



ENCARDIO RITE

ONE STOP MONITORING SOLUTIONS | HYDROLOGY | GEOTECHNICAL | STRUCTURAL | GEODETIC
Over 50 years of excellence through ingenuity

USERS' MANUAL

DIGITAL INCLINOMETER OPERATION

MODEL EAN-26



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Battery charging and care of rechargeable battery

CAUTION !

Always maintain cable reel's battery in charged condition. Failure to do so will cause premature battery failure. A battery which gets damaged due to non-compliance with the instructions given below is not covered by our standard warranty and is also not eligible for free servicing.

Cable reel's battery

The EAN-26 Digital Inclinometer Reel uses a removable sealed rechargeable Li-ion maintenance free battery as a power source. A separate battery charger unit operating from universal AC mains supply is supplied with each Inclinometer system. This battery charger operates from 90 to 260 V AC, 50 or 60 Hz which makes it suitable for operation from AC mains available throughout the world.

A fully discharged battery needs 4 hours of charge to get fully charged. A partially discharged battery will require proportionately less time but the time is difficult to calculate. As soon as the battery is fully charged the charging current gets automatically reduced to a safe value.

On receiving the Inclinometer system for the first time recharge the battery for 4 hours using the supplied mains powered battery charger.

If the DI Reel is not going to be used for more than 30 days, fully charge the battery before storing the DI Reel. Also fully charge the battery before use if the DI Reel has not been used for more than 30 days.

If the data logger is not going to be used for more than 30 days, recharge the battery at least once every 30 days or so.

When battery voltage is showing 7.3V in system information screen (at Readout unit) it means approximately 10 percent of battery capacity is left. Fully recharge the battery at the first opportunity.

Turn off mains AC supply to the charger before connecting to or disconnecting battery from the battery charger. A fully charged battery will not get damaged but the battery life gets reduced if a fully charged battery is kept connected to the charger for very long duration. It is recommended that the charger be disconnected after 4 hours charging period is over.

The rechargeable battery needs replacement every 3 to 5 years (irrespective of hours of use). Replace battery with Camcorder Battery BP522 or an equivalent from another manufacturer.

Phone's (readout unit) battery

The EAN-26DI Readout unit uses an internal sealed rechargeable Li-ion maintenance free battery as a power source. A separate battery charger/adaptor unit operating from universal AC mains supply is supplied with each DI Readout unit. This battery charger operates from 90 to 260 V AC, 50 or 60 Hz which makes it suitable for operation from AC mains available throughout the world.

On receiving the Readout unit for the first time discharge the battery fully and then recharge the battery for 2 hours using the supplied mains powered battery charger.

If the DI Readout unit is not going to be used for more than 30 days, fully charge the battery and switch OFF the phone before storing the DI Readout unit. Also fully charge the battery before use if the DI Readout unit has not been used for more than 30 days.

1 INTRODUCTION

The Digital Inclinometer uses an Android OS based mobile phone with a Bluetooth wireless interface as a readout device. The recommended phone types have a large 800 x 480 pixel colour display with capacitive touch screen that makes it easy to read the display while logging bore holes using Encardio-rite's range of traversing type vertical and horizontal borehole inclinometers.

EAN-26 Readout unit can be used to log bore hole profiles of boreholes up to 300 m deep in 0.5 / 1.0 meters increment or up to 999 feet deep in 2.0/4.0 feet increment using either biaxial or uniaxial inclinometers.

The readout unit can store readings from up to more than 1000 bore holes. The readings are not lost even if the power is turned off. Four readings are required for a biaxial inclinometer survey for each depth level in a bore hole. In case of any error during logging the probe can be lowered back to the problem depth and logging continued without having to start a fresh thus saving time.

A quick probe check mode allows verifying probe operation or calibration without having to configure a dummy borehole log as is required by most other commercially available inclinometer data loggers.

The stored readings can be uploaded to a remote FTP server using GPRS/3G cellular network. The uploaded data is in a format that allows the data to be easily imported in third party inclinometer data presentation software like GTilt™ or a spread sheet program like Microsoft Excel™.

Since readout unit is a mobile phone, most of the people are familiar with its operation. Working with a mobile phone readout unit is very easy and user friendly.

™ (TRADEMARKS): GTilt is a trademark of Mitre Software Corporation, Canada; Microsoft Excel is a trademark of Microsoft Corporation, USA.

2 OPERATING PRINCIPLE

2.1 Inclination measurement

The inclinometer probes employ an accelerometer to measure the tilt angle from the true vertical line or horizontal plane with respect to the earth's surface.

The accelerometer itself measures the change in acceleration due to gravity felt by it as it rotates about a horizontal axis. It experiences maximum acceleration when its sensitive axis is truly vertical and minimum acceleration when its sensitive axis is truly horizontal. In a vertical inclinometer probe the internal accelerometer is mounted such that when the inclinometer probe is truly vertical, the accelerometer sensitive axis is aligned vertically. In a horizontal inclinometer probe the accelerometer sensitive axis is aligned vertically when the probe is aligned along a true horizontal plane.

As the accelerometer rotates about a horizontal axis along a vertical plane its output changes proportionally to the sine of the angle its sensitive axis makes from the true vertical. So an inclinometer's output is generally proportional to the sine of the angle of tilt (or inclination) rather than the tilt angle of the inclinometer probe itself.

However, this sine law variation of an inclinometer probe output is more useful to us as the subsequent calculations to determine the ground profile uses the sine of the tilt angle rather than the tilt angle itself.

An uniaxial vertical inclinometer probe can measure the tilt along a vertical plane passing through the probe axis. A biaxial inclinometer probe can measure the tilt independently along two vertical planes, that are orthogonal to each other, with their intersection line coincident with the inclinometer probe axis.

A horizontal inclinometer probe is generally used to measure tilt along a vertical plane passing along the axis of the inclinometer. A second accelerometer is often provided to measure the tilt along a plane perpendicular to the horizontal inclinometer probe axis so that any rotation of the horizontal probe during a traverse can be detected and correction for this applied.

2.2 Digital Inclinometer cable and reel

The EAN-26 Readout unit is meant for use with EAN-26R cable reel. Reel interfaces with digital output uniaxial or biaxial digital inclinometer probes over a long cable.

EAN-26R cable reel is having a Bluetooth interface unit inside the reel and a long cable to interface with digital inclinometer probe. EAN-26R cable reel is powered with 7.2 V compact size rechargeable battery. Battery is accessible from outside. Battery can be removed for charging by opening battery holder. Power ON/OFF pushbutton is provided on reel's disk near battery holder.

EAN-26R cable reel uses two core cable to interface with digital inclinometer probe. The cable length varies depending on ordered option. Ferrules are crimped on cable at defined intervals to suspend the probe in borehole.

Cable reels are supplied with ordered length of cable marked at constant distances with ferrules in either metric or imperial units of measurement.



Figure 3.1

Cable in meters are having golden ferrule crimped at 0.5 meters interval while red ferrules are crimped at 1.0 meters interval. White ferrules are crimped at every 5.0 meters interval and are marked with the depth value.

Cable in feet are having golden ferrule crimped at 2.0 feet interval while red ferrules are crimped at 4.0 feet interval. White ferrules are crimped at every 20 feet interval and are marked with the depth value.

2.3 Digital inclinometer probes

The model EAN-26MV digital tilt sensing inclinometer probe is meant for use with EAN-26R cable reel. Reel interfaces with digital output biaxial inclinometer probes (often called torpedo by other manufacturers). These types of probes are known as digital output inclinometer probes in which the output is in the form of a series of pulses.

Inclinometer probes from Encardio-rite and most other manufacturers use accelerometers as the basic tilt sensor. In addition some kind of signal conditioning is also carried out to boost the signal voltage and then doing analog to digital conversion to make it suitable for noise free transmission over long cables.

EAN-26R cable reel is designed for use with probes that require an excitation voltage of +12 to +30 V. However, the EAN-26R cable reel is designed for use with variety of digital inclinometer probes from Encardio-rite. The probe calibration is independent of the Reel configuration.

The EAN-26MV digital Inclinometer probe uses two MEMS sensors that are mounted orthogonally inside the probe. They measure the tilt of the probe along a plane passing through the two wheel arms and the other in a plane perpendicular to the first. As measurement of inclination in two orthogonal direction is simultaneously available the probes are known as bi-axial probe.

The traditionally available analog probe which gave a voltage output proportional to the sine of the angle of tilt of the probe along any of the two axes. The EAN-26 digital probe however gives the output in digital form (in a numeric form). The output value is the distance between the two wheels multiplied by the sine of the angle of tilt in that plane. So essentially the output of the probe is the horizontal displacement of the top wheel arm centre from an axis passing through the centre of the bottom wheel arm assembly along the plane of rotation or tilt.

Inclinometer probes have a significant current consumption and thus introduce a drop in excitation voltage across the connecting cable. The EAN-26 cable reel supplies an excitation voltage of +29 V. The longest cable that can be connected between the data logger and the inclinometer probe is that which will not cause the excitation voltage to drop to less than +12 V at the inclinometer probe terminals.



