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USERS' MANUAL

DIGITAL INCLINOMETER OPERATION

MODEL EAN-26M

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ENCARDIO-RITE ELECTRONICS PVT. LTD.

A-7, Industrial Estate, Talkatora Road Lucknow, UP - 226011, India | P: +91 522 2661039-42 | Email: geotech@encardio.com | www.encardio.com

International: UAE | Qatar | Bahrain | Bhutan | Morocco | Europe | UK | USA

India: Lucknow | Delhi | Kolkata | Mumbai | Chennai | Bangalore | Hyderabad | J&K

Contents

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-26R 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 7.3 V 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 EAN-26M digital inclinometer system is used for reliable measurement of lateral movement in applications like:

- Earth movement in landslide zone.
- Detecting shear planes in hydraulic structures.
- Measuring stability during construction.
- Deflection of diaphragm/retaining walls and piles under load.

The inclinometer system provides significant quantitative data on magnitude of inclination and its variation with time. It gives information on pattern of deformation and effectiveness of construction control measures. It helps in monitoring behaviour after construction and indicates potentially dangerous conditions that may adversely affect stability of the structure, its foundation and surrounding area. It also provides basic data for design improvement that will promote safer and economical design and construction.

The EAN-26M digital inclinometer system is an accurate instrumentation system. Its readout has built-in data storage facilities and capability of transferring stored data to a computer. The inclinometer probe operates in a plastic grooved casing which may be "built-up" with embankment fill, inserted into boreholes or attached externally to structures or hillsides. The inclinometer casing may be installed with telescopic couplings as construction progresses providing opportunity for settlement measurements, or it may be installed with butt joints in drill holes in abutments or completed embankments if no significant settlement is anticipated.

1.1 Displacement measurement

For measurement of vertical displacement, magnetic targets may be fixed to access casing at selected points. Measuring settlement by using inclinometer casing has largely replaced the earlier method using separate settlement devices like the cross arm. The same installation is now used to measure settlement as well as lateral movement. For details refer to data sheet 1098 "Magnetic Extensometer System".

1.2 EAN-26M Digital Inclinometer Overview

The Encardio-rite model EAN-26M 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 pixel with colour display and a 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-26M digital inclinometer's 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.

Few functional advantages can be listed as follows:

- 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 (as will be explained in the manual). In case of any error during logging, the probe can be lowered back to the depth with problem and logging can be continued without having to start afresh, thus saving time.
- A quick probe check mode allows verifying probe operation or calibration without having to configure a dummy bore hole 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 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): Microsoft Excel is a trademark of Microsoft Corporation, USA.

1.3 How to use this manual

The manual is divided into a number of sections. Each section contains a specific type of information. The index tells you where to look for in this manual if you need some specific information.

1.4 Conventions used in this manual

WARNING! Warning messages calls attention to a procedure or practice, that if not properly followed could possibly cause personal injury.

CAUTION: Caution messages calls attention to a procedure or practice, that if not properly followed may result in loss of data or damage to equipment.

NOTE: Note contains important information and is set off from regular text to draw the users' attention.

1.5 General information

This users' manual is intended to provide you with sufficient information on operation of model EAN-26M digital inclinometer and its mobile readout unit. The manual also contains instructions on how to set-up for lowering inclinometer probe into gage well for purpose of taking inclination readings.

NOTE: Installation personnel must have a background of good installation practices and knowledge of the fundamentals of geotechnics. Novices may find it very difficult to carry on the installation work. The intricacies involved in installation are such that even if a single essential but apparently minor requirement is ignored or overlooked, the most reliable of instruments will be rendered useless.

A lot of effort has been made in preparing this instruction manual. However the best of instruction manuals cannot provide for each and every condition in the field, which may affect performance of the sensor. Also, blindly following the instruction manual will not guarantee success. Sometimes, depending upon field conditions, installation personnel will have to consciously depart from the written text and use their knowledge and common sense to find the solution to a particular problem.

This equipment should be installed, maintained and operated by qualified personnel. Any errors or omissions in installation, data or data interpretation are not the responsibility of Encardio-rite Electronics Pvt. Ltd.

For details on how to install inclinometer casing, please refer to operating manual # WI 6002.104.

1.6 List of Abbreviations

3G	3rd Generation of wireless mobile telecommunications technology
4G	4rth Generation of wireless mobile telecommunications technology
CSV	Comma Separated Values
DI	Digital Inclinometer
EAN-26	Digital Inclinometer System
FTP	File Transfer Protocol
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications

LED	Light Emitting Diode
PC	Personal Computer
SIM	Subscriber Identity Module
URL	Uniform Resource Locator
USB	Universal Serial Bus
WDMS	Web based Data Monitoring Service
Wi-Fi	Wireless Fidelity

2 EAN-26M DIGITAL INCLINOMETER SYSTEM

1.1 Operating principle

The first step is to make a near vertical gage well by installing casing in a borehole, embedding in an earth/rock fill or concrete structure during construction or fixing to face of a completed structure.

NOTE: For details on how to install inclinometer casing, please refer to operating manual # WI 6002.104

The inclinometer probe is then passed through entire length of gage well, taking readings at fixed pre-determined depths from bottom to top. A dual accelerometer probe senses inclination of casing in two planes at right angles to each other. Voltage output from probe is directly proportional to sine of angle of inclination of long axis of probe from the vertical. A positive output voltage indicates a negative angle of inclination.

A set of initial base reading is taken at given depths within the gage well. This forms the reference datum. Subsequent reading sets are compared with this reference datum. All subsequent readings are taken over a period of time at identical depths, thereby indicating rate, magnitude, and direction of lateral deformation. The inclination is displayed in terms of angular or horizontal displacement (deviation) on the electronic readout equipment at ground level with the operator.

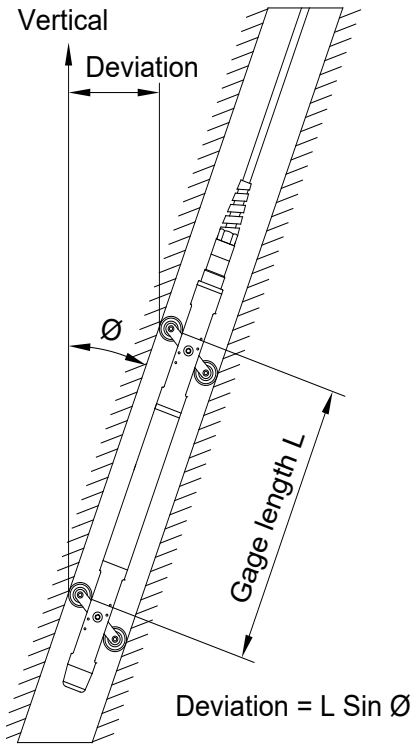


Figure 2-1

Provided that one end of access casing is known to be fixed, it is possible to obtain a complete profile of the gage well by taking a succession of readings. By comparing these profiles, the horizontal displacement of gage well at different depths over a period of time is determined.

1.2 EAN-26M digital inclinometer system

The EAN-26M digital inclinometer system basically consists of:

- Access casing and fittings
- Tilt sensing probe
- Interconnecting cable with reel and cable holder
- Mobile phone datalogger
- Accessories including:
  - Dummy probe
  - Suspension bracket
  - Calibration check jig
  - Pop rivet gun

2.1 Access tubes and fitting

Inclinometer ABS access tubes have longitudinal keyways, specially produced to close tolerances to allow inclinometer probe wheels run smoothly inside them.

Access tubes are 3 m (~9.85 ft) in length. Different kinds of couplings are available to rapidly join access tubes. Telescopic couplings are available in case settlement is expected to take place. Design of these couplings ensure that correct alignment of keyways is maintained throughout depth of gage well.

Figure 2-2 ABS access tubes with fixed and telescopic coupling and end cap

2.2 EAN-26MV digital tilt sensing probe

Encardio-rite model EAN-26MV inclinometer probe uses accelerometers as the basic tilt sensor. In addition some kind of signal conditioning is given to boost the signal voltage. Analog to digital signal conversion is done to make the signal noise free, suitable for transmission over long cables.

The digital inclinometer (tilt sensing) probe measures angles of inclination from the vertical in two planes oriented at 90° (orthogonal) to each other. The inclinometer probe of stainless steel construction is fitted with two pairs of pivoted sprung wheels that can rotate freely.

The standard gage length between the wheels is 500 mm (or 2 feet). The spring-loaded wheels help to accurately position the probe centrally inside the gage well at any required depth. The precision grooved casing forms an integral part of the gage well. The cylindrical portion of the probe has a diameter of 25.4 mm and a length of 685 mm.

The probe consists of two integral precision accelerometers, one with its axis in plane of the wheels and other at 90° to it. The probe senses horizontal deviation between the probe axis and the vertical plane, simultaneously in the 'X' and 'Y' directions.

The EAN-26MV 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.

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 the inclinometer probe output is more useful, as the subsequent calculations determining the ground profile uses the sine of the tilt angle rather than the tilt angle itself.

Figure 2-3 Inclinometer probe

Inclinometer probe has a significant current consumption and thus introduce a drop in excitation voltage across the connecting cable. The EAN-26R cable reel supplies an excitation voltage of +29 V. The cable length, connected to inclinometer probe, should not cause the excitation voltage to drop less than +12 V at the inclinometer probe terminals.

A four pin connector is provided in inclinometer probe for connection to the cable.

2.3 EAN-26MR Digital Inclinometer cable and reel

The inclinometer probe is connected used with EAN-26R cable reel. The cable reel comprises of a plastic winding reel on suitable frame to hold the specified length of the cable.

A PU sheathed two core cable is clamped at every 0.5 m (or 2 feet) with copper ferrules. The ferrules are number engraved at every meter. A four pin connector is provided for connecting read-out to probe.

Figure 2-4 Cable reel assembly (with probe)

The cable reel has a Bluetooth interface unit inside the reel and a long cable to interface with digital inclinometer probe. The 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.

2.4 Mobile phone datalogger

The Digital Inclinometer system uses an Android OS based mobile phone as a hand held datalogger. Any mobile phone with minimum features (as listed below) can be used for this application. The Android operating system of phone for providing powerful platform to manage applications efficiently. It has additional useful features like phone calls, SMS, MMS, GPRS/3G, Wi-Fi, Bluetooth, USB, high resolution camera and high capacity external memory card.

The Encardio-rite inclinometer application software on the phone enables it to configure and collect data from the digital inclinometer system. The application is very friendly and has ability to show borehole logs in tabular format and create plots of borehole data instantly after borehole reading is complete. This allows the operator to verify the logged data and investigate any anomaly immediately at site.

Figure 2-5 Mobile readout unit

2.4.1 Mobile phone datalogger (minimum requirements)

A mobile phone that is intended for use as readout unit for the digital inclinometer should have the following minimum features. If a mobile phone is ordered and supplied with the system it shall have the following minimum features.

Mobile OS	Android version 2.2 or above
RAM	512MB (recommended 1 GB).
External memory	2 GB or above
Display size	480 x 800 pixels or above
Display Type	Touch screen
CPU Speed	1 GHz or above
Blue tooth	Version 3.0 with A2DP or above

Mobile Network 2G Network: GSM850/900/1800/190
3G Network: HSDPA900/2100
(If the mobile phone readout will be used in an area covered by CDMA network services only, then a mobile phone suitable for CDMA should be used or ordered)

NOTE: Due to continuous improvements and change in availability of models no specific recommendations can be made about manufacturer and model number. Also the above features may change, if the application is upgraded. Please contact factory for latest update on minimum features requirement for mobile phone.

2.5 Accessories

2.5.1 EAN-DP Dummy probe

It has same dimensions as the actual probe. It is used for checking the gage well. Cord length is same as cable length in the actual probe.

2.5.2 EAN-26CB Cable suspension bracket

It is directly placed on casing at top of gage well to lower probe into borehole. It has a slot to hold the cable at the graduated marks (ferrules) for convenience in taking the readings.

Figure 2-6 cable suspension bracket

2.5.3 EAN-26CCJ Calibration check jig

Calibration check jig enables verification of calibration of the inclinometer probe at known angles of tilt. Please refer to Users' manual # WI 6002.107 on how to mount and use calibration check jig.

Figure 2-7
Calibration check jig

3 MANDATORY CHECKS AFTER INSTALLATION OF INCLINOMETER CASING

NOTE: For installation of inclinometer casing, refer to Users' manual # WI 6002.104 giving details on installation inclinometer casing in different applications.

