you can slide up and down in the waveform area to realize waveform rolling.

3.2.3.7 Move the Cursor

After the acquisition of the signal, if the user needs to see the parameters of a certain position of waveform in the waveform area, just click on location of the waveform to be viewed, a vertical cursor would appear, displaying in the cursor parameter area the acoustic time difference T (ms, with respect to the pile top), the depth L (m) and the velocity C (m/s). In addition, click the € and € buttons in the pile's information area to move the cursor; Press once to move a point, press for a long time to accelerate the cursor move.

3.2.3.8 Save the File

After finishing the signal acquisition of a pile, click Save button, there pops up a dialogue box to input the file name to save the file. The name of the default file—"pile- serial number" (the serial number is a digital) can be changed or not. After inputting the file name, click the OK button, then save the file and make the Save button gray. If there is the file of the same name, it is suggested that "file already exists, whether to overwrite it?" Click Yes and overwrite the original file; click No to cancel the command, and then the dialogue box pops up again to ask for a new file name.

If there is no test data, make the Save button gray; if the current data have been saved with several modifications only, click Save then, and the data will be saved into the original file. Make the Save button gray, there will be no dialogue box again.

3.2.3.9 Multiple tests on the current pile

If multiple tests need to be conducted on the current pile (change the measured point or percussion point or percussion equipment), click the Sample button and the sampling can be done directly after the replacement of measured point or percussion point or percussion equipment without the need of any modification when the previous test is completed and saved.

3.2.3.10 Test a new pile

When a new pile is to be tested, there are two ways to create the new pile:

1) Click the New Pile button in the pile information area on the right side of the main interface;

2) Click the Settings button on the main interface to enter the parameter setting interface, click the New Pile button, details can refer to Section 3.2.2.1.

The system will automatically clear the current data and create new pile files, but it checks first whether the current data is saved before clearing. If the current data is not saved, a box will pop up asking "Save changes to the file?", click the Yes button, then it is saved; click the No button, it is not saved.

Test can be done by clicking the Sample button after the creation of the new pile and modification of parameters such as pile number, pile length and wave speed.

3.2.3.11 Exit

Click the Exit button on the PAD panel twice continuously, and exit from the interface of the reflected wave to test pile. Before exiting, check the current data to see if they have been saved. If not, it is prompted that “Save changes to the file?”. Click Yes, and then exit with saving the data; click No, and then exit without saving the data.

3.2.4 Analysis

Click the analysis parameters section after data acquisition, and it enters the analysis interface shown in Figure 3.20. The upper left of the interface displays the current channel waveform (exactly the same as the waveform displayed in the waveform area), and the lower part of the interface is the analysis parameters adjustment area.

Figure 3.20 Analysis interface

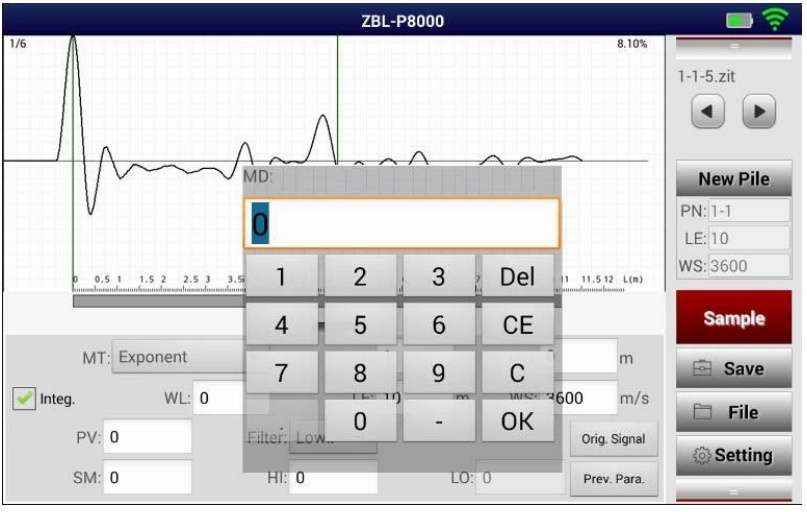


Figure 3.21 Digital panel

3.2.4.1 Parameter adjustment

In the parameters adjustment area of the analysis interface, various analysis parameters can be set as follows:

1) Click the edit box following the parameters to be modified, and then a digital panel pops up, enter a value directly, click OK button.
2) In the digital panel, click the Del button, and then it will delete the number in front of the cursor position; Click the CE button, and then it will delete all the number; Click the OK button, the input is confirmed and the soft keyboard is closed; Click the C button, the input is invalid and the soft keyboard is closed.
3) Click the Orig. Signal button, restore all the analysis and processing parameters to zero (integrator and filter are set to No; wavelet, smooth and rotation are set to 0, the index of amplification is set to 1.); a dialogue box pops up asking "Sure to restore?", press Yes, it restores; press No, it does not restore.
4) Click on the Prev. Para. button, and then all processing parameters are set to the previous processing parameters.

When setting the analysis parameters, real-time analysis and processing of the waveform in this channel is made and the processed waveform will be displayed.

After setting the analysis parameters, press any blank position on the analysis parameters section and then it will be hidden, and displays all the waveforms after analyzed and processed according to the set parameters in the current file.