Figure 3.2

3 PREPARING TO LOG A BOREHOLE

Site and borehole names must be created in readout unit before logging a borehole. Edit borehole parameters by providing required information. Then the inclinometer probe is lowered in the borehole down to the deepest level to be logged and gradually pulled up in 0.5 or 1.0 m (2 or 4 feet) intervals and readings stored. The interval by which the probe is raised after each reading is known as the depth interval. For the first run the face A+ of the inclinometer is kept pointing towards the reference groove of the inclinometer casing in the borehole. The reference groove is one of the four grooves in an inclinometer casing that has been chosen to be the reference groove. After the first run is over the inclinometer probe is taken out of the casing and rotated 180 degrees and reinserted in the inclinometer casing. Conventionally this traverse is known as A- face. For a biaxial probe the second axis is labeled as B+ during the first traverse and B- during the second traverse.

Borehole files (logs) uses face conventions as face A+ is referred as face A, face A- is referred as face B, face B+ is referred as face C and face B- is referred as face D.

For Encardio rite vertical inclinometer probes the side with the topmost wheel is labeled as face A+. When the inclinometer probe tilts towards the topmost wheel, i.e. towards face A+, the output of A axis increases in the positive direction. If the tilt is in reverse direction the sign of the output voltage is negative.

4 READOUT UNIT

The Digital Inclinometer system is using Mobile Phone as a Readout unit. Phone is running on Android operating system for providing powerful platform to manage applications efficiently. It has so many features like phone calls, SMS, MMS, GPRS/3G, Wi-Fi, Bluetooth, USB and high resolution Camera. User can use it as mobile phone for making calls. It has GPRS/3G which enables user to access internet from site to upload/download files and checking E-mails. Wireless Bluetooth can be used to send files to PC or any other Bluetooth device. High resolution camera can be helpful to take site conditions photographs and send them to the back office by sending MMS. It has higher capacity external memory card of 8GB which can store lots of data. Data backup can be taken on regular basis by connecting phone with PC through USB cable.

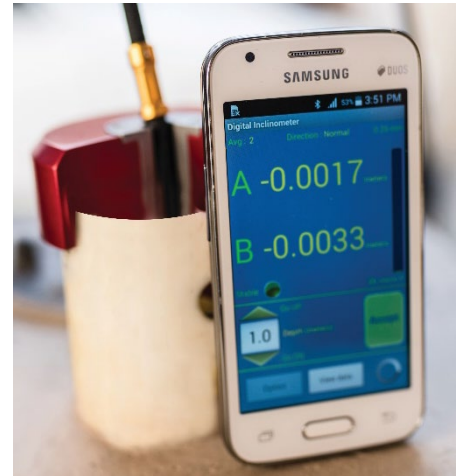


Figure 5.1

4.1 Using the readout unit

The inclinometer software running on phone can take borehole readings and store them into memory. Inclinometer software has ability to show borehole logs in tabular format and create plots of borehole data instantly after borehole reading is complete. Borehole data files are created automatically while saving borehole log. These files can be recreated from software database when needed. Borehole files can be uploaded to remote server through GPRS/3G/Wi-Fi.

4.1.1 Establishing Bluetooth connection

Inclinometer system is using Bluetooth connection for communicating Phone with Reel. Connect the probe with Reel. Turn ON the Reel by pressing push button provided on Reel's disk near battery holder. Once push button is pressed Reel becomes ON. The indicator will glow in bright RED colour to ensure that reel is ON. Now power ON the Phone and go to settings and then Bluetooth settings. Turn ON the Bluetooth and click on "scan" button showing on phone's screen. Phone will show the list of Bluetooth devices found. Find the Reel's serial number on phone screen and click for pairing the phone with Reel. Once pairing button is pressed it will ask to enter passkey for authentication. Enter pairing code "6965785054" and then press OK. On successful authentication it will show that device is paired. Now Phone is paired with Reel. This activity is required for first time connection with Reel.

4.1.2 Running inclinometer application on phone

Running Inclinometer application is very simple. It is as simple as playing games in mobile phone. The graphic user interface makes it users friendly and thus easy to operate. Go to applications and then click on Digital Inclinometer application icon as shown in figure 5.2. Once DI application is clicked to run, it will show the name of the application and its version (see figure 5.3). This screen will splash for few seconds and then option menu appears. Figure 5.4 shows the option menu where we can change password for database deletion or regenerate deletion password. We can see help information by pressing help button or we can go to main menu to proceed further.



Figure 5.2



Figure 5.3

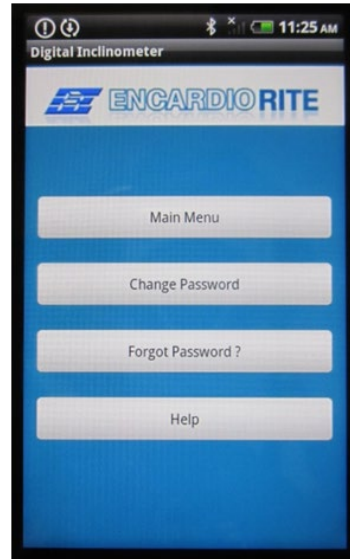


Figure 5.4

4.1.3 Main menu

Main menu is the place where we can do many functions. Figure 5.5 shows the main menu items. We can make connection with a reel over Bluetooth using connection button. System information can be seen by pressing system info button. It will show the information about reel, probe, Bluetooth and phone. New site and borehole can be created using create borehole button. Borehole parameters can be modified using edit borehole option. Borehole readings can be taken by pressing take reading button.

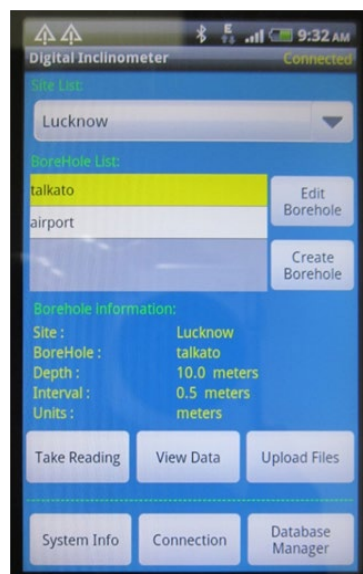


Figure 5.5

Borehole data can be viewed in tabular form or can be plotted on graph using view data option. Borehole files can be uploaded to a remote server using upload files button. Borehole logged database can be managed using database manager option. Site list shows the list of total sites created in this readout unit. Borehole list is showing the list of boreholes created under a site name which is selected in site list. Borehole information shows the borehole information of selected borehole from borehole list.

4.1.4 Connecting a digital inclinometer

Once the reel is turned ON and phone is paired with reel, we can connect phone with reel using connection button from main menu. Go to main menu and press connection button. It will show a list of paired Digital inclinometers as shown in figure 5.6. List is showing the serial numbers and Bluetooth addresses of the

reels. Click on desired reel to connect. Once clicked on a reel, it will try to connect and a message window will appear to acknowledge that phone is connecting to the reel. Figure 5.7 is showing an example of Bluetooth connection screen. Phone gets connected to the reel after few seconds.



Figure 5.6

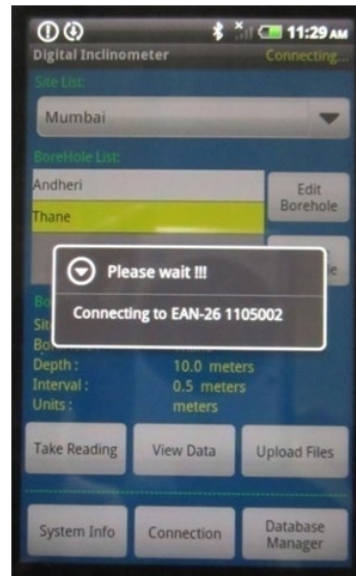


Figure 5.7

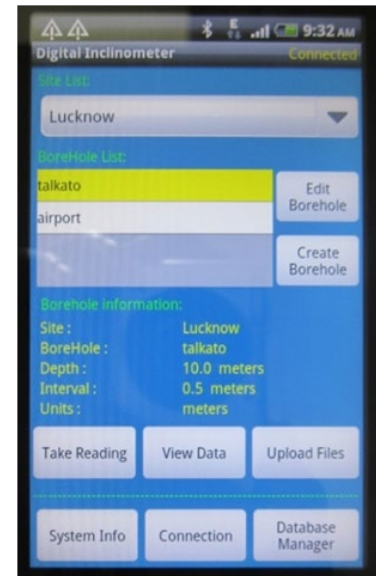


Figure 5.8

Bluetooth connection status can be seen on top right corner of the screen as shown in figure 5.8. Now we can check system information to see reel, probe, Bluetooth and phone information.

4.1.5 System information

System information can be seen by pressing system info button from main menu. It shows the information about reel, probe, Bluetooth and phone. On pressing system info button from main menu, it will show the inclinometer screen. We can choose to see other screens by clicking navigation tabs.