3.1 With Encardio-rite model EAN-26DP dummy probe

Lower dummy probe inside the inclinometer casing, first in grooves in one direction and then in the perpendicular direction to verify that the grooves are smooth with no concrete or foreign material stuck in them. Clean if necessary.

The monitoring instruments described in the introduction should never be lowered down in the gage well unless the latter is checked by the dummy probe. The monitoring instrument may get stuck in the gage well and you may permanently lose it in case this instruction is not followed.

NOTE: The model EAN-26DP dummy probe is not a part of the supply and has to be ordered separately.

3.2 X-Y coordinates with Prism target

a. Determine initial Northing (X) and Easting (Y) positions of casing top by surveying after the casing is set. An aluminium adaptor with holder pin (suitable for inclinometer casing EAN-AT-70) with ERT-10P2 prism target is available for taking X-Y coordinates. Refer to figure 3-1 for details.

b. Readings should be taken with an accurate and precise total station. This data should be treated as a reference during verification of deflection at a later date.

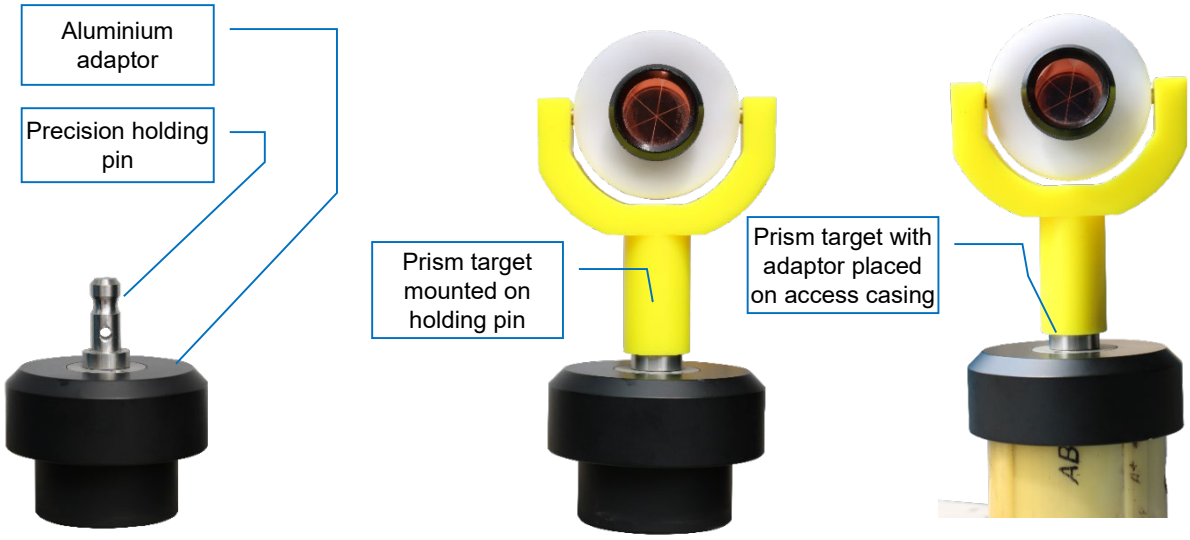


Figure 3-1 Prism adapter for inclinometer casing

3.3 Elevation by settlement point

Additionally, determine the elevation of the pipe top using a precision digital level. For this purpose a settlement survey marker should be mounted adjacent to top of inclinometer casing that will serve as survey reference point. The survey marker is illustrated in figure 3-2.

Figure 3-2 Survey target to be mounted on top concrete platform to determine elevation of casing top

This will allow inclinometer as well as settlement profile to be referenced to an absolute reference (elevation above sea level) should datum reference at the bottom be required to be verified due to any reason.

NOTE: The aluminium adaptor with holder pin, model ERT-10P2 prism target and the settlement point are not a part of the supply and have to be ordered separately.

CAUTION: The Northing (X), Easting (Y) and Elevation (Z) of the casing top taken by the precision total station and digital level is a reference for future use. It should be carefully stored and never be lost till the borewell is used for monitoring.

3.4 Sign convention

The inclinometer readout uses a sign convention for casing orientation. Follow sign convention strictly. Mark casing groove orientation with a permanent ink marker pen on outside of casing and inside of lockable cover.

Mark 'A+' in direction in which maximum deflection is expected. Looking down the well, mark other grooves clockwise as 'B+', 'A-' and 'B-'. While inserting probe into casing, the uppermost probe wheel near connector should be pointed in direction of major principle plane of movement i.e. in direction marked A+. (In some dataloggers, direction is marked as A, B, C and D). Refer to figure 3-3.

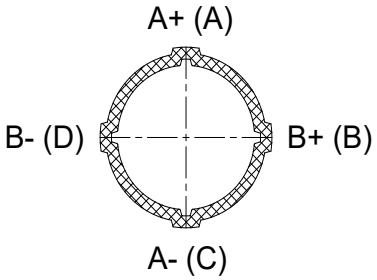


Figure 3-3

NOTE: While installation, one pair of inclinometer casing grooves are always maintained perpendicular to direction in which lateral movement is to be measured. If no such direction is known, one set of grooves are mainlined parallel to N-S direction.

4 PREPARATIONS FOR TAKING READINGS

4.1 Connecting probe to cable reel

a. Open lock on protective cover and remove top cap from casing.

b. Take out probe from transport case. **Remove protective cap from top of probe. You will find an Ó' ring on face of probe. Inspect condition of "O" ring.** Replace if damaged or permanently flattened.

CAUTION: Please ensure that the "O" ring is in proper form and correctly placed. Extra "O" rings are always provided with the supply in inclinometer probe carrying case.

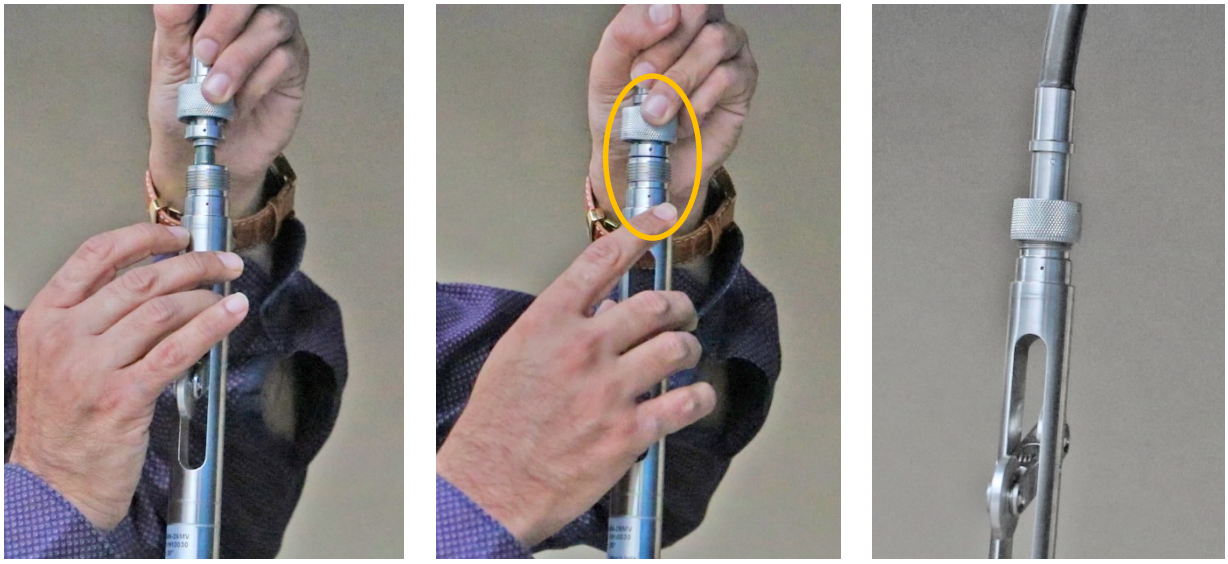


Figure 4-1 Connecting probe to cable reel

c. Carefully push connector part of connector assembly at end of cable on to inclinometer probe connector after ensuring that keying slots and splines of probe and cable connectors are properly aligned (otherwise the connector assembly will not fit).

d. While connecting the probe to the cable reel, ensure that the red dot marks on the connector and probe are aligned properly. Refer to the figure 4-1 and 4-2. A caution sticker is also provided on the probe for the same.

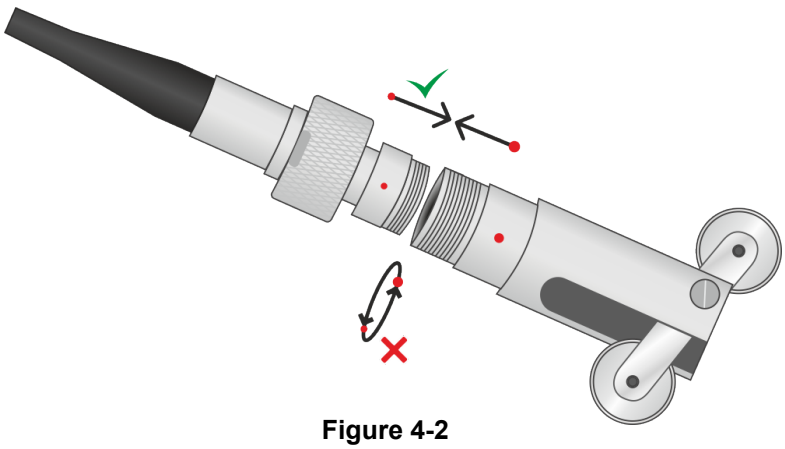


Figure 4-2

e. Once aligned, thread in the probe and connector together securely.

f. Ensure that the knurl nut over connector is not over-tightened. Do not apply unnecessary force. Screw on (not forcibly) with supplied spanner the threaded retaining shell of cable connector assembly to inclinometer probe to make a water tight connection.

4.2 Precautions while making connections

It is very important to take proper precaution while connecting probe to the reel to have correct and trouble free readings from the digital inclinometer system. Guidelines on taking care of probe and cable reel connector are given below. These should be followed stringently to avoid untimely wear and tear or failure of the connector.

1. While connecting probe to cable reel, ensure that the red dot marks on the connector and probe are aligned properly
2. Ensure that while connecting, only the coupling (on the connector) is twisted, and not the cable.
3. Ensure that the connector end of probe and cable reel are always clean; there should not be any debris or dust inside, while connecting. Soap and water can be used to clean it on a regular basis. One can also use alcohol for cleaning; rinse connector with alcohol and then allow it to air dry.
4. The 'O ring of probe and elastomer/compound in the probe connector can degrade when exposed to heat/sunlight or any solvent. To prevent this, always use the protective plug over connectors, when not in use.
5. Ensure that both connectors and the protective plug are clean and dry, before fixing cap on connectors, during transport and storage.
6. It is recommended to use a silicone spray to lubricate the connector ends for smooth connection. Never use grease or solvent based lubricants as these can damage the connectors.