3.2.4.2 Analysis Parameters

1. Integral Processing

When the acceleration sensor is used for testing, the signal collected is the acceleration signal, which seems to be "complex" and generally needs integral processing to transform into speed signal which is more distinct but cannot be integral processed. "Speed", "Acc." in the analysis parameters area means the signal is speed signal and acceleration signal respectively.

2. Signal Amplification

If you want to magnify the figures of the signals collected, you need to set the way (exponent, linear), starting point and multiple of amplification. The starting point of amplification refers to the start position of the exponential and linear amplification of the signals (relative to pile head, unit: m), and the input range of the starting point of amplification is 0m—0.8 times pile length. When the analysis parameters area displays "exponent, linear", it means that the signals have been magnified on exponent and linear, and the multiple of amplification often shows following the way. For example, "EXP: 5.0" indicates 5 times exponential amplification of the signal. The multiple of exponential and leaner amplification should be appropriate, as long as you can see the signal at the bottom of pile clearly.

3. Wavelet Analysis

Wavelet analysis is a new time-frequency analysis method developed in recent years. It makes a great breakthrough on signal processing, image compression, speech coding, pattern recognition, seismic exploration and many nonlinear fields of science and it is widely used. Making use of it to analyze dynamic testing signals can get good results. Wavelet factor can be set to be any decimal between 0.1 and 8.0. If the wavelet analysis is made on the signals, the analysis parameters area will display "WL" with wavelet factor following.

4. Digital Filtering

Digital filtering includes three filtering methods: low-pass, high-pass and band-pass. Low-pass filtering filters out the signals greater than a certain cut-off frequency, while high-pass filtering filters out the signals less than a certain cut-off frequency, and band-pass filtering filters out the signals greater than the high cut-off frequency and less than the low cut-off frequency. The diagrammatic drawing of filtering is shown in Figure 3.22. Generally the low-pass filtering is often used for analysis. The value of cut-off frequency can be set according to experience. The longer the pile is, the lower the low-pass cut-off frequency should be. It can be also set after the spectral analysis of the signals. With the low-pass, high-pass or band-pass filtering on the signals, it displays "LP", "HP" and "BP" in the analysis parameters area and presents the value of cut-off frequency after them.

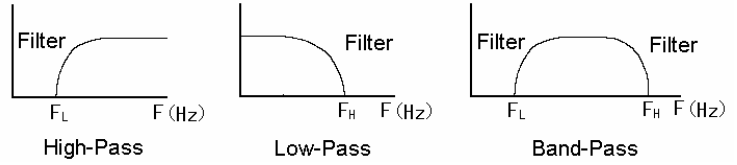


Figure 3.22 Diagrammatic Drawing of Filtering

5. Smoothness

When there is high frequency "clutter" in the signal, you can use smoothness to filter it out. The higher the smoothness point is, the more "gentle" the waveform after the smoothness will be. The smoothness points range from 3 to 512, generally setting to 10. With the smoothness on the signals, the analysis parameters area will display "SM", and the smoothness points followed.

6. Waveform Rotation

Sometimes after the integral processing of the signal, the end of waveform will be upturned. Then the waveform needs to rotate, making the end back to the position of the baseline. The percentage of

the rotation is relative to through amplitude. If the through amplitude is A, and the amplitude of the signal end is B, then the percentage of the rotation is (100×B/A), which can be positive and negative (No matter the rotation is clockwise or anticlockwise, the higher the number is, the more the rotation will be.). After the waveform rotation, the analysis parameters area will display "PV" with the percentage of rotation followed.

NOTE: Due to the filter action of wavelet analysis, digital filtering and smoothness among the processing methods above, you can take one of the methods or all methods at the same time. The parameters used should be appropriate, or some useful signals would be processed, causing misjudgment.

3.2.4.3 Analysis of pile shape

Click the button  or the button  or slide up or down on the function button section, you can switch to the analysis interface as shown in Figure 3.23.

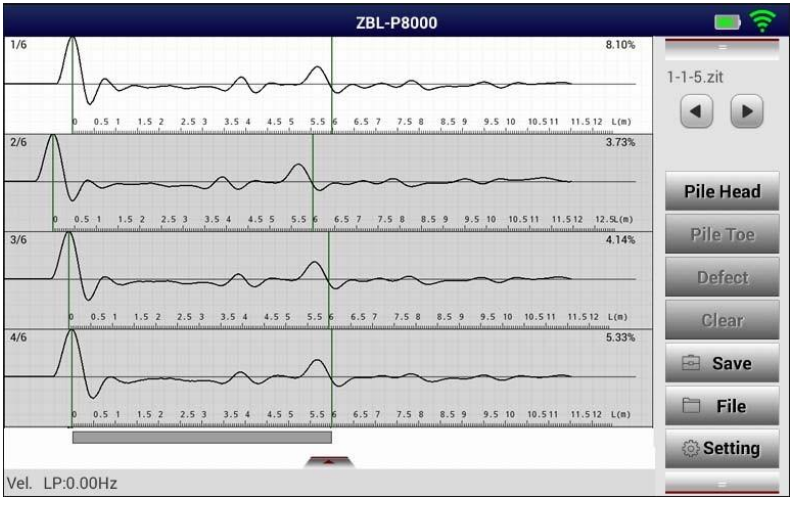


Figure 3.23 Analysis of pile shape

1. Set the Pile Head and Pile Toe

When the waveform area displays time-domain waveform, click the waveform area. Move the cursor to the click point, and then click Pile Head button, setting the cursor position to pile head.