4.1.5.1 Inclinometer information

Inclinometer screen shows the information about reel and the probe. Figure 5.9 is showing an example of inclinometer screen of a reel. It is showing the Reel's battery voltage, serial number, model number, firmware version of reel's processor, reel's connection time and connectivity. It shows the probe's serial number, model number, firmware version of probe's processor, probe's connection time and connectivity. Battery voltage can be useful for reel's health monitoring. It is recommended to get battery full charged before going to the site.



Figure 5.9

4.1.5.2 Calibration information

Calibration screen shows the calibration information of the probe. Figure 5.10 shows the calibration screen of a probe. It shows the Probe type vertical or horizontal, sensor type, probe measurement units, probe length, probe calibration date, calibration factor for axis-A, calibration factor for axis-B, offset value for axis-A and offset value for axis-B. These information is useful for data verification.

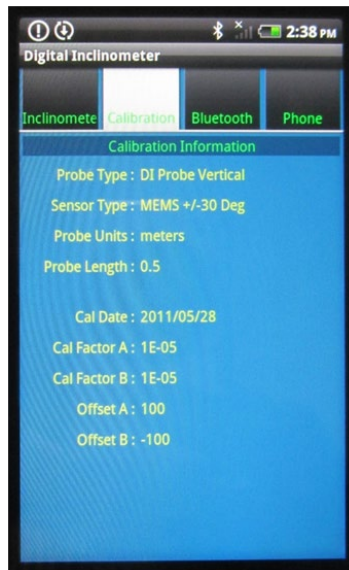


Figure 5.10



Figure 5.11

4.1.5.3 Bluetooth information

Bluetooth screen shows the Bluetooth connection information. Figure 5.11 shows the Bluetooth screen of a reel. It shows the Reel's serial number, Bluetooth address and connectivity.

4.1.5.4 Phone information

Phone screen shows the phone information as shown in figure 5.12. It shows phone's IMEI number and the network service provider.

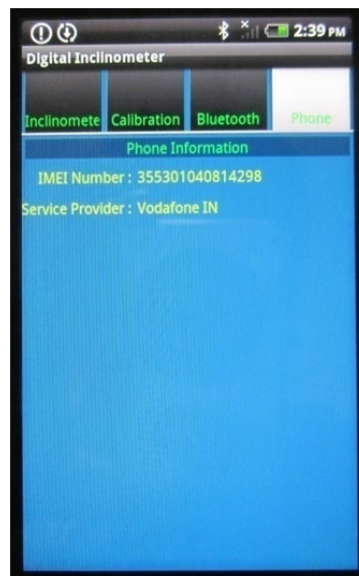


Figure 5.12

4.1.6 **Creating a site**

Site and Borehole menu can be opened on pressing create site button from main menu. Figure 5.13 shows the site and borehole menu. On pressing create button under site list, it will open site creation menu as shown in figure 5.14. Enter site code in edit box under site name. Site code cannot be of more than 7 letters. Enter site description in edit box. Site details can be written here. Press on save button to create this site. Site and its description can be seen under site list in site and borehole menu (figure 5.13). Any site can be deleted by selecting a site name from site list and then press on delete button.

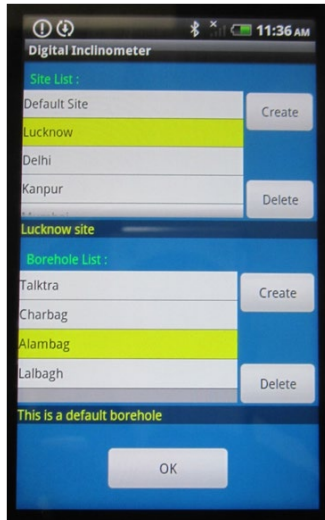


Figure 5.13

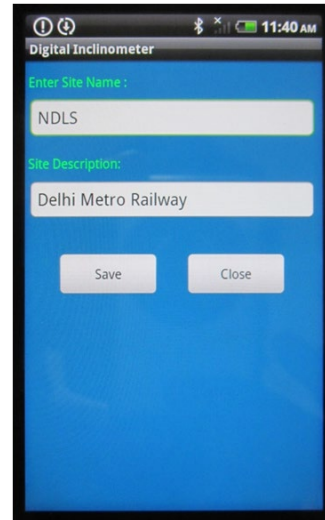


Figure 5.14

4.1.7 Creating a borehole

Open Site and Borehole menu on pressing create site button from main menu. Select site name under which new borehole is to be created. On pressing create button under borehole list, it will open borehole creation menu as shown in figure 5.15. Enter Borehole code in edit box under site name. Borehole code cannot be of more than 7 letters. Default settings for this borehole can be imported from previously created boreholes. Press on change button to reset default borehole to import settings. On pressing change button, it will open default borehole selection menu. Choose desired borehole to import parameters from. Figure 5.16 is showing an example of default borehole selection menu. Any borehole can be deleted by selecting a borehole name from borehole list (figure 5.13) and then press on delete button.

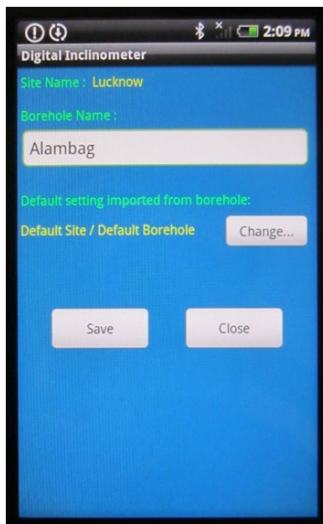


Figure 5.15

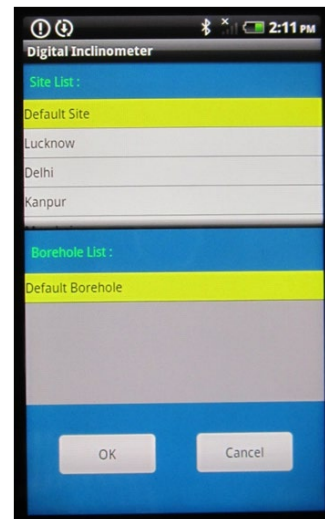


Figure 5.16

4.1.8 Default site and default borehole

No borehole can be created under default site. Default site and Default borehole cannot be deleted. Default site and default borehole are given only for reference. Default Borehole readings can't be stored in database while borehole readings can be taken.

4.1.9 Editing borehole parameters

Borehole parameter can be edited using edit borehole option. Select site and borehole from main menu and then press on Edit borehole to edit parameters of selected borehole.

Figure 5.17 is showing an example of edit borehole menu option. Site and borehole names are showing on top of the screen. Select probe unit in meters or feet from drop down menu under units. Set depth of the borehole and select reading interval using drop down menu.

It is recommended to enter interval equal to the length of the probe. Enter operator name and borehole comments in edit box provided under operator and comments heading. File name prefix for borehole log is showing under file name prefix heading. Press OK to save borehole settings.

Pressing on cancel button will exit from this menu and borehole settings will not be updated. Borehole comments can be seen under site list in site and borehole menu (figure 5.13).

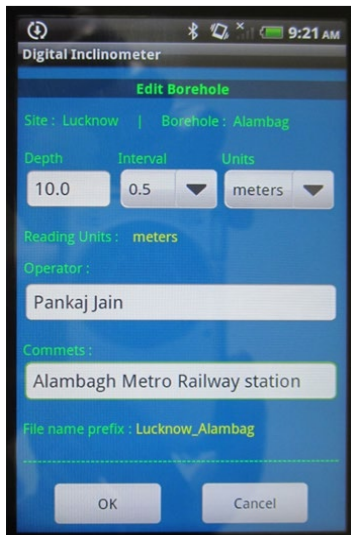


Figure 5.17



Figure 5.18

4.1.10 Taking readings

Once the site and borehole are selected from main menu (figure 5.5) and phone is connected with reel, readings can be started by pressing take reading button from main menu. Pressing on take reading button from main menu, it will open reading screen as shown in figure 5.18.

Lower the probe into borehole at depth showing on phone's screen. Axis-A and Axis-B displacement values are showing in meters/feet. Noise bar showing right side of the screen represents the present noise level in the readings received from probe. Present noise level in terms of micro volts is showing the noise contents in electrical signal at probe. Noise bar limit is showing in terms of displacement unit on top of the noise bar to correlate the noise level in terms of displacement units. Noise bar limit represents the 100% noise level in the noise bar. Red arrow above noise bar showing in figure 5.18 indicates that noise level is exceeding the noise bar limit. Solid green circle near stable in figure 5.18 represents that present reading is stable while red circle near stable in figure 5.19 represents that present reading is not stable. Noise window must be set from advanced menu to check readings are stable or not. It is recommended to accept readings only when readings are stable.