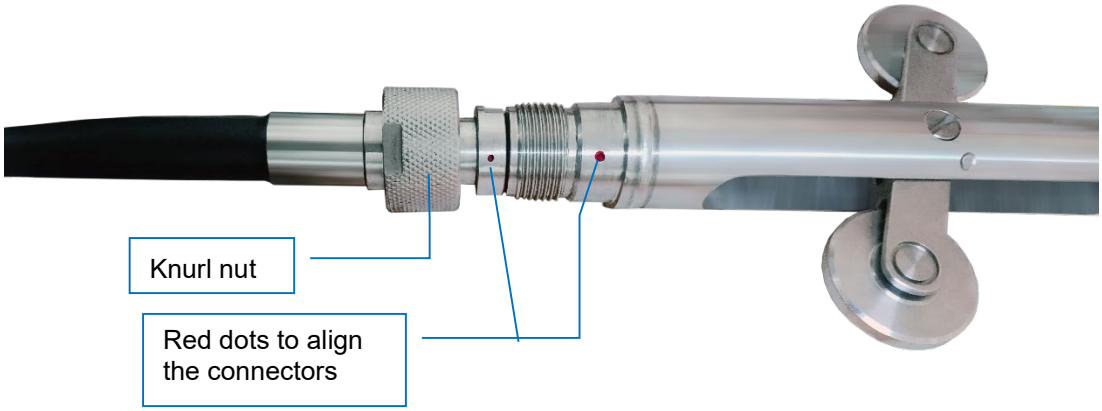


Figure 4-3 Connector alignment

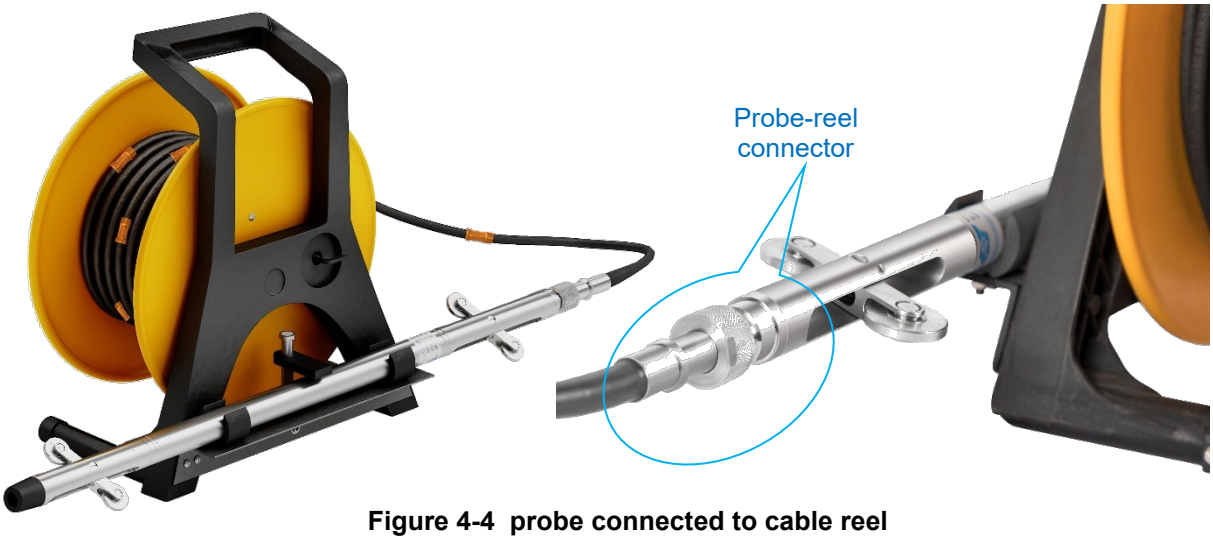


Figure 4-4 probe connected to cable reel

4.3 Preparing to log a borehole

NOTE: Section 6 and 7 "Mobile Readout Unit" and "Inclinometer application software for mobile" describes the procedure for setting up a bore hole and logging the borehole. Follow the instructions given to log the borehole.

Site and borehole names must be created in readout unit before logging a borehole. Edit borehole parameters be 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 ft) 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 labelled 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 labelled 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.

5 TAKING READINGS

5.1 Taking readings with Digital inclinometer system

NOTE: Depth up to bottom of casing should already be known so that probe can be eased on to bottom without jolting it or damaging it.

NOTE: Section 6 and 7 "Mobile Readout Unit" and "Inclinometer application software for mobile" describes the procedure for setting up a bore hole and logging the borehole. Follow the instructions given to log the borehole.

a. Before taking the first reading make sure that the grout filled in the annular space between the borehole and inclinometer access casing is set. It is recommended to take the first reading at least one week after the grouting

b. Put the pipe extension jig over the pipe top, if required. Secure cable suspension bracket over the casing or the extension jig.

c. Lower inclinometer probe EAN-26MV to bottom of gage well with uppermost torpedo wheel pointing in direction marked 'A+'. Inclination of the probe is displayed in terms of horizontal displacement on the smartphone datalogger at the ground level with the operator.

d. Raise probe along entire length of gage well from bottom to top, resting the ferrule (at 0.5 m interval on inclinometer cable) over the suspension bracket. Refer to figure 5-1. This will give readings at intervals of 0.5 m. The two sensors inside the probe will sense the inclination of the casing in two planes at right angles to each other.

e. Again lower probe to bottom of gage well with uppermost torpedo wheel pointing in direction 'A-'. Raise probe along entire length of gage well from bottom to top, taking readings at intervals of 0.5 m.

f. Provided one end of the casing is known to be fixed, complete profile of gage well may be obtained by taking a succession of readings. By comparing the profiles, horizontal displacement of gage well at different depths over a period of time is determined.

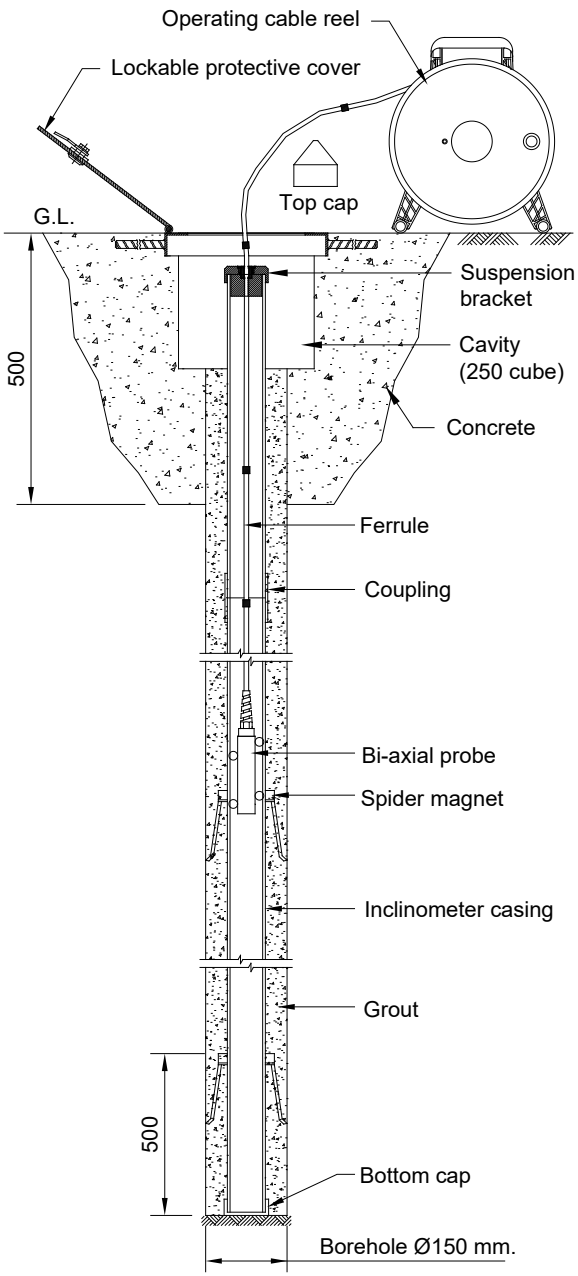


Figure 5-1 Taking readings

g. The base or initial reading is formed after taking at least three sets of readings. Choose one out of the most repeatable readings of the set and make it the base. All subsequent readings are compared with this base reading thereby indicating rate, magnitude and direction of lateral deformation.

h. When the logging is complete remove the cable grip from the access tubing and take out the inclinometer probe.

i. Disassemble cable from probe. Wipe clean the probe and replace protective caps on the cable and the probe. Oil the wheel, springs and axle pivots with the supplied oil (or any other locally available light duty machine oil).

j. Rewind cable onto cable reel, clean it and fix the connectors in place.

k. Replace the top plug on the casing and lock it. In case any additional protection is provided, install it.

NOTE: Not properly cleaning probe, associated cable, connectors and datalogger after use is the most frequent cause of failure of the inclinometer system. Not oiling the wheel, springs and axle pivots will invariably result in costly repairs and equipment downtime.

5.2 Guidelines and maintenance for correct readings

5.2.1 Maintenance Inclinometer Probe

1. Before connecting inclinometer probe to cable reel, remove the protective cap and check for the Ó' ring on face of probe. Ensure that the "O" ring is in proper form and correctly placed. Replace if damaged or permanently flattened. Extra "O" rings are always provided with the supply in inclinometer probe carrying case.
2. Constantly check conditions of "O" ring on probe face to maintain a watertight seal.
3. After taking reading, always ensure to wipe clean the probe and replace protective caps on the cable and the probe.
4. Ensure to oil the wheel, springs and axle pivots with the supplied oil (or any other locally available light duty machine oil). If piling is not done on regular basis, it will invariably result in untimely failure and costly repairs.
5. Replace probe wheels and axles if they become wobbly or sticky.
6. Keep protective plugs in place on all electric outlets to prevent physical damage or liquids spilling into them.
7. Keep all electrical connections clean - use alcohol or a spray cleaner suitable for electronics that will not damage the outer cable covering or panel finish.

5.2.2 Guidelines for correct readings

Do's

- If large deformations are expected to take place, use dummy probe to check condition of gage well before lowering the actual probe.
- Check if directions 'A+', 'B+', 'A-' and 'B-' are clearly marked on casing top. In case the marks are fading away, re-mark them.
- Always allow enough time for the accelerometers (inside the probe) to "settle down" before taking any reading.
- When raising probe during a set of readings, take extreme care in duplicating depths A+ and the A- reading runs such that errors contributed by casing irregularities are minimized.

- Replace the discharged cable reel battery with a fully charged battery if battery voltage goes below 6 V. The inclinometer system is supplied with two Lithium batteries for the reel unit.

Do not's:

- Hard bumps to probe can misalign and/or break the accelerometers or break internal electrical connections.
- Hard bumps to indicator can dislodge internal batteries, break electrical connections, shift LCD readouts or rupture the watertight case seals.
- Bending connecting cable over sharp objects or walking on it can sever internal conductors or puncture the outer waterproof coating.

NOTE: The inclinometer system is like other delicate equipment and its use requires common sense and reasonable care!

6 MOBILE READOUT UNIT

6.1 Overview

The Digital Inclinometer system uses an Android OS based smart-phone as a readout unit. The Android operating system of the phone provides powerful platform to manage applications efficiently.

The mobile phone communicates with the inclinometer cable reel through its in-built Bluetooth wireless interface. The wireless link eliminates the traditional slip ring and cable connection between the reel unit and the hand-held readout that often became unreliable due to frayed cable and slip ring problem.

The phone readout has a number of additional useful features like:

Figure 6-1 Mobile readout

- The huge computational and image processing power allows to display the logged borehole data as tables or various types of graphs commonly used at back end computers to visualize the data. This allows the operator to verify the logged data and investigate any anomaly immediately at site.
- User can use the phone at site to make calls, to upload/download files or check 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 photographs of site conditions and send them back to office from site itself for immediate attention.
- A higher capacity external memory card can be used to store large amount of data.
- Data backup can be taken on regular basis by connecting phone with PC through USB cable.

6.2 Inclinometer software for phone

The Encardio-rite in-house developed 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 mobile phone internet connection via GPRS/3G/4G/Wi-Fi.

6.3 Establishing Bluetooth connection

Inclinometer system uses Bluetooth connection for communicating phone readout with the cable reel. For making connection follow the steps given below:

- Connect the inclinometer probe with cable reel.
- Turn ON the cable 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.
- 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 cable reel.
- Once pairing button is pressed it will ask to enter passkey for authentication. Enter pairing code "**6965785054**" and press OK.
- On successful authentication it will show that device is paired. Now phone is paired with reel.

The above activity is required for first time connection of phone with cable reel.

7 INCLINOMETER APPLICATION SOFTWARE FOR MOBILE

7.1 Application Installation

It is strongly recommended to exit all programs before installation. Follow the steps below for installing the application for the first time.

NOTE: Please make sure that option for Unknown sources (allow installation of non-Market apps) in Setting-> Security must be checked.

- Copy the "EAN26R1_xx.apk" into the mobile via Bluetooth or USB cable.
- Go to copied location and tap on EAN-26R1_xx.apk. Tap on install. Refer to Figure 7-1.