When the waveform area displays time-domain waveform, click the waveform area. Move the cursor to the click point, and then click Pile Toe button, setting the cursor position to pile toe; the default setting is to compute wave speed according to pile length. If adjust the position of pile toe after setting the wave speed, then the pile length will be computed on the basis of wave speed.

2. Set and Clear the Defect

When the waveform area displays time-domain waveform, click the waveform area. Move the cursor to the click point, and then click Defect button, it will pop up a dialogue box shown in Figure 3.24. After choosing the type of the defect and the extent of severity, click OK, and then set the corresponding defect at the current cursor position. Then the cursor position of the oscillogram will appear a vertical tag line, the defect position showing on the right.

Figure 3.24 Dialogue Box for Defect Setting

If you set various defects at the same position, only the last setting is useful. The diagrammatic drawing in the pile charts area will change accordingly after setting the defect.

Besides, after setting the defect, click the Clear button, and clear

all the defects.

3.2.4.4 Edit the Waveform

It is identical to the testing interface, and you can see the details in Section 3.2.3.5.

3.2.4.5 Change the Pile Information

Pile number and the pile length can be changed on the analysis interface, which requires clicking the edit box behind the relevant parameters in the pile information area.

3.2.4.6 Move the Cursor

It is identical to the testing interface, and you can see the details in 3.2.3.7.

3.2.4.7 Spectrum Analysis

Click the  or  button or slide up or down on the function buttons section, and it will switch to the spectrum analysis interface, as shown in Figure 3.25, and the amplitude spectrum of all the signals will be analyzed, their frequency spectrogram displaying in the waveform area. F0 at the upper right corner of the figure presents frequency resolution. Fm presents the value of main frequency, and F_n-F_{n-1} is the difference of peak frequency.

Figure 3.25 Spectrum Analysis

When the waveform area displays the frequency spectrogram, move the cursor to a certain position, and then the frequency value of the cursor position will be shown in the cursor parameters area. Click the Set Peak button, and the frequency of the current cursor position will be taken as peak frequency and compute the difference of all the peak frequencies. Five peak frequencies can be set at most. If you want the frequency be identified automatically, press the Auto Ident button.

If you want to clear the mark of a certain frequency peak, move the cursor to the position near to the mark and click Remv Peak.

If you want to set the length of spectrum analysis, click the drop-down list on the right side of the spectrum analysis length, you can choose spectrum analysis length, 1024, 2048 or 4096. After setting different values, the spectrum can be displayed in real-time.

3.2.4.8 Save the File

It is identical to testing interface, and you can see the details in

Section 3.2.3.8.

If the current data have been saved with several modifications only, the Save button is valid. Click Save then, thus the data will be saved. And make the Save button gray; if it is a new data file, there will pop up a dialogue box to input the file name (The name of the default file is "pile- serial number") when it is saved for the first time. After inputting the file name, click the OK button, then save the file and make the Save button gray; if there is the file of the same name, it is suggested that "whether to overwrite it?".

3.2.4.9 Quick access to the pile files

Click the filename of current data under the  button for a long time, a file list box pops up to display all the saved files of current project, click one file of the list box, then the data of the file will be read and displayed. Before the file is opened, it will check whether the current data has been saved, if not saved, you are prompted to save the data.

3.3 Fast Operation Guide

3.3.1 Preparations before Testing

3.3.1.1 Site Preparations

1. Clean the Pile Head

The coupling point of the sensor and the striking point of the hammer must be clean, flat and hard, so it is necessary to do something with the pile head before testing— clean the floating cement and other sundries on the pile head, and polish two or three smooth surface used for placing the sensor and knocking the hammer, as shown in Figure 3.26.

Figure 3.26 Clean the Pile Head

2. Install the Sensor

In the *Technical Norms of Building Pile Testing JGJ106*, the installation of the sensor has the requirements as follows:

1) Defects or cracks are not allowed at the installation point of the sensor or somewhere near it;
2) When the hammering point is at the center of the pile head, the distance between the installation point of the sensor and

the center of the pile should be two-thirds of the pile radius, as shown in Figure 3.27;

3) When the hammering point is not at the center of the pile head, the distance between the installation point of the sensor and the striking point should be more than a half of the pile radius;

4) As for the prestressed pipe pile, the angle between two planes formed by the installation point of the sensor, the hammering point and the center of the pile head should be 90 degree, as shown in Figure 3.27;

5) As for the major diameter pile, two or three measured points should be selected at different places;

6) Try to avoid the places with steel and concrete quality problem.

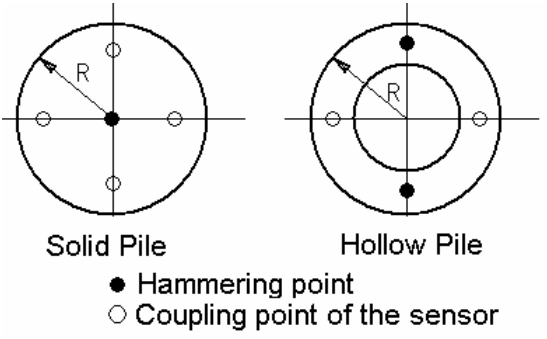


Figure 3.27 The Coupling Point of the Sensor and the Hammering Point

When installing the sensor, the grease, vaseline and plasticine with greater consistency can be used for the couplant, which should be thin but with great viscosity. And the viscosity should not be affected by water or other substances. The sensor installed must be vertical with the pile head and stick to it, not slipping or loosing during the course of the signal acquisition.