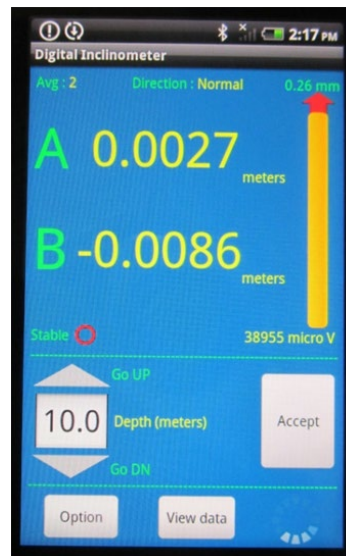


Figure 5.19

Readings showing on screen are calculated by taking average of displacement readings. Number of readings for averaging is showing on top left side of the screen. It can be set from option menu. It is good to take average of large number of readings but run-time become slower. Borehole data log are taken in two sets. First set of readings are taken when probe direction is normal while second set of readings are taken when probe direction is rotated to 180 degree or we can say probe direction is reversed. Probe direction is showing on top centre of the screen. UP and DN buttons near depth are used to go up or go down the probe position into the borehole. This button is useful in EDIT mode.

Let us take an example to understand how to take readings. Borehole depth is set to 10.0 meters and interval is 0.5 meters in this example. Lower the probe into borehole at depth showing on phone's screen (depth is 10.0 meters for this example) and wait until noise level in noise bar becomes low. Press Accept button (when readings are stable) to save reading for the depth showing (10.0 meters) on screen. Once accept button is pressed it will save the reading and the depth and moved to next interval (9.5 meters in this case). Pull the probe and fix it at 9.5 meters marking. Wait until readings are stable and then press accept button to store readings for 9.5 meters. Repeat the process again and again to take readings for each interval until top of the hole is reached. On accepting reading for 0.0 depths, first set of reading gets completed and a message will appear on screen to reverse the probe and repeat the readings again. Press OK button to proceed further.

Probe direction showing on top of the screen will now show 'Reverse'. Rotate the probe direction to 180 degree and lower the probe again into borehole at depth (10.0 meters) showing on the screen. Small digits in yellow colour below axis-A and axis-B readings are showing run time face error. Figure 5.20 is showing an example of reading screen. Face error is the difference in reading from normal to reverse probe direction for same interval. Face error should be zero in ideal case. It should be approximately same for a probe at each interval. Wrong readings can be identified with the help of face error. Progress bar showing right-bottom on screen indicating that probe is connected. Stored borehole logs can be viewed any time by pressing view data button to compare readings.

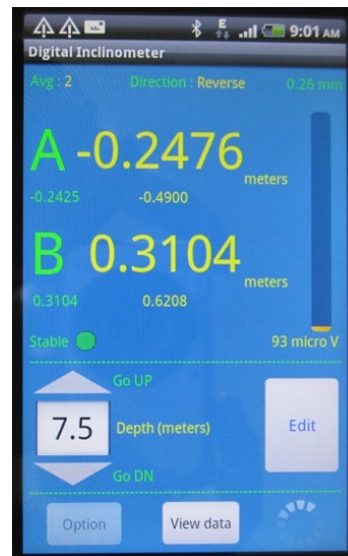


Figure 5.20

4.1.10.1 EDIT readings

Readings can be verified or retaken using EDIT mode. Pressing Down button once enters application in EDIT mode. Once DN button is pressed, Accept button becomes Edit button and small digits in green colour below axis-A and axis-B will appear for showing stored log for the interval showing on screen. Lower the probe into borehole and press DN button corresponding to probe position into borehole. Monitor stored log and present log to verify the reading log. If any stored log found wrong, new reading can be stored by pressing EDIT button. UP and DN button can be used to reach the desired probe position. Verify all readings at different intervals up to which readings are doubtful. Application automatically exits from EDIT mode when highest logged interval is reached. This feature saves lots of time and efforts.

4.1.10.2 Reading option settings

Pressing option button from readings screen (figure 5.20) opens options screen. Figure 5.21 shows the reading options screen. Number of readings for averaging data for axis-A/B can be set using UP/DN arrows. Taking average for displacement can be disabled by un-checking the tick box. Borehole log file name contains pre-fix as site code and borehole code while suffix having reading start date and time stamp. Comments can be entered for borehole log file. Advanced options menu can be opened by pressing advanced button.

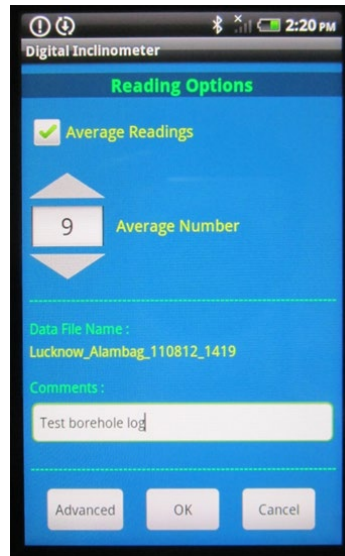


Figure 5.21

4.1.10.3 Advanced options

Figure 5.22 shows advanced options menu. Single set of readings can be set by checking the tick box. Beep on accept reading can be enabled/disabled by checking/un-checking the corresponding tick box. Similarly vibration on accept readings can be enabled/disabled by checking/un-checking the corresponding tick box.

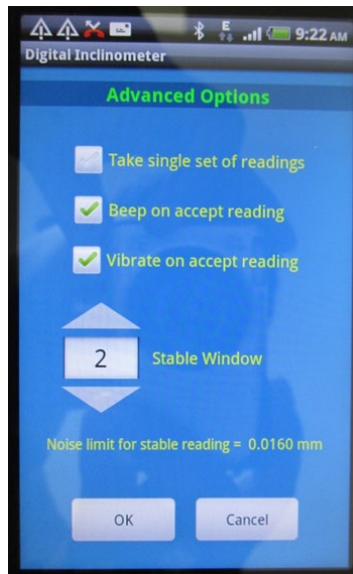


Figure 5.22

Stable window is showing the noise window for detection of stable readings. It is the window of standard deviation for readings received from probe. Set noise limit can be seen in terms measurement units. Stable window can be adjusted depending on how noisy the readings are in the field. It is recommended to keep stable window minimum.

4.1.11 Saving borehole log

Once borehole readings are taken at each interval and probe reached at 0.0 (top of the hole), after accepting last reading application will show reading complete message. Press OK to complete the reading process. On pressing OK button application opens save file formats screen as shown in figure 5.23. Standard or extended file format can be selected for generating CSV file. Additional file can be generated in web view data format (DI1) for analyzing data at server. Refer section § 7 for more details about file

formats. Operator name can be entered in text box. Pressing on save button will save reading log into borehole database and files will be generated at external memory (SD card). Refer section § 10.3 for viewing created borehole files.

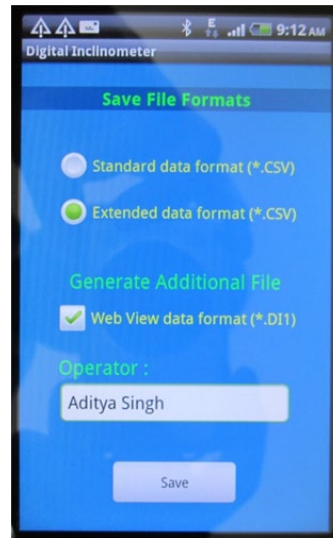


Figure 5.23

4.2 Viewing data

Reading log can be viewed using view data option. Go to main menu (figure 5.5) and select site and borehole for which borehole data to be viewed. Pressing view data button will open view data menu as shown in figure 5.54. Borehole Base file can be set on pressing reset base file button. Figure 5.25 shows reset base file menu. Choose a borehole file to set it base file and press OK. View data menu (figure 5.24) will show a list of borehole logs which are taken later to base file. Select only those borehole logs for which we want to see data. Borehole data can be viewed in tabular form by pressing view table button. Data can be plotted on graph by pressing view graph button.



Figure 5.24

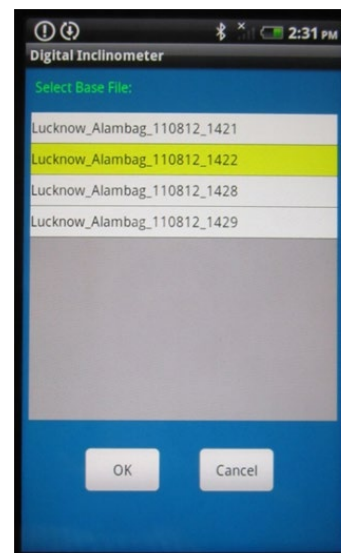


Figure 5.25

4.3 Viewing data in table

On pressing view table button from view data menu (figure 5.24) application will show data in tabular format. Figure 5.26 showing an example of a borehole log in table form. Drop down list at top of the screen showing list of borehole files. Since site/borehole are same for all files of this borehole so only file name suffix is

displayed in file list. **B**: before file name represents base file while **S**: represents selected file. Select a file from drop down list to view its data.