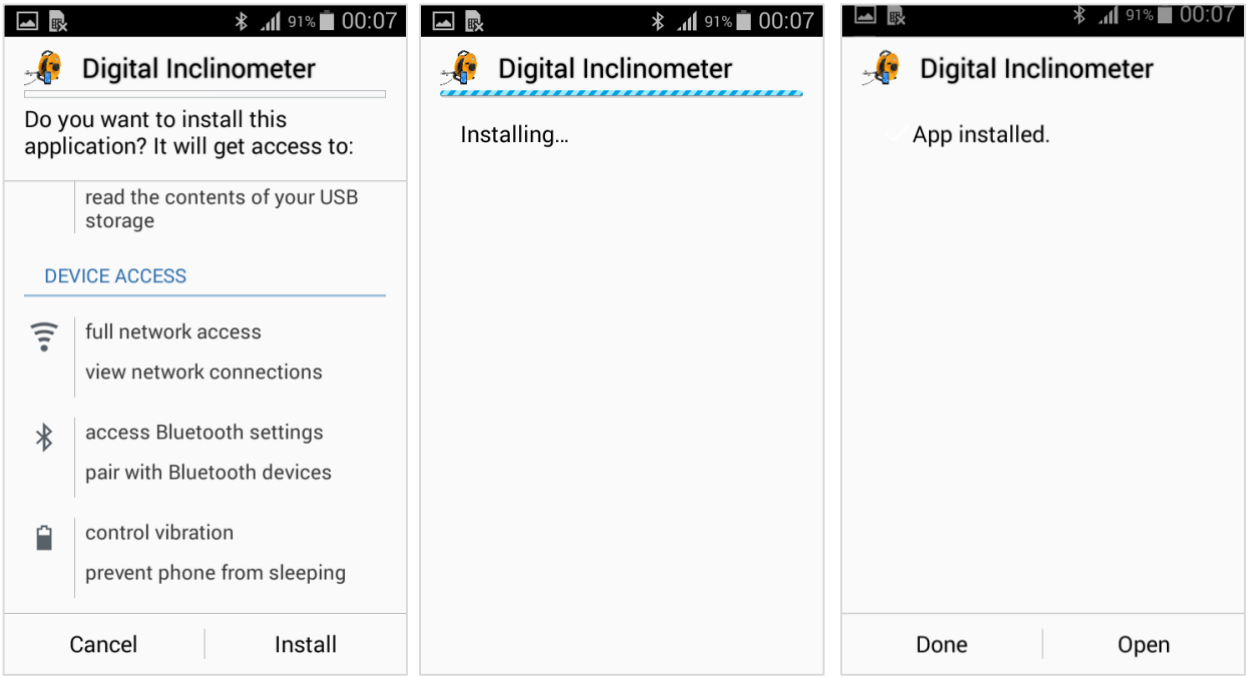


Figure 7-1 Digital Inclinometer Android Application Software Installation

- After installing press 'Done' or application can be opened directly by pressing 'Open'. User can open the application through application launcher also. Refer to figure 7-2
- Click on Digital Inclinometer (DI) application icon as shown in figure 7-2.

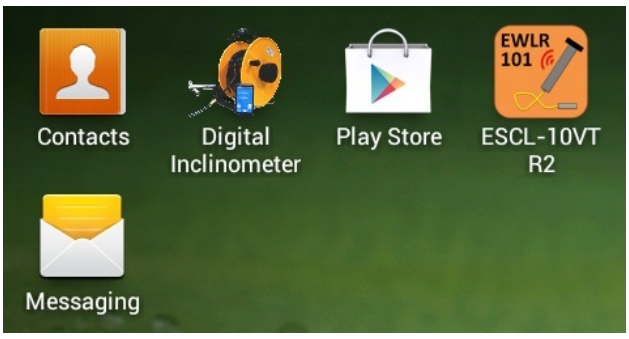


Figure 7-2 Application launcher

- The app will show the name of the application and its version (refer to left screenshot in figure 7-3). This screen will splash for few seconds and then option menu appears.

- Figure 7-3 (right screenshot) shows different function buttons. With 'Change Password' button, the password for database deletion can be changed or it can be regenerated with 'Forgot Password?' button. Help information can be accessed by pressing 'Help' button. 'Main Menu' button is used to proceed further.

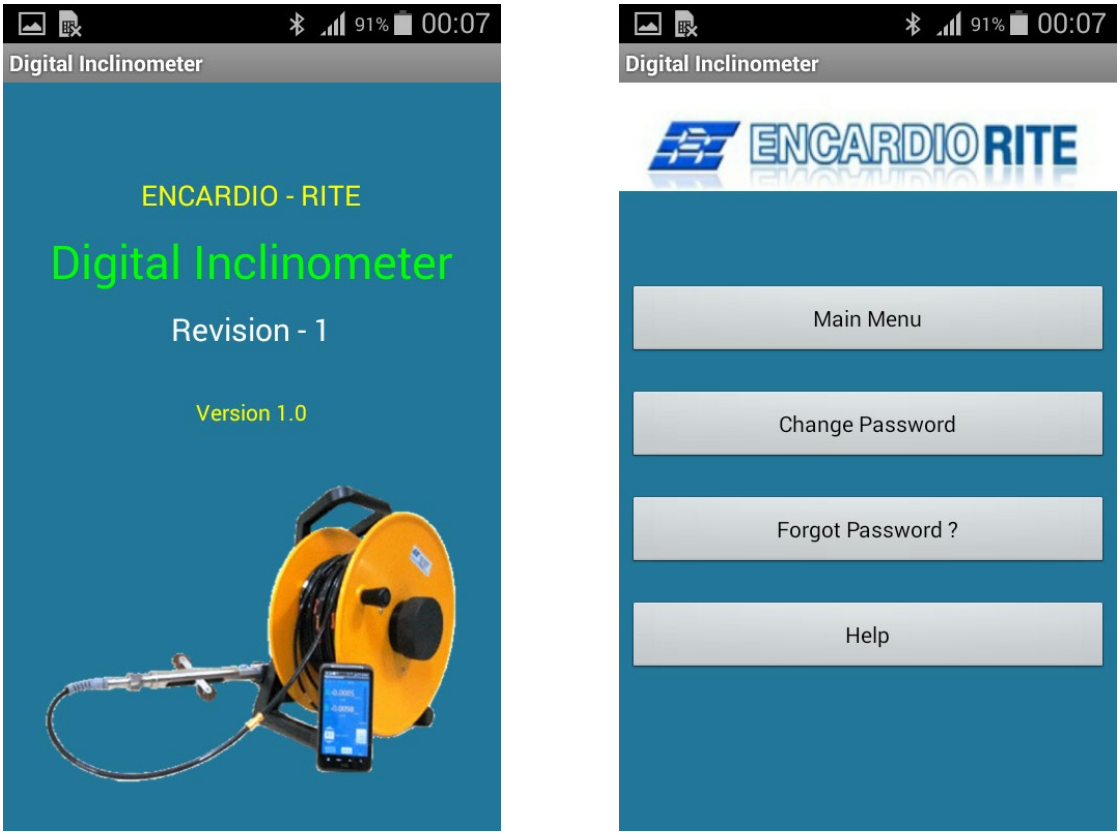


Figure 7-3 Splash Screen & Home Screen

7.2 Main Menu

'Main Menu' option allows numerous functions as given below. Refer to figure 7-4

1. **'Device Connection**' button – For connecting phone with a reel using Bluetooth.
2. '**System Information**' button – To view system information. It will show the information about reel, probe, Bluetooth and phone.
3. '**Create Borehole**' button – To create new site and borehole.
4. **'Edit Borehole'** button – To modify borehole parameters.
5. '**Take Reading'** button – To view borehole readings.
6. **'View Data'** button - Borehole data can be viewed in tabular form or can be plotted on graph.
7. **'Upload Files'** button - Borehole files can be uploaded to a remote server.
8. **'Database Manager'** button - Borehole logged database can be managed.
9. **'Select Site'** function - Shows the list of total sites created in the readout unit.
10. **'Select Borehole '** function – Shows the list of boreholes created under a site name which is selected in 'Select Site ' from site list.

11. **'Instrument information'** function – Shows instrument IDs of currently connected Digital Inclinometer Reel and Probe.

12. '**Borehole Information'** function - Shows the borehole information of selected borehole from 'Select Borehole'.

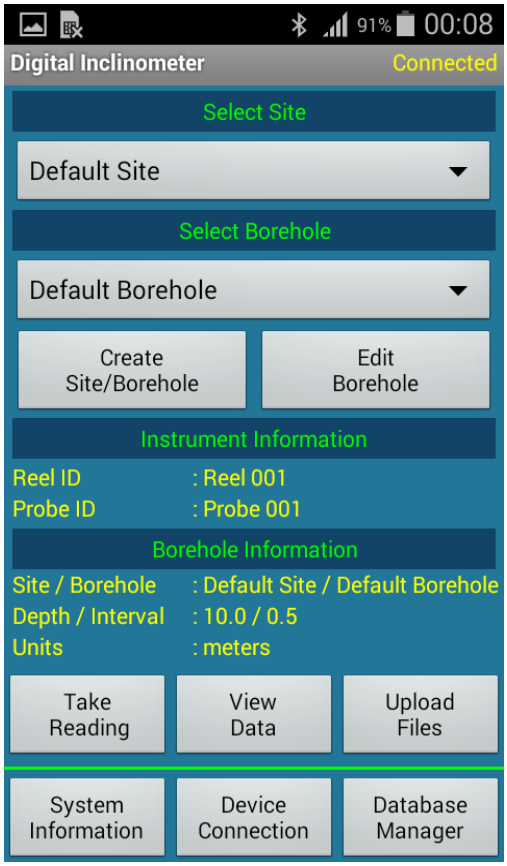


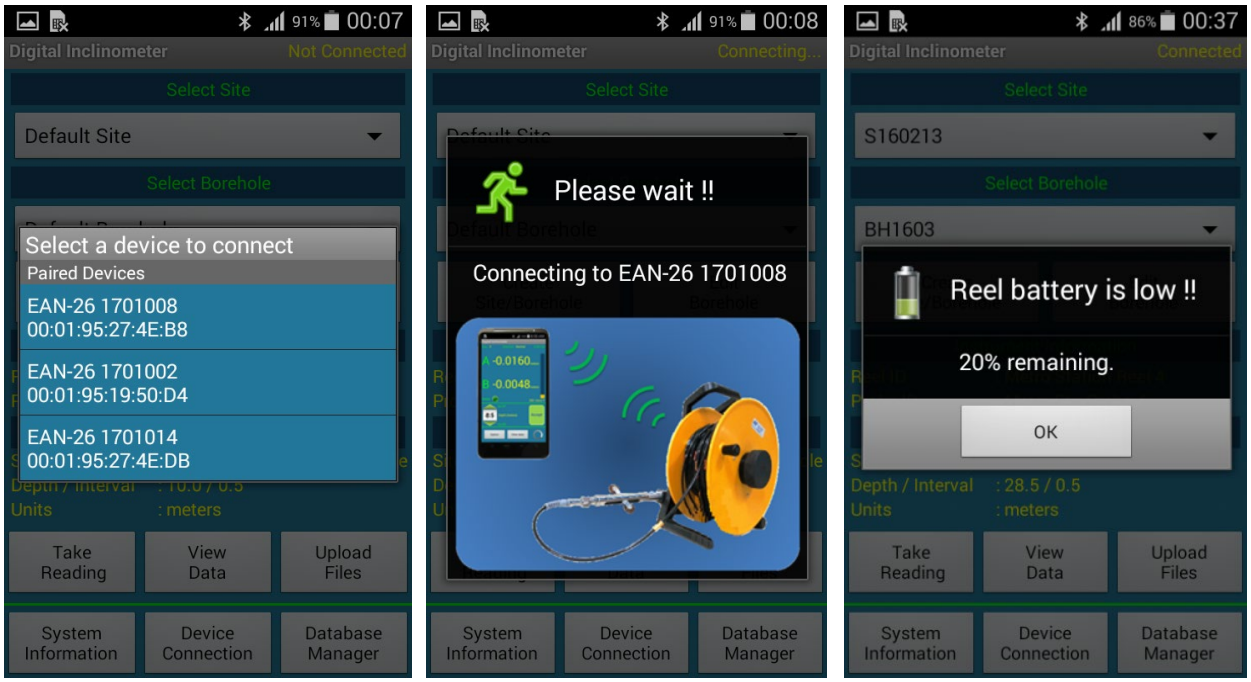
Figure 7-4 Main Menu

7.2.1 'Connection' function for connecting mobile readout to cable reel

- Turn ON the cable reel. Pair the phone with reel. Now connect the phone with reel using 'Connection' button from 'Main Menu'.
- It will show a list of paired Digital inclinometers as shown in figure 7-5(a). List will show 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 7-5 (b) shows an example of Bluetooth connection screen. Phone gets connected to the reel after few seconds.
- Bluetooth connection status can be seen on top right corner of the screen as shown in figure 7-5 (c).