NOTE: After the sensor is glued well with the couplant, flick the profile of the sensor with your finger. If the sensor is

absolutely still, it means the sensor has been installed well and is ready for testing.

3. Choose the Appropriate Striking Equipment

Excitation technology is one of the most important links in testing the integrity of the pile with reflected wave. Different piles with different lengths need to adopt corresponding materials and excitation equipment. Generally speaking, the big and long pile requires a stick with great power (strong power, low frequency), while the short and slender pile or testing the superficial defects requires a hammer (weak power, high frequency). And the in-between pile can use a stick with small power (Power and frequency are between the stick with great power and the hammer). Certainly the selecting of the striking equipment also has something to do with the geological condition. You can choose it according to your experience. Under some complex circumstances, the way combing high frequency and low frequency helps to acquire the complete signals from the pile. That is to say, the low frequency impulse wave can be used for obtaining reflection from the pile toe, and the high frequent impulse wave for testing the defects on the pile.

On striking, the striking equipment needs to be raised to a certain height (The higher the height is, the greater the power is). And then release it to make it drop freely and vertically. Catch it when it rebounds to avoid repeated striking.

The quality of striking will affect the result of the test directly, which requires the experienced workers to operate. The hammer should strike accurately and quickly. The direction of striking should be vertical with the plane of pile head, to avoid a secondary impulse, and to produce instant shot point sources. Thus the pulse is narrow, corresponding to the Half-sine law.

Besides, the strength of striking should be appropriate. Underweight or overweight striking will influence the quality of

signals (If it is underweight, and the reflection signals from the pile toe or defection will be weak; if it is overweight, it will bring in undesired signal like "noises"). So, when the signal is strong enough (You can observe the reflection signal from the pile toe), you are suggested to strike slightly.

3.3.1.2 Instruments Connections

Power on wireless dynamic tester for foundation pile and PAD, find out and click the application icon of "wireless dynamic tester for foundation pile" in PAD to enter into data collection interface, then click the wireless icon at the right side of title bar to enter into list of wireless network, select the wireless network to be matched and enter correct password, the wireless network icon stops flashing and battery level is shown at the title bar, which means it is connected with the instrument. Now the indicator of the instrument turns into green and data collection may be implemented normally. Refer to Section 3.2.3.1 for more details.

3.3.2 New Pile Testing

3.3.2.1 Parameter Setting

Click the Settings button on the interface of the testing software with reflected wave, and it will pops up a parameter setup dialogue box. Input the project name, pile number, pile length and wave speed and other parameters on the attribute page of Pile Param.. All the parameters on the attribute page of Sampling Param. do not need to be set but to take the default value (The sampling mode is continuous sampling; the type of the sensor is ICP; the amount of sampling is six;

there are three lines on each screen and each hammer speed is one; and the accepting mode is manual.) After the setting, click Exit button on the PAD panel, and then the setting is finished and the system will return to the main interface of the pile software with reflected wave. You can see the details in the 3.2.2.

3.3.2.2 Signal Acquisition

Click the Sample button on the interface of the pile with reflected wave, waiting for the sampling. It pops up the message "sampling now…", waiting for your striking. Then you can begin striking by using a hammer or stick with an interval of two seconds. The striking point and the strength should keep consistent every time. If it prompts overweight striking, please decrease the strength or striking height; if it prompts underweight striking, please increase the strength or striking height. Click Stop to quit sampling after finished testing. See the details in 3.2.3.

After the sampling stops, click the analysis parameters area to enter the analysis interface. Then choose Integ., and set the proper multiple of Exp. Amplification(MA) and Wavelet factor(WL), and process the current waveform in time after changing the parameters, and then refresh the display in the waveform area. You can see the details in 3.2.4.

The better waveforms processed should be:

1) The restoration of the waveform with multiple striking is good;
2) The waveform can reflect the real situation of the pile, and the pile toe of the intact pile reflects clearly;
3) The waveform is smooth, not containing any burr or oscillating waveform;
4) The waveform can go back to the baseline at last.

If the signals collected after processing do not meet the requirements above, go back to the testing interface, and then analyze the reasons. Study at the test site in time, and test again after eliminating the negative factors affecting the test. With a better waveform, click Save and it will pops up a dialogue box to input the file name. After that, click OK to save the data.

Click the Sample button again to strike repeatedly with the change of the coupling point of the sensor or the striking point or the striking device. After finishing signals acquisition, the signals will be analyzed and processed according to the previous setting parameters automatically, displaying in the waveform area (Of course you can enter the analysis interface to set the parameters again). If the waveform collected is good, click Save directly.

When another pile needs to be tested with the completion of testing a pile, click the New Pile button and then change the pile number, pile length and wave speed, coupling the sensor to the polish position of the pile head to be detected. And then click the Sample button to collect the signals. The subsequent steps are the same as the above. You can see the details in 3.2.3.10.