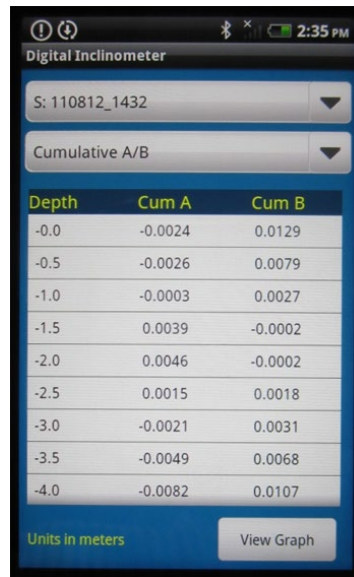


Figure 5.26

Drop down list below file list is showing reading parameters list. Different data options can be selected from this drop down list. These options are Raw data A, Raw data B, mean A/B, Face error A/B absolute A/B and deviation A/B.

Measurement unit is showing at left bottom side on the screen. We can plot data on graph on pressing view graph button. Use phone's back key to exit from this menu.

4.3.1 Viewing data on graph

On pressing view graph button from view data menu (figure 5.24) application will plot data on a graph. Figure 5.27 showing an example of a borehole data on a graph. Drop down list at bottom left of the screen showing axis of measurement. Axis-A or Axis-B can be chosen with this drop down list. Borehole log file name suffix is displayed under graph in various colours. File name colours are displaying corresponding to their data on graph area.

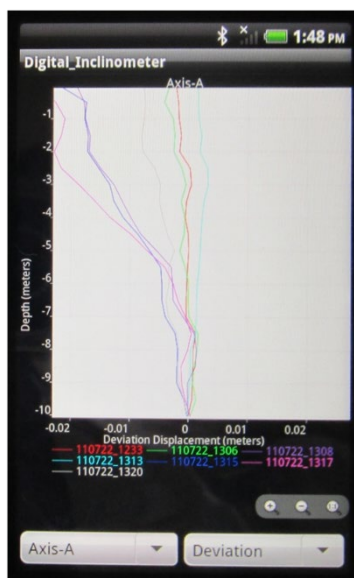


Figure 5.27

Drop down list at right bottom of the screen is showing reading parameters option. Different data options

can be selected from this drop down list. These options are Mean, Face error Absolute and Deviation.

Axis of measurement is showing on top of the graph. X-axis represents borehole parameter while Y-axis represents borehole depth. Buttons given near right bottom side on the screen can be used for manipulating the zoom in, zoom out and pan. Since phone's screen is a touch screen so user can scale and move the graph using finger tips also.

4.4 Borehole files storage

Borehole files are stored at external memory (SD card). Open phone's **File manager** and explore phone's external memory. Explore root directory and find folder **Inclino Files** at path **/mnt/sdcard/**. This folder will be having two sub folders CSV files and Web view file.

Figure 5.28 showing contents of CSV files folder. It is having one archive folder and different CSV files. These CSV files are borehole log files generated while saving borehole log after taking readings (refer section § 5.1.11). Archive folder is used to keep uploaded files (refer section § 5.6).

Figure 5.29 showing contents of Web view files folder. It is having one archive folder and different DI1 files. These DI1 files are borehole log files generated while saving borehole log after taking readings (refer section § 5.1.11). Archive folder is used to keep uploaded files (refer section § 5.6).

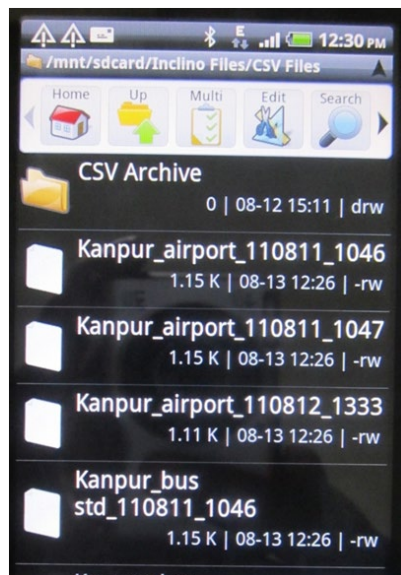


Figure 5.28

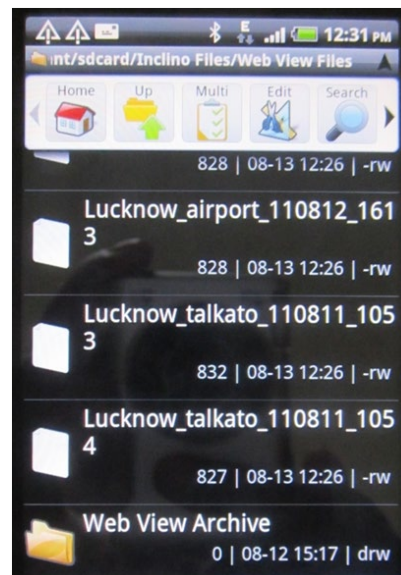


Figure 5.29

4.5 Borehole log database manager

Borehole database can be managed using Database Manager. It can be opened by pressing database manager button from main menu (figure 5.5). Figure 5.30 is showing an example of database manager screen. Borehole logs are listed on centre of the screen. Borehole log list can be filtered using Filter list button. Selected logs can be deleted using delete record button. Borehole files (CSV / DI1) can be re-created using create files button. Once a log is clicked, its information will show under log information heading irrespective of whether log is selected or not.

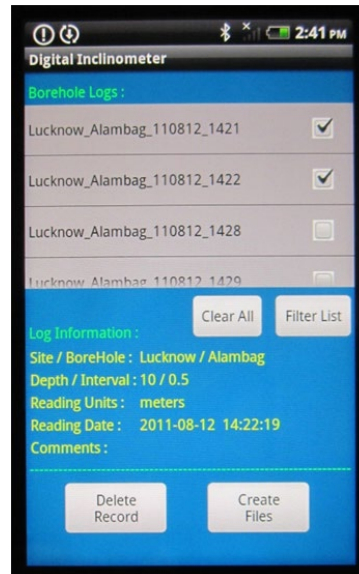


Figure 5.30

4.5.1 *Selecting multiple log files*

Borehole log list can be filtered based upon site, borehole or date. Filter menu can be opened on pressing filter list button from database manager menu (figure 5.30). Figure 5.31 is showing an example of filter log list menu.

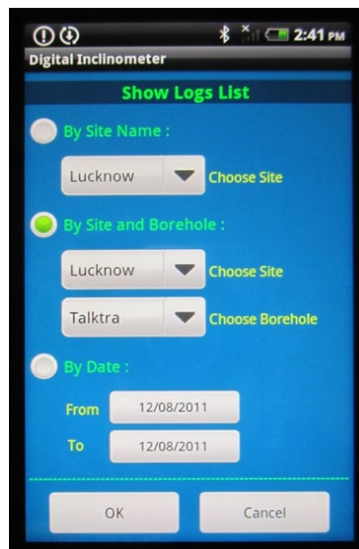


Figure 5.31

To filter log list based on site, select option “by site name” and choose a site using drop down menu.

To filter log list based on borehole, select option “by site and borehole” and choose a site using drop down menu and then select borehole for which we want to see the logs.

To filter log list based on dates, select option “by date” and choose “from” date and then choose “to” date to filter all borehole logs generated between specified dates irrespective of site/borehole.

Press OK button to filter the logs list. Now database manager screen (figure 5.30) will show the filtered list of borehole logs. Select borehole logs by checking the tick boxes corresponding to borehole logs.

4.5.2 Deleting borehole log

Selected borehole logs can be deleted by pressing delete record button from database manager. On pressing delete record button application asks for confirmation. On pressing YES button it will ask to enter deletion password for authentication. On providing correct password it will delete those records from database permanently. Once a borehole log deleted from database it cannot be recovered. So use this button when actually required.

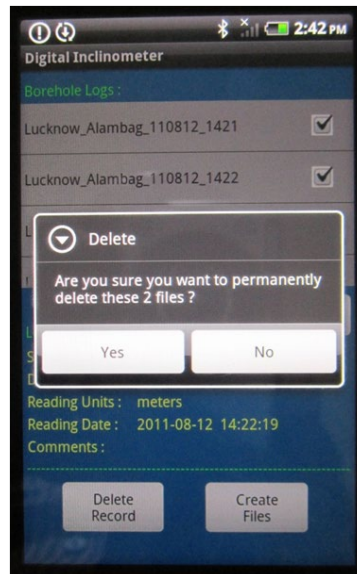


Figure 5.32

4.5.3 Creating files from borehole database

Borehole files (CSV, DI1) can be created using create files button from database manager menu (figure 5.30). Select borehole logs whose files are to be created. Pressing on create files button will open save file formats menu. Figure 5.33 showing an example of save file formats menu. Choose file format options and then press on save button. On pressing save button application will create borehole files of specified file formats at external memory. Created files can be seen by exploring SD card from phone's file manager. Refer section § 5.3 to find created files in memory card.

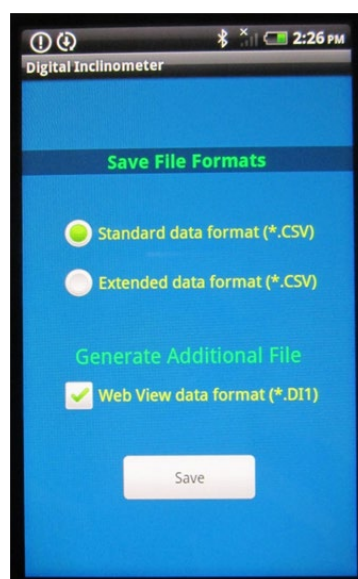


Figure 5.33

4.6 Setting database deletion password

Database deletion password is required when deleting borehole logs from database manager (refer section § 5.4.2). This password can be set from option menu (see figure 5.4).