Now we can check system information to see Reel, Probe, Bluetooth and Phone information.

Application checks the Reel's Battery Voltage while making connection. A Low Battery message pop ups when application founds Reel battery low. Refer to figure 7-5 (c).



(a) Device list **(b) Device connectivity** **(c) Battery low**

Figure 7-5

7.2.2 'System Information' function for system information

'System Information' button provides system information about reel, probe, Calibration, Bluetooth and phone as can be seen in figure 7-6. On pressing this button, the 'Digital Inclinometer' screen appears from where desired information can be selected through related tabs. Details are given below.

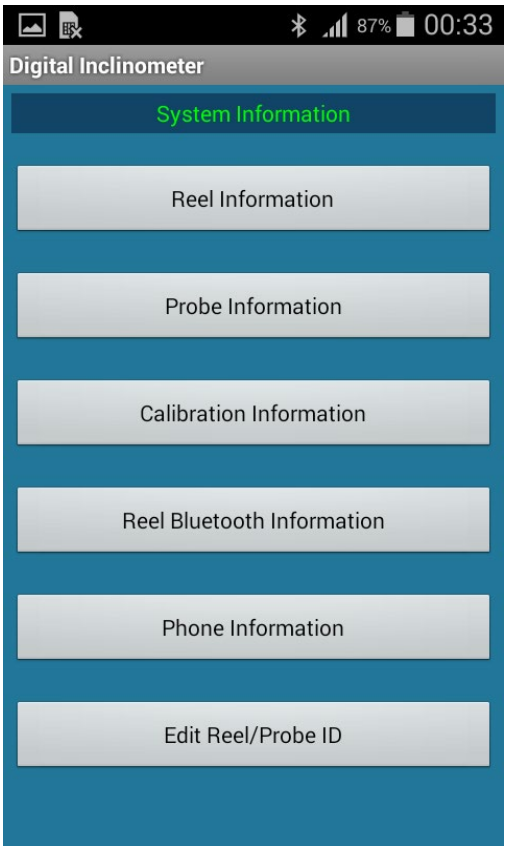
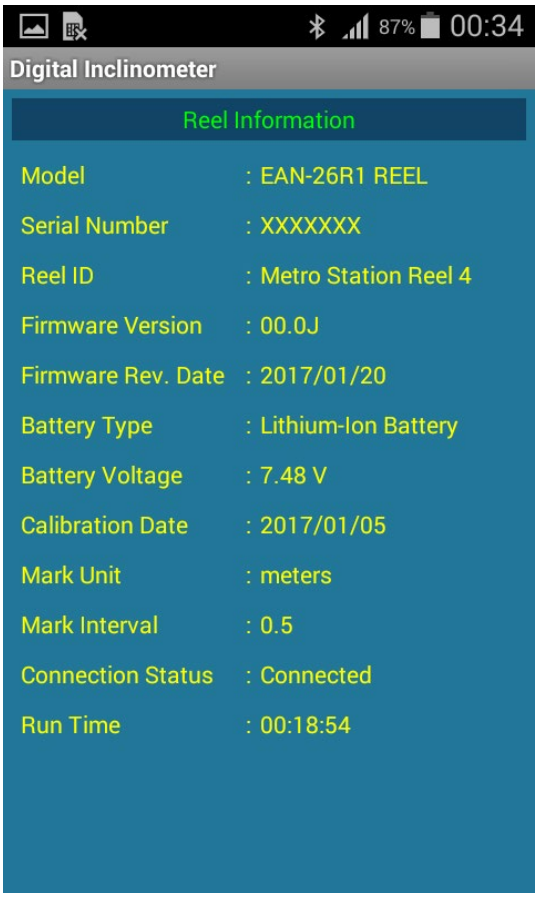


Figure 7-6 System information Menu

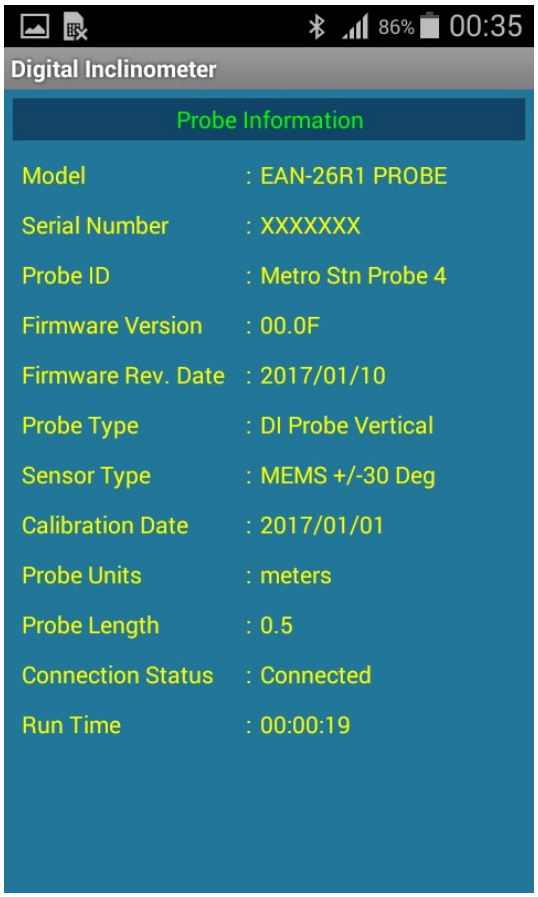
A. Reel and Probe Information

Pressing on **'Reel Information**' button will open reel Information screen. Figure 7-7 (a) shows an example of reel Information screen of a reel. It displays reel's model, serial number, reel ID, firmware version of reel's processor, firmware revision date, reel's battery type, battery voltage, calibration date, cable ferrule marking unit, interval, reel'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.

Pressing on **'Probe Information'** button will open Probe Information screen. Figure 7-7 (b) shows an example of probe information screen of a probe. It displays the probe's model, serial number, probe ID, firmware version of probe's processor, firmware revision date, probe type (vertical or horizontal), tilt sensor type, calibration date, probe measurement unit, probe length (pitch between two wheels), reel's connection time and connectivity.



a) **Reel information**



b) **Probe information**

Figure 7-7

B. Calibration information

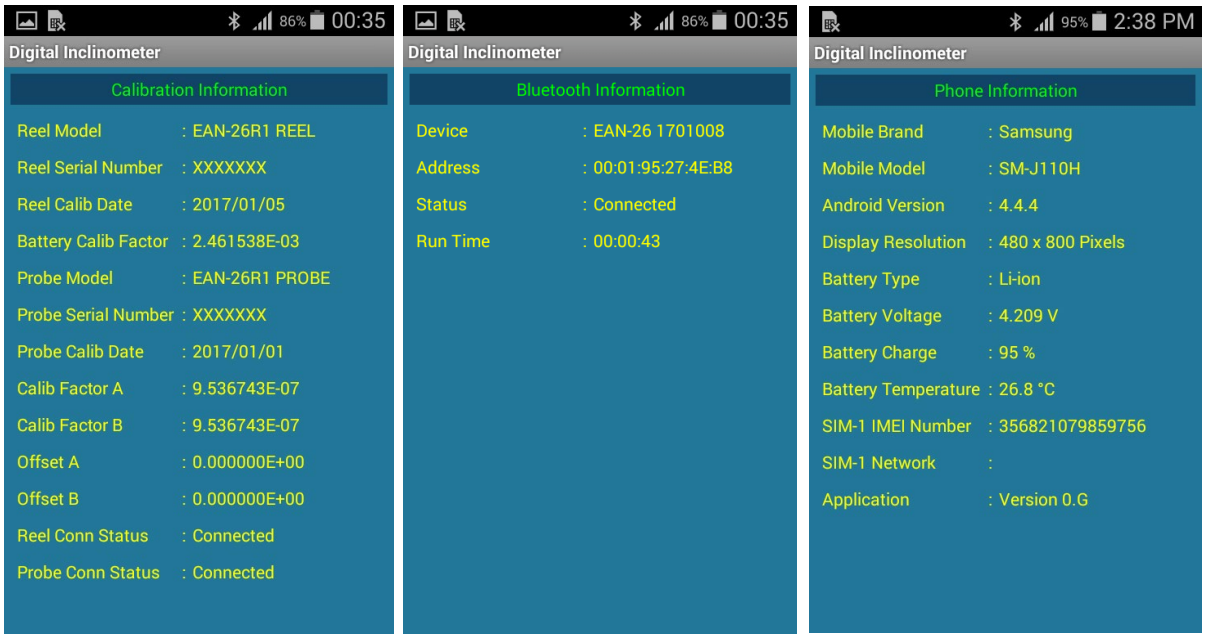
Calibration information of the probe. Figure 7-8 (left screenshot) shows the calibration screen of a probe. It shows the Probe type vertical or horizontal, sensor type, probe measurement units, probe length, probe calibration date, calibration factor for axis-A, calibration factor for axis-B, offset value for axis-A and offset value for axis-B. These information is useful for data verification.

C. Reel Bluetooth Information

Bluetooth Information screen shows the Bluetooth connection information. Figure7-8 (center screenshot) shows the Bluetooth screen of a Reel. It shows the Reel's Bluetooth Identification, Bluetooth address, run time and connectivity.

D. Phone information

Phone Information screen shows the phone information as shown in figure7-8 (right screenshot). It shows Mobile phone's brand, model, android version, LCD touch screen display resolution, phone's battery type, battery voltage, battery charge, battery temperature, IMEI number and the network service provider. It also shows the Digital Inclinometer application software's version.



a) **Reel/Probe Calibration Information** **b) Reel Bluetooth Information** **c) Phone Information Screen**

Figure 7-8

7.2.3 Editing Reel and Probe ID

Though, reel and probe have their unique serial number but user may want to assign a tag for reel and probe for identifying reel or probe assigned to any specific person or site or project. Reel and probe ID can be used for this purpose.

Pressing on Edit 'Reel/Probe ID' button will open a screen as shown in figure 7-9 where we can read or edit Reel/Probe ID. Press 'Read Reel ID' button to read reel ID of connected reel. Type the new reel ID in provided text field. Now press the 'Update Reel ID' button to update the new reel ID.

Similarly, press 'Read Probe ID' button to read probe ID of connected probe. Type the new probe ID in provided text field. Now press the 'Update Probe ID' button to update the new probe ID.

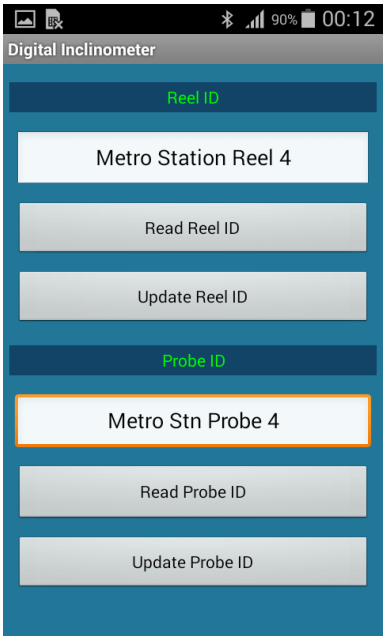


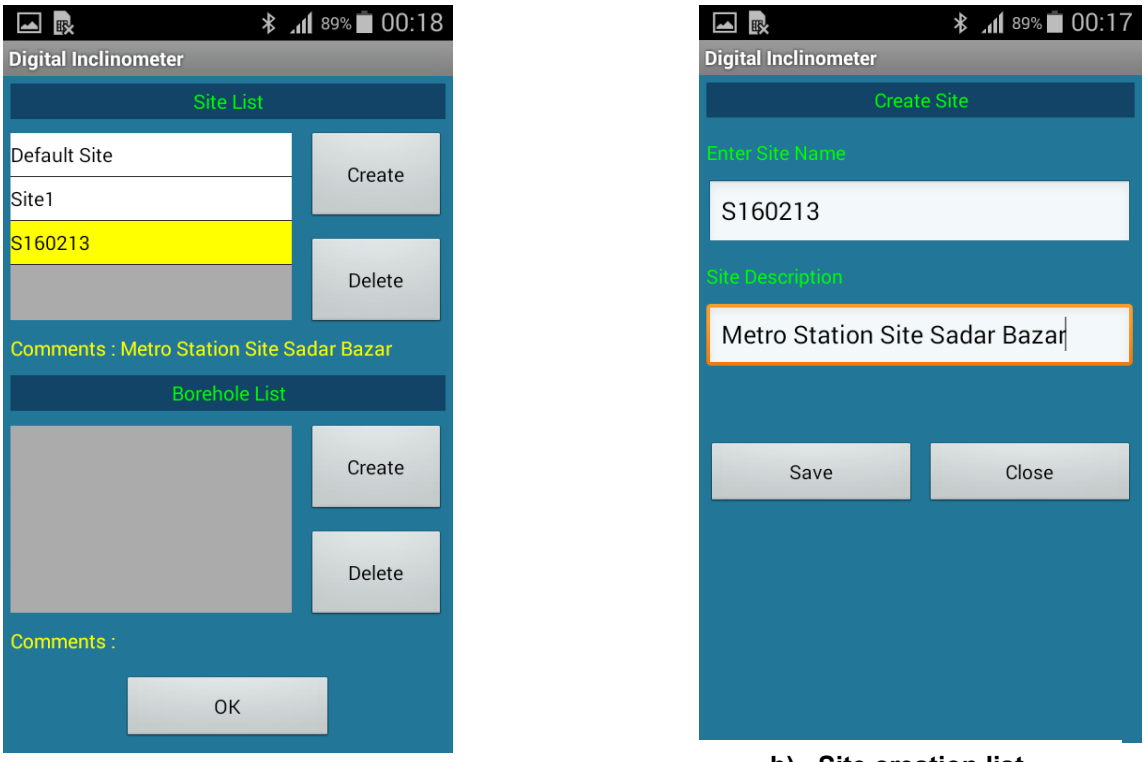
Figure 7-9 Updating Reel ID / Probe ID

7.2.4 'Create Site/Borehole' function for creating a site

From 'Create site/borehole' button from main menu, screen as shown in figure 7-10 (left screenshot).