Repeat until finishing testing all the piles and click Exit button on PAD panel to exit the testing interface. Afterwards, turn off the power switch to finish the on-site testing.

3.3.3 Data Post-processing

Finishing the on-site testing, you can copy the test data saved in the instrument to your computer with FTP. Analyze and process the test data with the reflected wave analysis software under the Windows platform, and then issue a test report. See details in *The Operation Instruction Manual for the Reflected Wave Detecting pile Data*

Analysis Software.

3.3.3.1 Copy the Data Files

After connection with LAN WIFI network, click File and select FPT upload, enter username and password and click Start button, IP address (ftp://192.168.1.220:2121/) of data accessed by PC will be generated automatically after system access address field. Open IE browser on PC, input such IP address, and enter username and password on pop-up dialog box, you can find out all data files, select data file and copy it into PC. Refer to Section 3.2.1.2 for more details.

3.3.3.2 Analyze and Process the Data

1) Run "the reflected wave detection software". If you haven't installed this software, please find the installation file from the enclosed compact disk or download the installation file from the "download center" in our company website to install it.
2) Select the menu item File→New Site, and click OK button after inputting the project name in the pop-up dialog box, and then select all the saving the data files from the pop-up dialog box "open the file", click Open button, all the selected files will be displayed in the list.
3) Double click on the list of the pile file, and then the file opens and displays all waveforms in the waveform area.
4) If necessary, reset processing parameters in the "waveform processing" of the pile information area.
5) Set the position of the pile toe and defect.
6) Modify the pile information, and select integrity classification, and then click the menu item File→Save file

to save the data file.

7) Repeat the steps 3 to 6 until all pile files are analyzed and processed.

8) Select the pile file ready to print in the list area of pile file.

9) Select the menu item File→Print setup, setting the content and format to be printed, and then select File→Print to print the content selected on basis of the setting.

3.3.3.3 Delete the Data

After the data are analyzed and tested, you can delete the data in the PAD to save the disk space.

Enter the reflected wave detection software interface, and click File to enter the file management interface. Select (click) the project to be deleted, and then click Delete to delete the project selected and all pile files in it. See the details in 3.2.1.

3.3.4 Announcements for On-site Testing

The reflected wave method is suitable for testing the pile integrity of the concrete pile, judging the extent and the position of the pile defect. It is a semi-direct method to checking the quality of pile quickly. Because of the advantages of high speed detection, low cost and wide coverage of the detection, this method has been applied in testing the pile integrity extensively.

3.3.4.1 Key Points for On-site Testing

1. Fully understand the instrument, the features of the site and pile type, making a careful preparation.

1) Choose a proper hammer. Usually the small pile needs a specialized hammer and an undersized stick.

2) Choose a proper sensor based on the pile type, the conditions of the pile head.

3) Choose a proper couplant and installation method according to the weather, the preparations of pile head and the sensor selected.

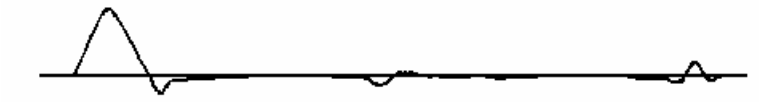
2. Test the first piles carefully, paying ATTENTION to the waveform and the reflection of the pile toe and the superficial defects.

3. After debugging the sensor, vibration source, installation method and parameter setting on the first piles, you can expand it on the following piles quickly. The piles with problems should be noted down in the process (or spend more time in testing these piles thoroughly.). Pay ATTENTION to the situation of the reflection of the pile toe and the superficial defects. Also you should mind the consistency of the signals, making sure that every pile has more than three signals with good consistency.

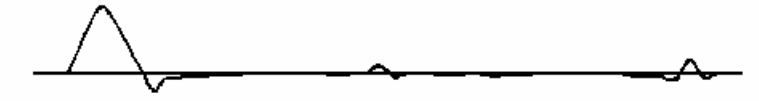
4. Test the piles with problems thoroughly with different sensor, excitation hammer and point, scrutinizing the possible problems of the pile.

3.3.4.2 The Influence of Pile Soil on Squiggle

On testing the pile with low strain reflected wave method, the influence of pile soil on squiggle should be taken into full consideration. In general, if the soils around the pile have a better mechanical property, the stress wave will suffer a greater wastage. When the soft clay is transformed into hard soil, those collected squiggles will generate reflected wave similar to hole enlargement in corresponding position (shown in Figure 3.28a). However, when the hard clay is transformed into soft soil, those collected squiggles will generate reflected wave like necking instead (shown in Figure 3.28b).



a) When the soft clay is transformed into hard soil



b) When the hard clay is transformed into soft soil

Figure 3.28 The Influence of Pile Soil on Squiggle

If the influence of pile soil on the collected squiggles is out of consideration and the geologic status of the foundation pile is unknown, the misjudgment happens naturally. Therefore, to have a better judgment and analysis on the quality of the pile, the relevant materials for testing the construction site should first and foremost be comprehensively collected and understood, including collecting the geological data, consulting the physical mechanics index of rocks, and making clear the distribution and trend of the soil layer. Especially, the moisture content, void ratio, compression modulus, volume-weight, internal friction angle, bearing capacity of foundation soil and the suggested value of the side friction and end resistance of all layers within the range of the length of the pile should be mastered.