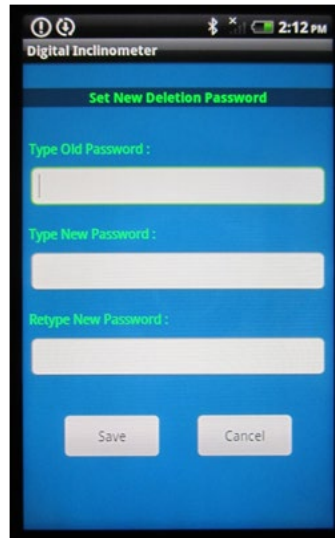


Figure 5.34

4.6.1 Change password

Database deletion password can be changed using change password menu. This menu can be opened by pressing change password button from option menu (see figure 5.4). Type old password, new password and retype new password. Password should be typed carefully. Letters are case sensitive. Press save button to save new password. Remember this password for use in future.

4.6.2 Forgot password

If user forgets database deletion password then it can be reset and new password can be created using forgot password option from option menu (see figure 5.4). On pressing forgot password option application will open new password generation menu (figure 5.35). Master password for generating new password is **X7q9Zft4**. Letters are case sensitive. Type master password carefully and then press generate deletion password button. New password message will pop up on screen. Remember this password and change deletion password using change password option (refer section § 5.5.1).

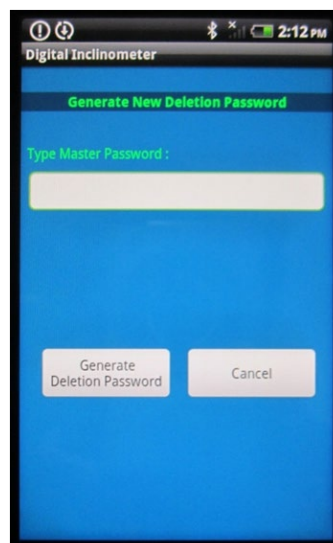


Figure 5.35

4.7 Uploading files

Digital inclinometer system has one excellent feature that Borehole data files can be uploaded to back end server instantly after completing borehole log. This can be done from site. Upload files menu can be opened on pressing upload files button from main menu (figure 5.5). Figure 5.37 showing an example of upload files menu.

4.7.1 URL settings

On pressing reset URL button from upload files menu (figure 5.37) application will open URL settings menu. Figure 5.36 showing an example of URL setting. Type FTP server URL address. Provide port number of the FTP server. Enter user name and password for authentication. After providing all credentials press on save button to update URL settings. Make sure that mobile phone have internet access. Once save button is pressed, application will try to connect to the server. URL setting will be updated on successful connection to the server. URL settings will not be changed in case of connection failure. Old URL settings will be restored in this case. URL settings once saved it will be stored in application's database.

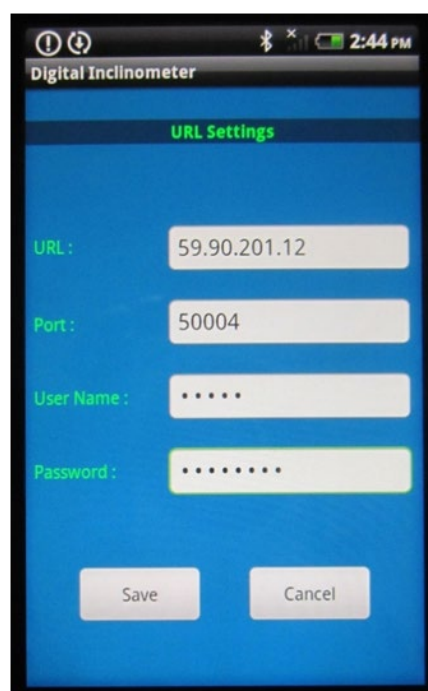


Figure 5.36

4.7.2 Uploading multiple files to server

Upload files menu can be opened on pressing upload files button from main menu (figure 5.5). Figure 5.37 showing an example of upload files menu. Back end FTP server URL address showing on top of the screen.

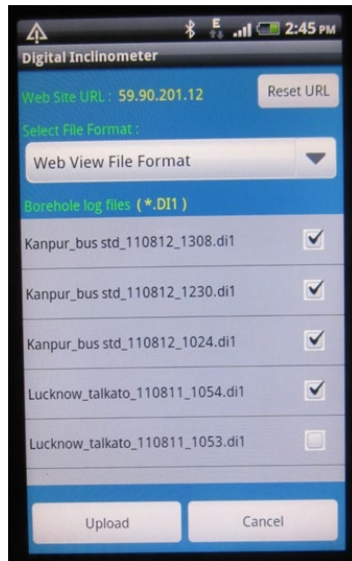


Figure 5.37

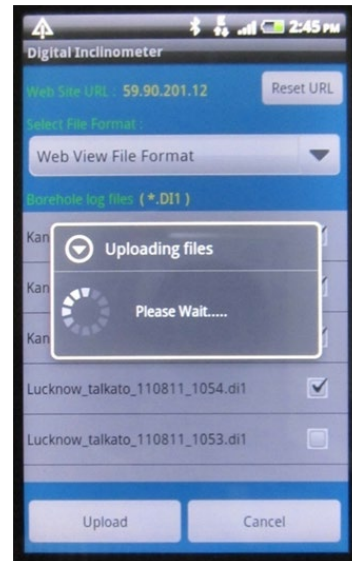


Figure 5.38

Borehole log files showing list of files which are not uploaded on FTP server. CSV files list or DI1 files list can be chosen using drop down menu for showing file types in list view. Files can be selected by ticking on check boxes. Select files which are to be uploaded. Now press on upload button to upload selected files to FTP server. Uploaded files will be moved to archive folder on successful completion of upload process. Press cancel button to exit from this menu. Refer section § 5.3 to view archive folders.

4.8 Help menu

Help information can be seen by pressing Help button from option menu (see figure 5.4). Help information is very useful while working on site. It may be helpful while troubleshooting. Figure 5.39 is showing an example of Help information screen.

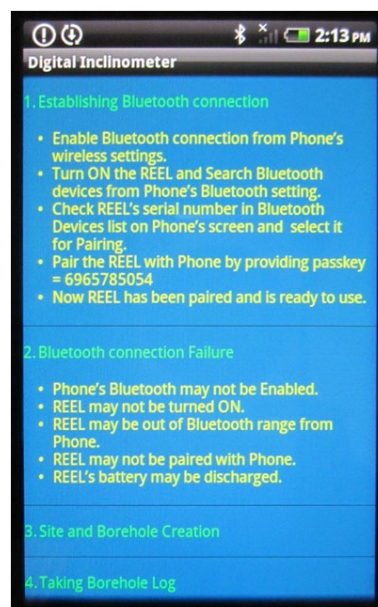


Figure 5.38

5 CALCULATING DATA

Inclinometer probe is passed through the inclinometer casing. The Digital Inclinometer system uses MEMS sensors at probe to measure inclination of the tube in two axes (Axis A & B). Sensors readings are taken at every 0.5 meters (or 2.0 feet). Displacement is calculated from inclination and interval. Readout unit displays the angular displacement in terms of meters (or feet) at each depth. It is recorded for particular depth by accepting reading from readout unit. Following terms are using for data calculation.

A+ = Face A+ displacement = Raw data of axis- A in Face A+

A- = Face A- displacement = Raw data of axis-A in Face A-

B+ = Face B + displacement = Raw data of axis-B in Face B+

B- = Face B - displacement = Raw data of axis-B in Face B-

5.1 Face error

Face error is calculated using expression given below. Face error should be almost constant with very small variations at every interval. Ideally it should be zero. Large and inconsistent face error indicates that there is some problem.

Face error A = (Raw data A+) + (Raw data A-)

Face error B = (Raw data B+) + (Raw data B-)

5.2 Mean displacement

The Mean displacement represents the actual displacement at each depth. It is calculated using expression given below.

Mean Displacement A = ((Raw data A+) - (Raw data A-))/2

Mean Displacement B = ((Raw data B+) - (Raw data B-))/2

5.3 Absolute displacement

The absolute displacement at a particular depth can be calculated by taking summation of mean displacements starting from the bottom up to that particular depth. It represents the profile of the borehole.

5.4 Deviation displacement

It is the difference values of absolute displacement between base file and the selected file. The profile represents the actual movement at all depths with respect to base file.

6 FILE FORMATS

The borehole data files used for transferring digital inclinometer data to other software have the following formats. All data is in standard ASCII text format (7 bit). Variables are separated with commas (.). Text strings are always enclosed within double quotes (" "). Numeric values are recorded as it is. Numeric values may or may not have a leading plus (+) sign but a minus (-) sign is always explicitly included. The contents of the data file are printed in Courier mono space font below.