A. Create Site

- 'Create' button under 'Site List' open site creation menu as shown in figure 7-10 (right screenshot).
- 'Enter Site Name' button - Enter site code in edit box. Site code cannot be of more than 7 letters.
- 'Site Description' edit box – Enter site details here.
- Press on 'Save' button to create this site.
- Site and its description can be seen under 'Site List' in site and borehole menu screen (figure 7-10, left screenshot).
- Any site can be deleted by selecting a site name from site list and then pressing 'Delete' button.



a) Site list **b) Site creation list**

Figure 7-10

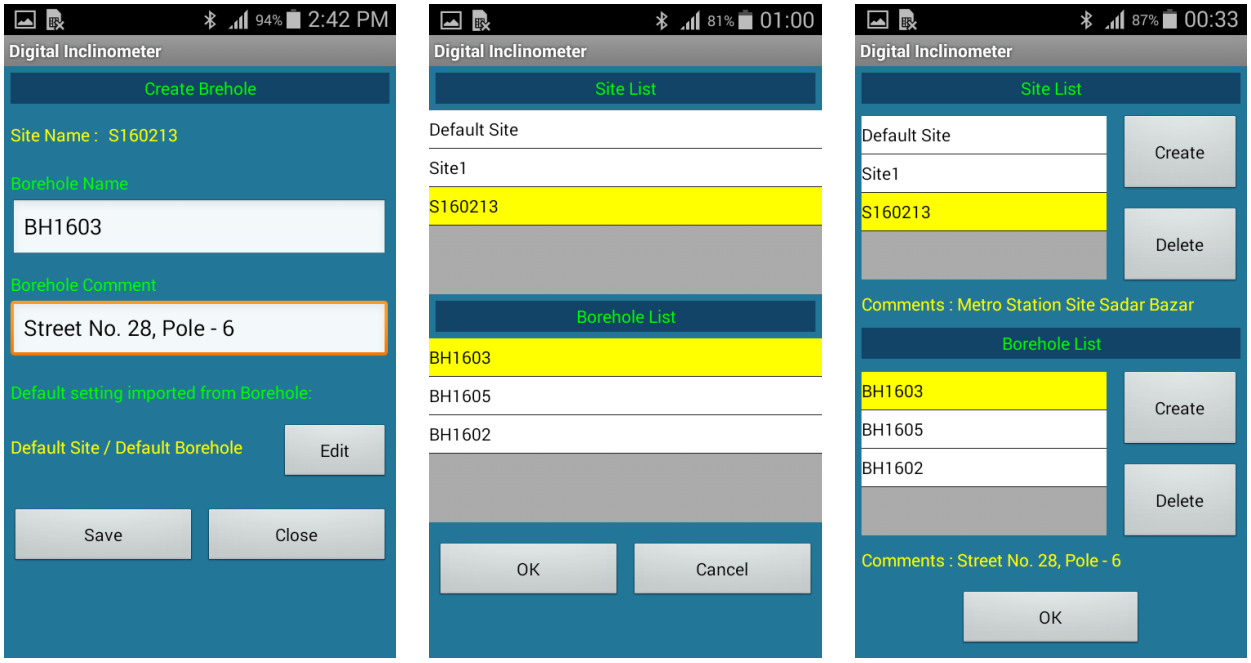
B. Create borehole

- Select site name from 'Site List' under which new borehole is to be created.
- Clicking on 'Create' button under 'Borehole List' will open borehole creation menu as shown in figure 7-11 (c).
- Enter Borehole code in edit box under 'Borehole Name' (figure 7-11 (a). Borehole code cannot be of more than 7 letters.
- 'Default Site/Default Borehole' function: Default settings for this borehole can be imported from previously created boreholes. Press on 'Edit' button to reset default borehole to import settings. On pressing 'Edit' button, it will open default borehole selection menu. Choose desired borehole to import parameters from. Figure 7-11 (b) shows an example of default borehole selection menu.

- Any borehole can be deleted by selecting a borehole name from borehole list (figure 7-11 (c)) and then pressing 'Delete' button.

C. Default Site and Default Borehole

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



a) Borehole Creation Screen **b) Import Borehole** **c) Borehole List**

Figure 7-11

7.2.5 'Edit Borehole" function to edit borehole parameters

Borehole parameter can be edited using 'Edit Borehole' option.

- Select site and borehole from main menu (figure 7-4) and then press on 'Edit Borehole' to edit parameters of selected borehole.
- Figure 7-12 shows an example of edit borehole screen. *Site* and *borehole* names are displayed at 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 displayed under *file name prefix* heading.
- Press *OK* to save borehole settings.

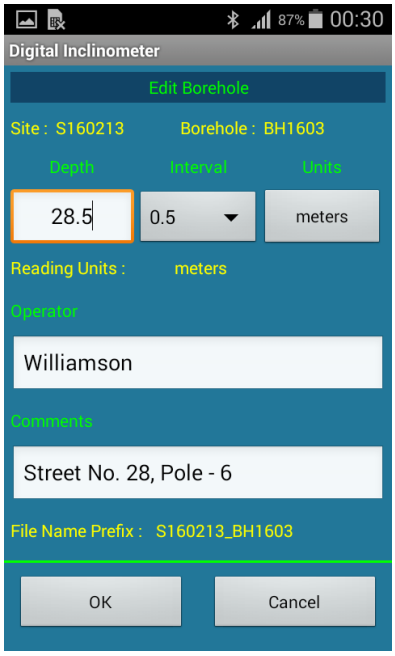


Figure 7-12 Editing Borehole Parameters

- Pressing on *cancel* button will exit from this menu and borehole settings will not be updated into database.
- Borehole comments can be seen under site list in site and borehole menu (refer to figure 7-11 (c).

7.2.6 Taking readings

- Select the desired site and borehole from main menu after phone is connected with reel. System is ready for taking readings.
- Press 'Take Reading' button from main menu (figure 7-4). Screen as shown in figure 7-13 (a) will appear.
- Lower the probe into borehole at depth showing on phone's screen.
- *A, B* - Axis-A and Axis-B displacement values are displayed in meters/feet (as selected by user).
- *Noise bar* - *Noise bar* at right side of the screen represents the present noise level in the readings received from probe. In figure 7-13 (a), the noise level in terms of micro Volts shows the noise contents in electrical signal in probe.
- Noise bar limit is shown in terms of displacement unit (0.26 mm in figure 7-13 (a)), 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, in figure 7-13 (b), indicates that noise level is exceeding the noise bar limit.
- *Stable* - Solid green circle near Stable represents that present reading is stable while red circle against *Stable* 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.

a) Reading Screen

b) Reading Screen when reading is unstable

Figure 7-13

- *Avg - Readings seen on screen are calculated by taking average of displacement readings. Number of readings considered for averaging is shown on top left side of the screen against Avg ('2' in figure 7-11). This can be set from 'Option' menu at the bottom of the screen.*

NOTE: It is good to take average of large number of readings but run-time become slower.

- *Direction* - 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 i.e. probe direction is reversed. Probe direction is displayed on top centre of the screen under 'direction'.
- GO UP and *GO DN* buttons near depth are used to go up or to 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 28.5 m and interval is 0.5 m in this example.

Figure 7-14 Reading Screen in Edit Mode

- Lower the Probe into borehole at depth showing on phone's screen (depth is 28.5 m 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 (28.5 m) on screen. Once accept button is pressed it will save the reading and the depth and moved to next interval (28 m in this case).
- Pull the Probe and fix it at 28.0 m marking. Wait until readings are stable and then press accept button to store readings for 28.0 m.
- 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 (28.5 m) showing on the screen.
- Small digits in yellow colour below axis-A and axis-B readings depict run time **face error**. *Figure 7-14* shows 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 at the right-bottom on screen (circle) indicates that Probe is connected.
- Stored borehole logs can be viewed any time by pressing view data button to compare readings..

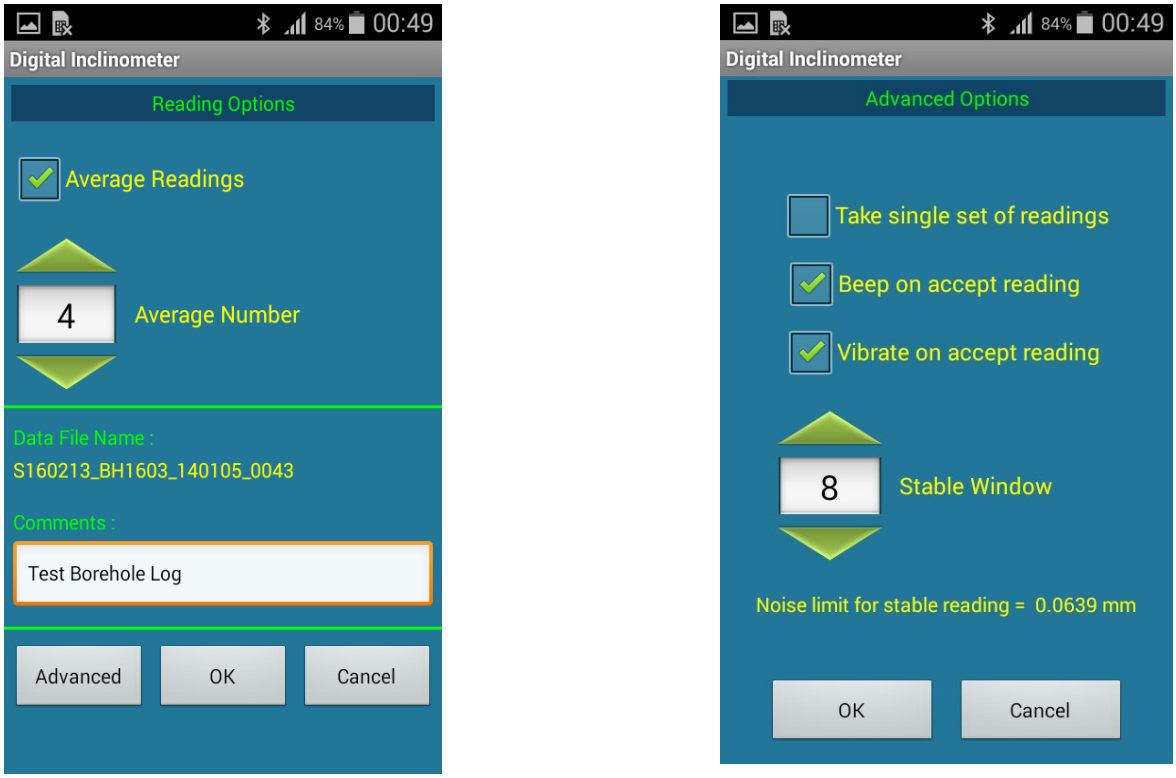
7.2.7 EDIT readings

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 (see Figure 7-14). 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..