3.3.4.3 Advantage and Disadvantage of Exponential Amplification

In the process of collecting the signals, the signals from the pile toe often appear to be obscure. Here exponential amplification is a very useful function which could reveal the signal from the pile toe on the condition that the signal in the pile head is not affected. But some testing personnel think it make waveform lose its original property, over-highlighting the defects of the pile toe. It seems to be reasonable

as excessive exponential amplification may even artificially cause a reflection from the bottom. However, appropriate exponential amplification on the waveforms combining the original waveform, as a method to reveal the deep defects and the pile toe, is still of great usefulness.

3.3.4.4 Curve Rotation

In general, those signals collected by acceleration transducer should receive integral processing so that speed signal is acquired. As a result of the drifting characteristic and soil resistance, signals may drift in a pure linear way so that the negative or positive components account for the majority of the waveform and the end doesn't return zero. At this moment, the curve should be rotated in clockwise or anticlockwise to make the curve to increase or decrease the migration acceleration from a certain point. Such modifications ensure the rationality and accuracy of the curve.

3.3.4.5 About "Blind Zone"

From the perspective of the spread of stress wave, the knock of hammer to pile head in the practical testing can be regarded as the point vibration source. The hemispherical wave produced after the knock can be approximately looked upon as a plane wave, thus satisfying the hypothesis of flat section, only when it spreads to a certain depth. Within this depth, the spread of stress wave is very complicated with serious signal disturbance, and both the theory and practical testing show that the scope of "blind zone" is about a pile diameter to 1/2λbelow the testing point. Low strain excitation frequency is about 1000~4000Hz, so generally the scope of 2m below the testing point is the "blind zone" of reflected wave testing. The existence of "blind zone" leaves covered the defects in the very

shallow part of the pile, which means the effect of "blind zone" on testing results should be reduced as much as possible. Therefore, in practical testing, the scope of "blind zone" should be reduced by changing the quality of hammer and the stiffness of contact surface as well as by using the right sensor and detection parameter. In this way, some serious defects existing 1m below the testing point can be detected. As for defects in a more shallow position, they can only be speculated by experience and verified by excavating as they are nearby the pile head.

3.3.4.6 Testing Technique of Large Diameter Pile

When testing large-diameter bored concrete pile, because of the disturbance of shallow defects, partial three-dimensional effect and the effect of surface wave, oscillation often occurs and signals captured in different testing points (the coupling points of sensor) and knocking points are often poor in consistency. On this occasion, you can use the average superposition to obtain the ideal non-oscillating signals which can reflect the practical situation of the pile body. Generally, by fixing the sensor and knocking pattern, and averaging the testing signals produced in repeated knocking, the result can free from the disturbance of shallow parts, three-dimensional effect and the effect of surface wave, thus highlighting the ideal signals.

3.3.4.7 The Elimination of Signal Oscillation

Various factors can cause signal oscillation, such as poor coupling of the sensor, improper selection of knocking device, concrete porosity of the knocking point or being too close to the rebar, exterior rebar of the pile head being too long, defects of shallow parts of the pile body. Disturbance of 50Hz can also cause low frequency oscillation. Spectrum analysis can be used to distinguish oscillations

caused by different factors. The observation of oscillation in testing signals of acceleration sensor should be conducted after the integral becomes velocity.

In site test, when oscillating signals occur, you should first examine if the position of sensor is reasonable, the couplant suitable, and the coupling in good condition (solid cementation without displacement). Then you should transfer the knocking point to a smooth and close-grained concrete surface and try to knock at the center of the pile, keeping away from the rebar.

Besides, it is better to have more than one testing point in a pile, which means you can change the coupling position of sensor and knocking point before testing, and then compare the signals.

If oscillating signals still occur after all the aforementioned improvement, the problem must have originated from the defects in the shallow parts of the pile body. Breaking the pile head tends to cause fissure around the pile, which makes coring impossible but excavating possible. For manual hole digging pile, the dado can also cause signals with similar oscillation.

3.3.4.8 The Protection of Online Connector and Signal Wire

Since the instrument is connected to the sensor by wiring, problems are most likely to occur in the connector parts. Whether it is the sensor connector, the signal wire connector or the power line connecter, the phenomenon of hard-to-soft connection exists. Usually fixed by welding, silica gel, and line card, these connectors are of poor weight capacity and flexural and tensile capacity. Therefore, while strengthening the linkage of these parts, load-bearing, folding and pulling should be prevented as much as possible in practical use. When changing the scene, you should hold the sensor, because, if

hung in the air, the joint is very likely to come off. As for the signal wire, in addition to special protection for the connector, aging and transformation can also decrease its service life and reliability. Therefore, the signal wire should not be left in a state of tension (being bent or pulled) for a long time; neither should it be put together with corrosive substance. Sand, salt, and blot should be washed away in time. In site testing, excessive traction and switch should be avoided as much as possible. To avoid being tripped over by people passing by, the front head of the signal wire connector must be fastened. For any signal wire which cannot work properly due to decrease of insulation resistance or poor contact, you had better abandon it and buy a new one.