6.1 Digital inclinometer standard data format (*.CSV)

This format is suitable for direct import in Microsoft Excel (All versions) or other commercially available spread sheet programs for formatted printing and graphical plotting. It can also be imported in GTilt®.

"INCLINOMETER DATA"

"SITE CODE : Lucknow"

"BOREHOLE CODE : Charbag"

"FACES LOGGED : ABCD"

"TIME/DATE TAKEN : 10:54 ON 11/08/11"

"DEPTH OF TUBE : -10.0"

"READING INTERVAL : 0.5"

"OPERATING UNITS : meters"

"DEPTH","FACE A+","FACE A-","FACE B+","FACE B-"

"meters","meters","meters","meters","meters"

-0.0,-0.0061,-0.1625,-0.0059,-0.1610

-0.5,-0.0058,-0.1618,-0.0053,-0.1614

-1.0,-0.0056,-0.1614,-0.0055,-0.1628

.....

.....

-9.0,-0.0059,-0.1620,-0.0047,-0.1619

-9.5,-0.0061,-0.1622,-0.0050,-0.1612

-10.0,0.0056,0.1630,-0.0054,-0.1627

6.2 Digital inclinometer extended data format (*.CSV)

This format is same as above except that the serial number of the probe used for logging borehole data and operator name are also kept on record for conformance with statutory record keeping requirements.

"INCLINOMETER DATA"

"SITE CODE : Lucknow"

"BOREHOLE CODE : Charbag"

"FACES LOGGED : ABCD"

"TIME/DATE TAKEN : 10:54 ON 11/08/11"

```
"PROBE SERIAL NO : 0123456789"
"OPERATOR NAME : Operator Name..."
"DEPTH OF TUBE : -10.0"
"READING INTERVAL : 0.5"
"OPERATING UNITS : meters"
```

```
"DEPTH","FACE A+","FACE A-","FACE B+","FACE B-"
"meters","meters","meters","meters","meters"
-0.0,-0.0061,-0.1625,-0.0059,-0.1610
-0.5,-0.0058,-0.1618,-0.0053,-0.1614
-1.0,-0.0056,-0.1614,-0.0055,-0.1628
.....
.....
-9.0,-0.0059,-0.1620,-0.0047,-0.1619
-9.5,-0.0061,-0.1622,-0.0050,-0.1612
-10.0,0.0056,0.1630,-0.0054,-0.1627
```

6.3 Digital inclinometer webview data format (*.DI1)

This file format will be utilized for transferring data to Encardio-rite web based data monitoring software (WDMS). This file only transfers the logged borehole data points. Each header line or record shall appear on an individual line and shall be terminated with a <CR> <LF> character.

```
"ER DIV1.0 Borehole Data File"
"SITECODE","BOREHOLEID","MAXDEPTH","DATE","TIME","A -0.0","A -0.5","A -1.0",
"A -1.5",.....,"A -9.5","A -10.0","B -0.0","B -0.5",.....,"B -9.5","B -10.0"
"Lucknow","Talktra",-10.0,"2011-08-11","10:46:07",-0.0008,-0.0008,-0.0007,
-0.0007,.....,-0.0001,-0.0000,0.0011,0.0013,.....,0.0011,-0.0004
```

Note: As some of the above record lines are wider than print margins the lines have wrapped around to the next line in print. The ellipsis (....) represents data points that have been edited out of this print record to reduce space. The data contained in the above data format is different from the data in formats number 1 and 2 above. In formats 1 and 2, the raw data contains 2 readings for each of the axes A and B for each depth level as taken by the Inclinometer. In format 3 only one data reading for each axis at each depth is included. The single data point is calculated by taking the average of A+ and A- for the A axis and B+ and B- for the B axis for that particular depth.

7 INCLINOMETER DATA BACKUP

The inclinometer data can be backed up to the PC. After taking borehole readings in the field it is a good practice to backup up borehole files at a safer location or multiple locations.

It is recommended to take inclinometer data backup on regular basis.

7.1 Connecting Phone to the PC

Connect the Phone with PC through USB data cable. On connecting data cable phone will ask for connection type. Choose connection type to “Disk Drive” and then click on “Done”. A popup screen will appear on Desktop/laptop’s screen (see figure 8.1). Select “open folders to view files” option and then click on “OK”. Explorer will open the contents of phone’s SD card. Figure 8.2 is showing an example of phone’s SD card contents.

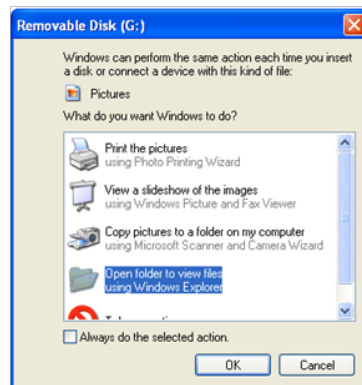


Figure 8.1

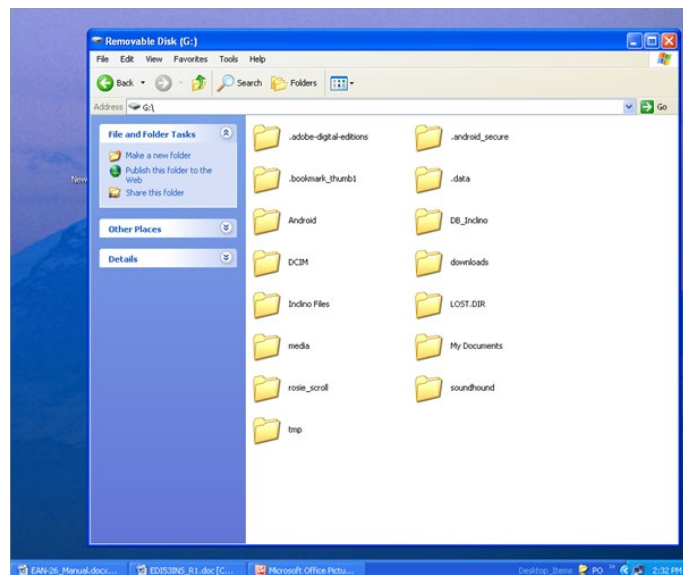
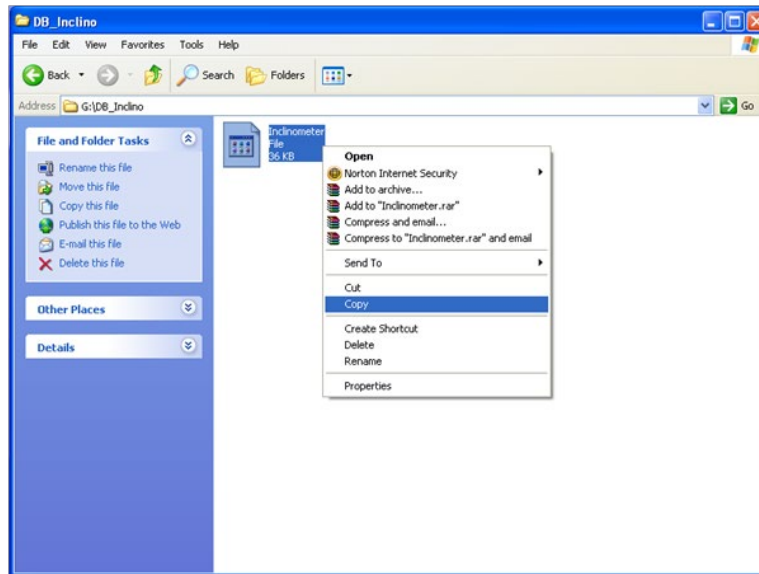


Figure 8.2

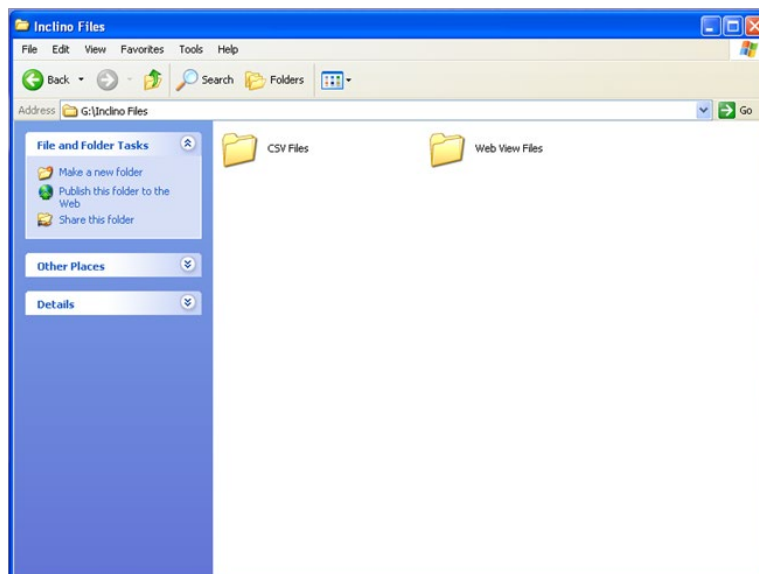
7.2 Backing up the inclinometer database

Open folder “DB_Inclino” to view database folder contents. Figure 8.3 is showing an example of database folder contents. Select the database file (named Inclinometer) and copy this file to a safe location (i.e. network servers etc.).