7.2.8 Reading option settings

Pressing option button from readings screen (*Figure 7-13 (a)*) opens options screen. *Figure 7-15 (a)* 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.



a) Reading Option Screen **b) Advanced Options Screen**

Figure 7-15

7.2.9 Advanced options

Figure 7-15 (b) 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.

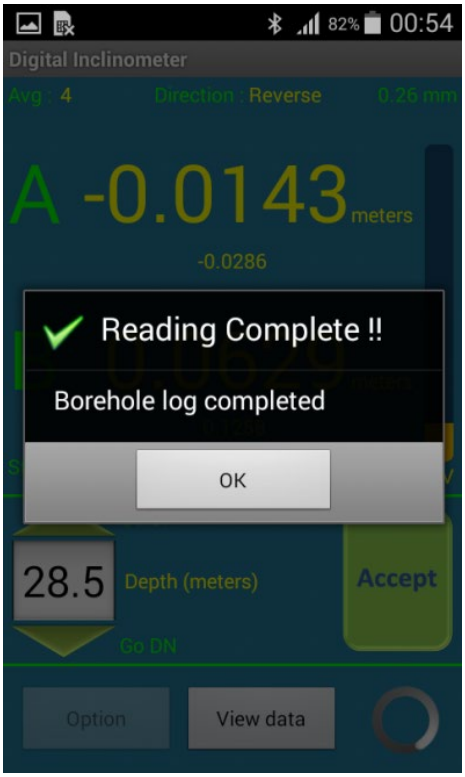
Stable window is showing the noise window for detection of stable readings. It is the window of standard deviation for readings received from Probe. Set noise limit can be seen in terms measurement units. Stable window can be adjusted depending on how noisy the readings are in the field. It is recommended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

.

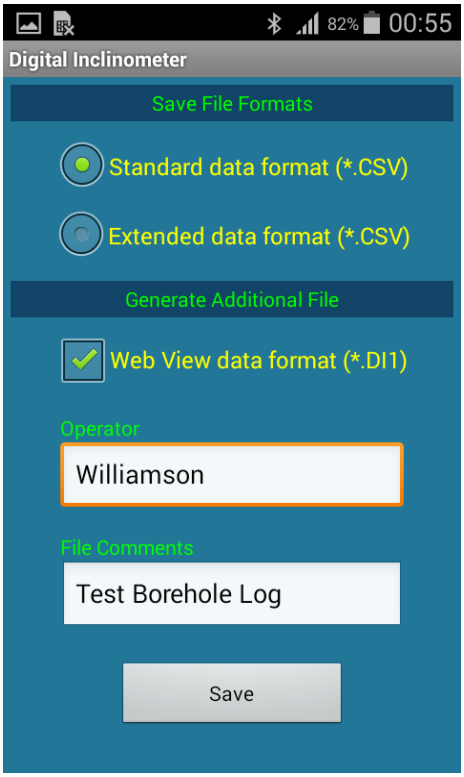
7.2.10 Saving borehole log

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 as shown in figure 7-16 (a). Press OK to complete the reading process.

On pressing OK button application opens 'Save File Formats' screen as shown in figure 7-16 (b). 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 to section §9 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 to section §7-5 for viewing created borehole files..



a) **Reading Log Complete**



b) **File Format Options**

Figure 7-16

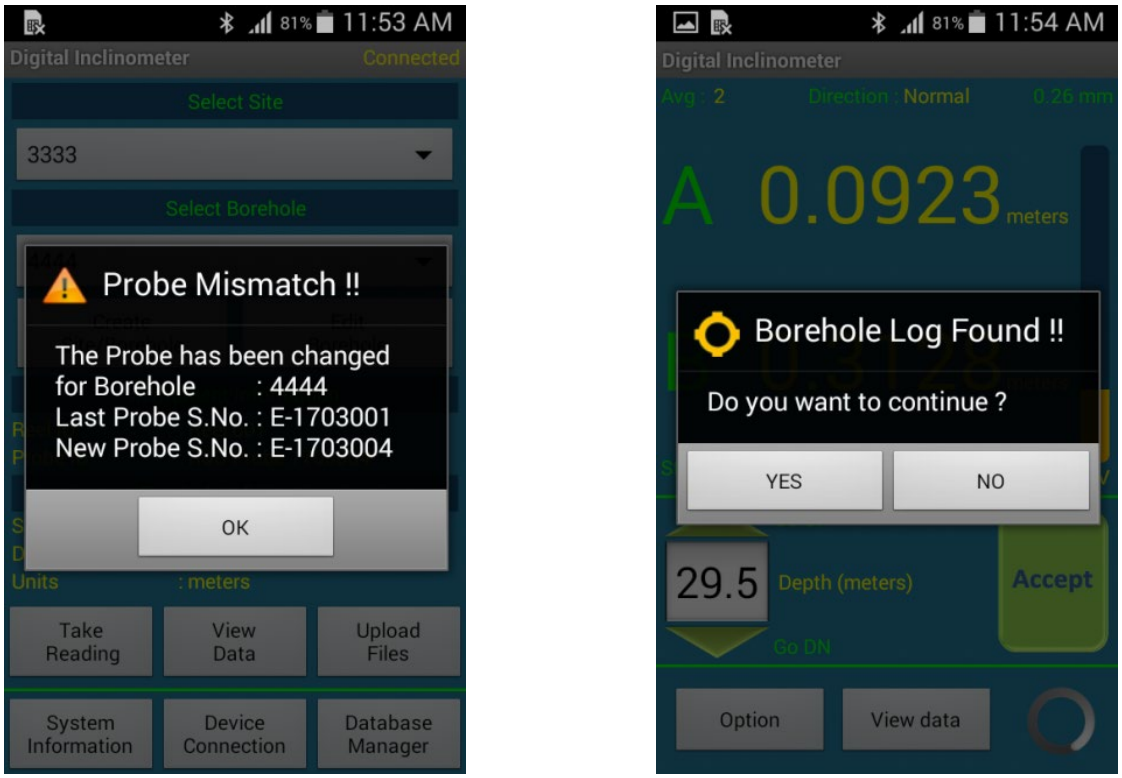
7.2.11 Probe Mismatch Warning

Inclinometer Probe after long use may have some offset error introduced due to wheels wear and tear. Probe offset error should be checked with the calibration test jig on regular basis. Probe having significant offset error than specified should send for re-calibration. It is recommended to use the same Probe each time for taking a Borehole log so that the Probe offset error will be almost same for base file log and the latest reading log and it has no effect on cumulative deviation plot.

When we take a log for a Borehole, the Readout software remembers the Probe serial number used for logging that Borehole. There may be the case that the same Probe used for a logging a Borehole is not available. When we go to reading screen for taking a Borehole log, the Readout software checks the serial number of the current Probe and compares it with old probe's serial number for the Borehole. A "Probe mismatch" warning dialog pops up on screen if a different Probe is used.

7.2.12 Resume Borehole Log

Taking reading may get interrupted from reading screen due to any reason like reel's battery become very low or user exits from reading screen by mistake or due to any breakdown occur at site. User may resume his borehole log from last position. 'Borehole Resume' option will be available for taking borehole log again within 1 hour for the same Borehole. When a borehole log interrupted and user again goes to reading screen it will ask user to resume the last borehole log or a fresh reading to be logged. Refer to figure 7-17 (b).



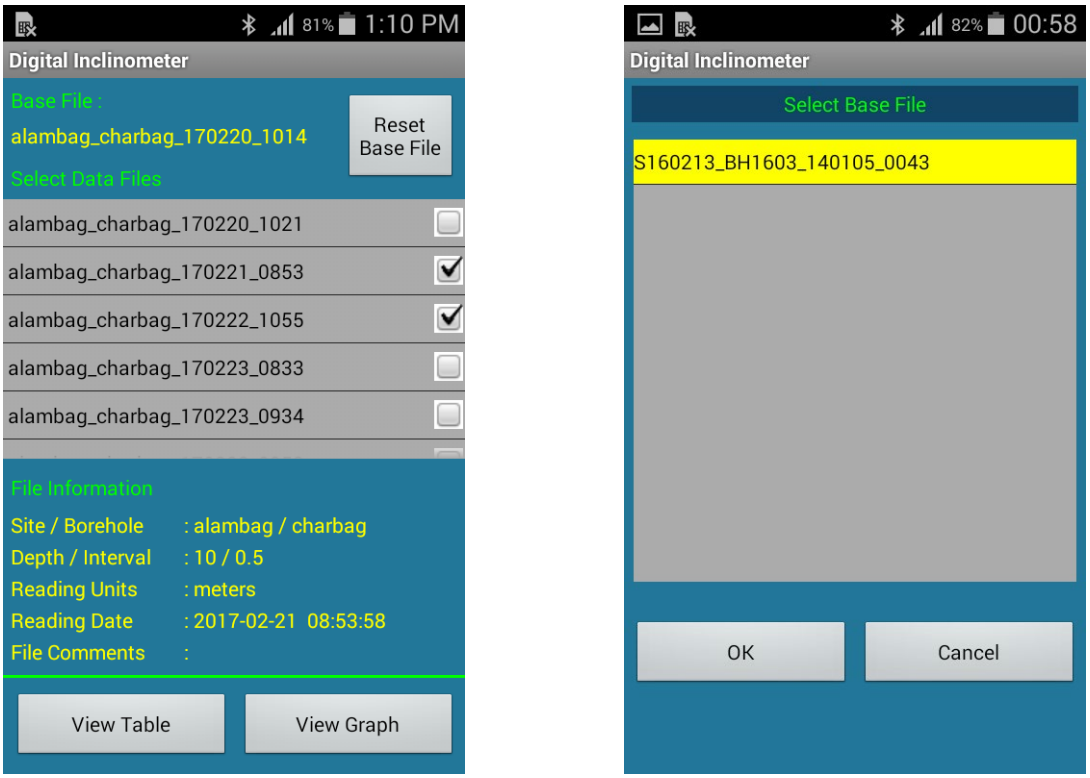
a) Probe mismatch warning **b) Resume Borehole Log**

Figure 7-17

WARNING: Please do not connect or disconnect the Probe if Reel is power ON. Always turn OFF the Reel and then connect or disconnect the Probe.

7.3 Viewing data

Reading log can be viewed using view data option. Go to main menu (figure 7-4) 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 7-18 (a). Borehole Base file can be set on pressing reset base file button. Figure 7-18 (b) shows reset base file menu. Choose a borehole file to set it base file and press OK. View data menu (figure 7-18 (a)) 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.



a) View Data Screen **b) Selecting Base File**

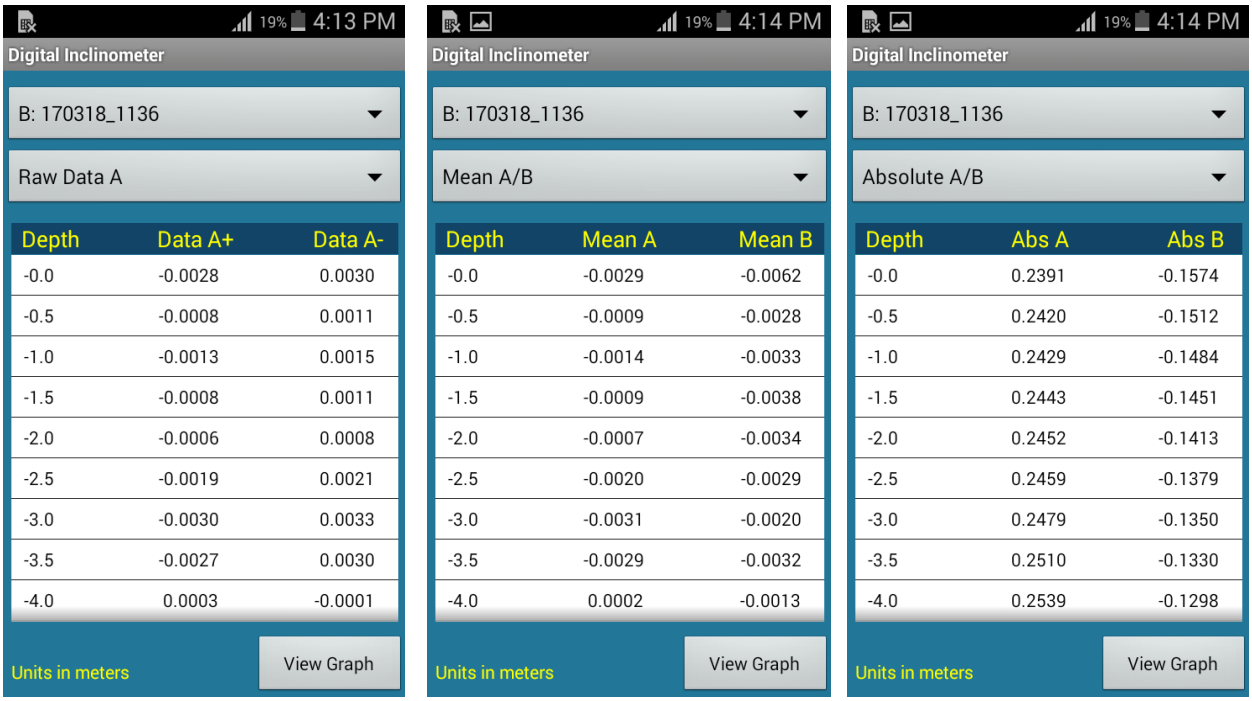
Figure 7-18

7.3.1 Viewing data in table

On pressing view table button from view data menu (*figure 7-18 (a)*) application will show data in tabular format. *Figures 7-19 (a, b, c)* show examples 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.