3.3.4.9 Limitations and Improvement Analysis of Low-strain Reflected Wave Method

1. Limitations:

1) While reflected wave method can test the relative changes of generalized wave impedance, distinguish hole shrinkage from hole enlargement, and calculate the position of defects, it cannot determine the nature and direction of defects. For example, it cannot differentiate quite well necking from segregation, serious segregation from breaking pile, or interlayer from fissure. To further determine the nature of defects, testing experience and other supplementary materials are required.

2) The quantitative analysis of defect degree is hard to achieve the ideal effect. By now, it can only give the quantitative defect degree. Because of the inaccuracy of calculation or selection of wave velocity, the error of defect position calculated in this way can be up to 10%. It is also difficult to accurately calculate the distribution of defects in the axial direction and the radial direction of the pile, as well as the degree

of the decreasing quality of defects.

3) The relationship between wave velocity and concrete strength cannot be provided accurately.

4) Low-strain reflected wave method cannot measure the defects in piles with excessive draw ratio, or defects in the very shallow part or too small, due to reasons like inaccessibility of high frequency signals, limited area of testing, insufficient resolution ratio of low frequency signal, or the possibility of missing defects.

5) In case of many defects existing in the same pile body, deep defects are easy to be misjudged. If the first defect is in the shallow part, you can test it after excavating and chiseling the upper defects. Otherwise, you will have to use other methods for further detection.

6) For defects of changing impedance, it is hard to judge and may even get the opposite result. For example, when necking, segregation, and enlargement occur in a certain part of the pile body, the defect degree ranges from mild to severe or from severe to light and corresponding wave impedance gradually decreases or increases, which cannot be reflected in actual testing signals. On special occasions, for example, when the pile body gradually shrinks and suddenly returns to the original section, you may draw the conclusion of “beneficial” defects that enlargement exists in the pile body, which is very dangerous.

2.In order to correctly analyze defects in the pile body, it is necessary to：

1）Combine geological data and construction records to analyze the wholeness of the pile. Pile type and construction technique have great effect on the wholeness and defect type of the pile. For example, precast pile and manual hole digging pile is unlikely to shrink; stratum changes can also affect the waveform(to produce reflected wave), etc. Therefore, it is very helpful to check geological data and learn about construction records in determining the position of defects.

2) Make use of quantitative analysis software to judge the defect degree of the pile. In spite of its own deficiencies, the software can analyze the detailed process of stress wave spreading in the pile body. As long as the selection of parameters of the soil around the pile is reasonable, the function of quantitative analysis software in judging waveformdefects will be far more powerful than our observation.

3) Give a comprehensive analysis to all tested piles in the same project. Since the geology and construction situations in the same project is generally the same, by looking for similarities among the piles before analyzing the situation of every single pile, the analysis effect will be largely enhanced. Only analyzing one single pile, instead of getting an overall understanding of the whole project, is prone to misjudgment.

Chapter 4 Metering and Verification

The series of ZBL-P8 Pile Dynamic Testers must undergo examination according to the corporate standard *ZBL-P8 Series of Pile Dynamic Testers (Q/XCZBL006-2006)* before leaving the factory. User must also have periodic verification in metering department after purchasing the P8 series in accordance with *The Verification Regulations of Dynamic Pile Tester (JJG930-1998).*The verification should be conducted according to the following steps.

4.1 Preparations before metering

Run the software of Wireless Pile Dynamic Testers, and click the left upper corner of the testing interface, you will enter the software interface of metering and verification (as shown in Figure 4.1).

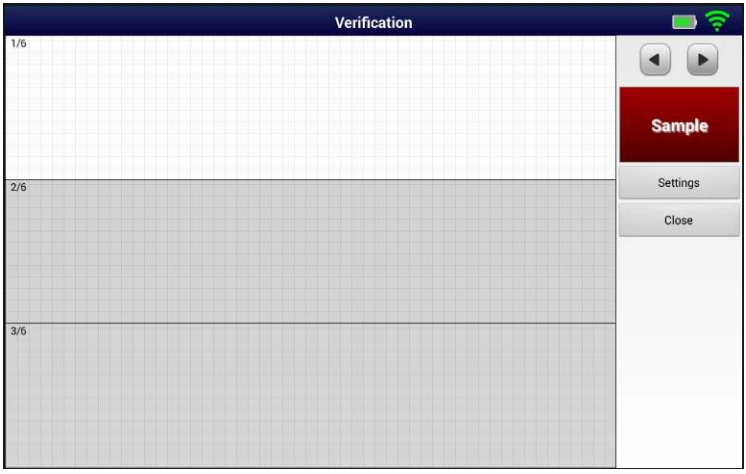


Figure4.1 Metering and verification

Turn on the dynamic tester. Preheat the instrument for about 10

minutes after the start-up. Install the sensor on the oscillating platform.

4.2 Parameter Setting

Click button Settings in the main interface of the soft, the interface shown in Figure 4.2 will come out. Then you should set the **gain**, **sensitivity**, **sampling interval**, etc.