**Figure 8.3**

7.3 Backing up the borehole logs

Open folder "Inclino Files" to view folder contents. This folder contains two sub folders "CSV files" and "web view files" (see figure 8.4).

**Figure 8.4**

Open folder "CSV files" to view CSV files folder contents. Figure 8.5 is showing an example of CSV files folder contents. Select the files which backups are to be taken. Copy these files to a safe location (i.e. network servers etc..).

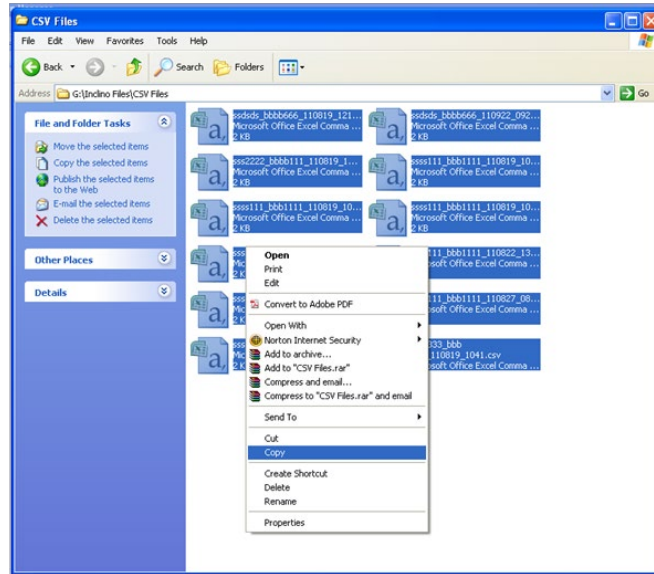


Figure 8.5

Open folder "Web view files" to view Web view files folder contents. Figure 8.6 is showing an example of Web view files folder contents. Select the files which backups are to be taken. Copy these files to a safe location (i.e. network servers etc.).

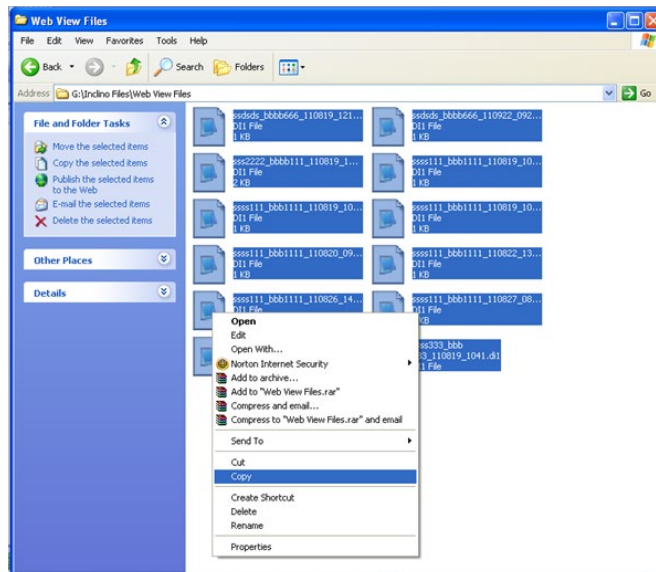


Figure 8.6

8 RESTORING INCLINOMETER DATA

Clear Digital Inclinometer application data from phone's application manager. Connect the phone through USB cable and explore SD card as explained in section § 10.

8.1 Restoring the inclinometer database

Copy the preserved inclinometer database from safe location (i.e. network servers etc.). Open folder "DB_Inclino" to view database folder contents. Paste the database here and overwrite the existing database as shown in figure 9.1.

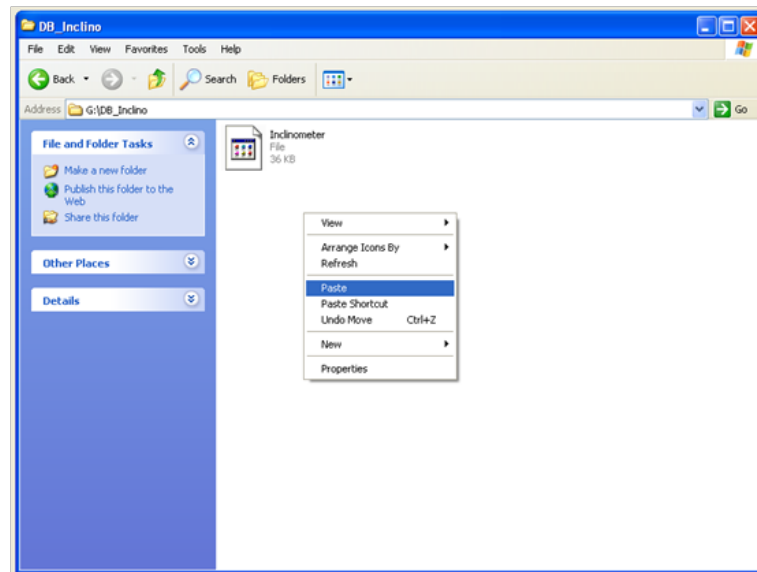


Figure 9.1

8.2 Restoring borehole logs

Copy the preserved inclinometer CSV files from safe location (i.e. network servers etc.). Open folder "CSV files" to view CSV files folder contents. Paste the selected CSV files here as shown in figure 9.2.

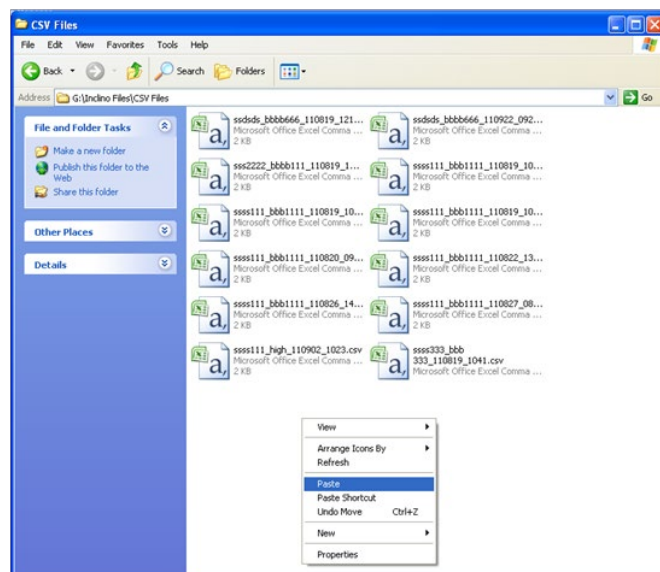


Figure 9.2

Copy the preserved inclinometer Web view files from safe location (i.e. network servers etc..). Open folder "Web view files" to view Web view files folder contents. Paste the selected Web view files here as shown in figure 9.3.

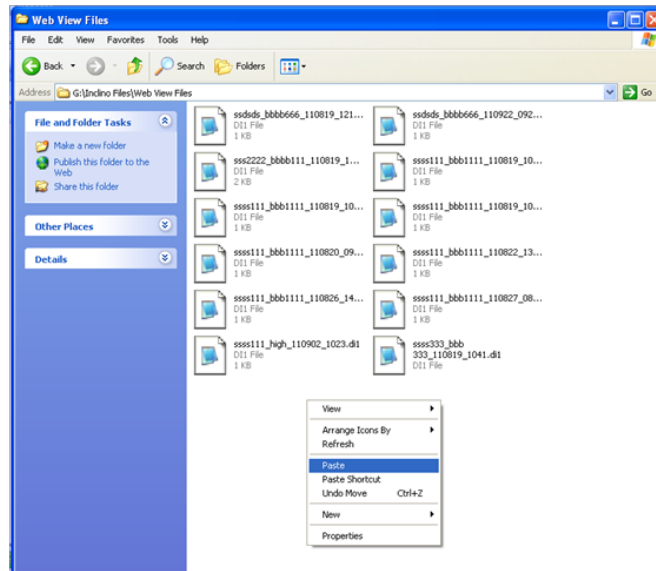


Figure 9.3

9 TROUBLESHOOTING

9.1 Unable to connect Bluetooth

- Phone's Bluetooth may not be enabled.
- Reel may not be turned ON.
- Reel may be out of Bluetooth range from phone.
- Reel may not be paired with phone.
- Reel's battery may be discharged.

9.2 Unable to connect to the probe

- Probe connector may be loose. Turn OFF the Reel and reconnect the probe with reel cable and then turn ON the Reel.
- Check the probe's connector for damage.
- Reel's cable may be broken.
- Reel's battery may be discharged.

9.3 Files not uploading on FTP server

- Mobile network may be disabled.
- Mobile network may not be available.
- URL or port setting may be incorrect.

9.4 Inserting new SD card

- Always clear data from phone's application manager when inserting new SD card.