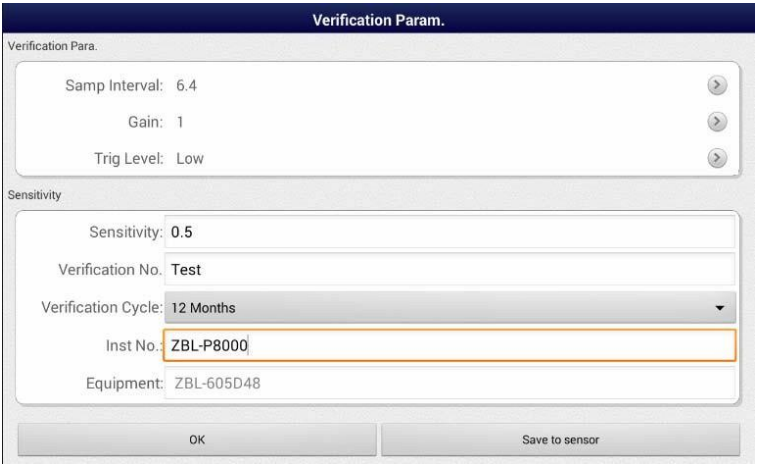


Figure4.2 Parameter Setting

1. Sampling Interval

Table 4.1 Signal Frequency and Sampling Interval

No.	Signal frequency (Hz)	Sampling interval (μs)	No.	Signal frequency (Hz)	Sampling interval (μs)
1	20	204.8	4	2000	6.4
2	160	51.2	5	≥5000	6.4
3	1000	6.4			

1) The sampling interval is the time difference between every two sampling signal, you can select one of the 9 intervals, 6.4μs, 12.8μs, 25.6μs, 51.2μs, 102.4μs, 204.8μs, 409.6μs,

819.2μs and 1638.4μs. This value can be set according signal source frequency as shown in table 4.1.

2) Gain is the amplification of the electrical signal received by sensor of instrument, it's designated fixed magnification, 1, 2, 4, 8, 16, 32, 64 can be chosen.

3) Trigger level is the level of signal collected when starting the instrument, there are three levels: Low, Medium, and High. Higher the set is, stronger the receiving signal be required. In pile testing, average gain is no greater than 8 in case of "low ", gain greater than 8 in case of "high". If the interference signal in scene is so strong that signal produced without knocking after sensor be set, set to "high level"。

2. Sensor Parameter

1) System sensitivity settings: the system sensitivity value is determined by the measurement department, generally been set in the factory, the user does not have to modify. Users need to modify only when the system re-calibrated or connect with sensor different from that of our company.

2) Verification card No.: The certificate number after the Wireless dynamic tester passing the inspection , The measurement department input and save it to the instrument..

3) Verify date and cycle: Verify date refers to the most recent test date of the instrument; verify cycle refers to the time interval for each test, generally about one year. Judged according to the verify date and cycle, one month before the expiration of the certification date, each boot will remind the user of the inspection to be made.

4) Instrument No.: The serial number of current equipment, it's set in the factory.

5) Equipment name: Display the name of the bound

instrument, if there's not bound instrument, it is empty.

After setting the above verification information, click OK button, the current settings will take effect. Click Save to sensor, the system sensitivity, verification certificate number and periodic, instrument No. is sent to the instrument for storage.

4.3 Verification steps

1. Turn on the dynamic tester. Run the software of Wireless Pile Dynamic Testers, and click the left upper corner of the testing interface, you will enter the software interface of metering and verification (as shown in Figure 4.1).

2. Click button Settings in the main interface of the soft，the interface shown in Figure 4.2 will come out. After you finished setting the **gain**, **sensitivity**, **sampling interval** (shown in Table 4.1), etc. Click OK to return to the main interface.

3. Install the sensor on the oscillating platform as shown in Figure 4.3. Adjust the frequency and amplitude of signal source to the specified value in the regulations. When the oscillating platform has stabilized, clickSample in the interface of testing and wait for the sampling, prompting "sampling…". When the sampling finishes, the prompt message disappears. Signals gathered are displayed in the waveform area instead.

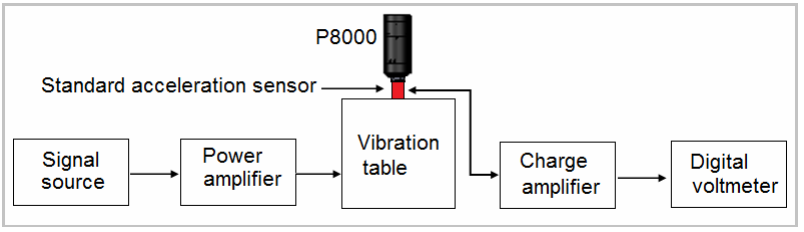


Figure 4.3 Wire connection of oscillating platform

4. If you want to gather the next wave form, click the

corresponding area, and then click Sample, waiting for the sampling, prompting "sampling…". When the sampling finishes, the prompt message disappears. Signals gathered are displayed in the waveform area instead.

5. When the collection completes, click a wave peak (the position of the maximum signal amplitude) or a wave trough (the position of the minimum signal amplitude) in the waveform area, and a vertical cursor shows in the clicking position. Then click € , € in the information area to adjust the cursor position. Information like time and amplitude appears in the cursor parameter area. Find out the position where the amplitude is maximum or minimum, and read and record the signal amplitude.

NOTE：While reading the signal amplitude, you should move the cursor right and left near the wave peaks and wave troughs, so as to make sure the value read is the maximum or minimum.

6. Repeat steps 2-5, until the verification is completed.

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