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 cumulative 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..

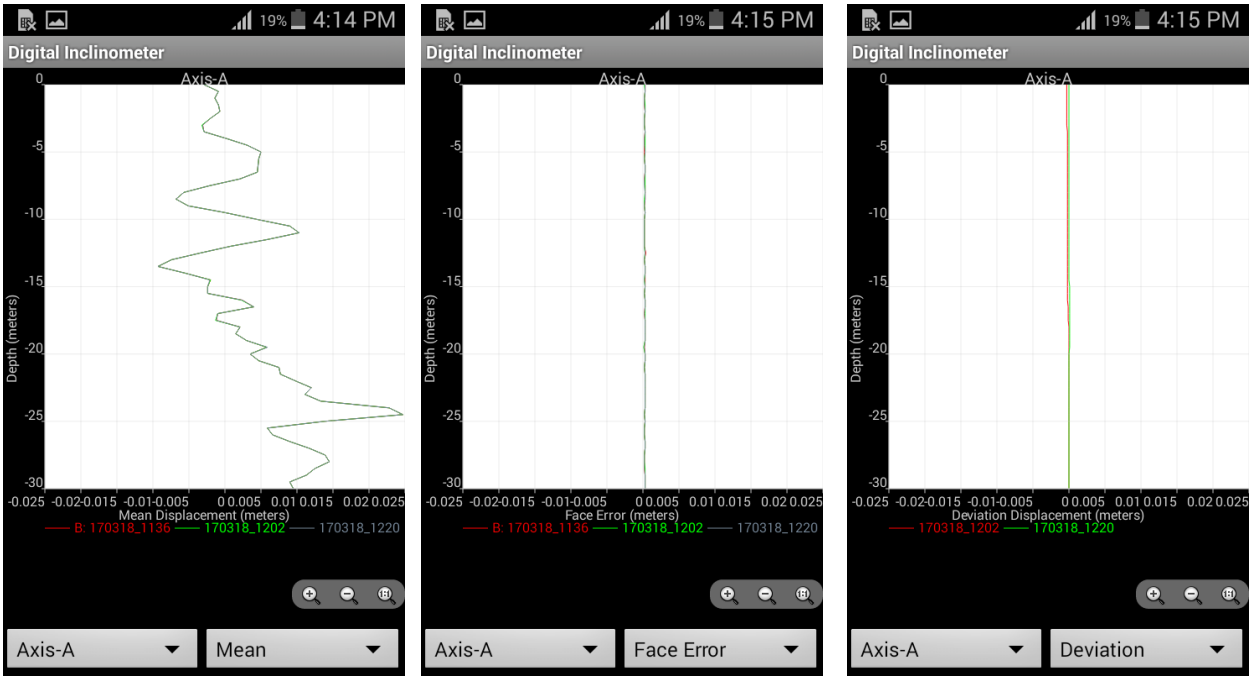


a) Raw Data **b) Mean Data** **c) Absolute Data**

Figure 7-19

7.3.2 Viewing data on graph

On pressing view graph button from view data menu (*figure 7-18 (a)*) application will plot data on a graph. *Figures 7-20 (a, b, c)* show examples 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.



a) Raw Data **b) Face Error** **c) Cumulative Deviation**

Figure 7-20

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 Cumulative 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.

7.4 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 files*.

Figure 7-21 shows 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 to section § 7.2.10). Archive folder is used to keep uploaded files (refer to section § 7.8.2).

Figure 4.29 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 to section § 7.2.10). Archive folder is used to keep uploaded files (refer to section § 7.8.2).

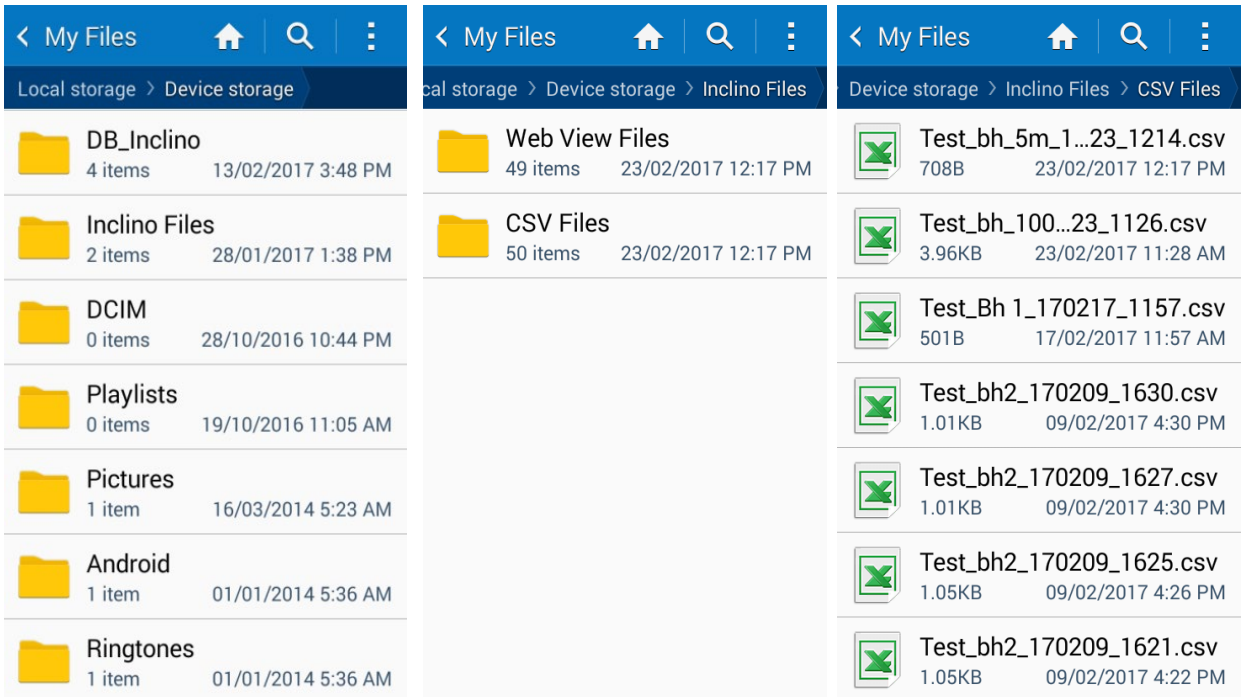
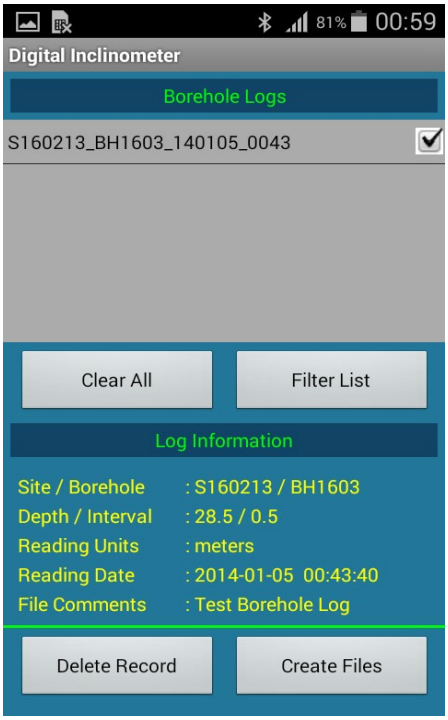


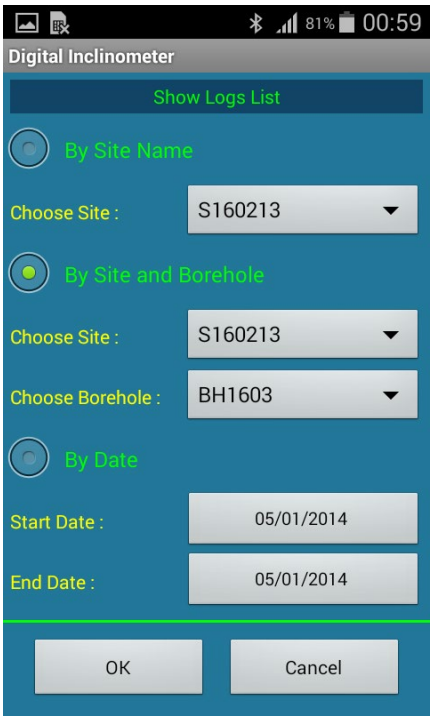
Figure 7-21 Data File Storage Path

7.5 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 7-4)*. *Figure 7022 (a)* shows 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.



a) **Database Manager Screen**



b) **Filter Data Log Options**

Figure 7-22

7.5.1 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 7-22 (a)). Figure 7-22 (b) shows an example of filter log list menu.

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 7-22 (a)*) will show the filtered list of borehole logs. Select borehole logs by checking the tick boxes corresponding to borehole logs.

7.5.2 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 as shown in *Figure 3-42*. 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.

.

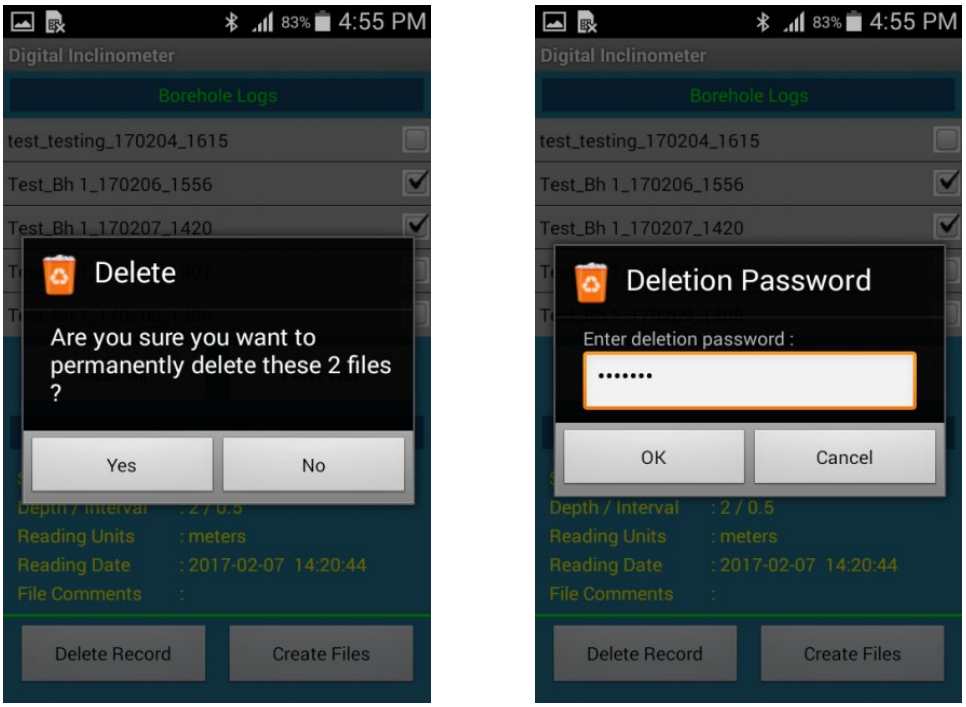


Figure 7-23 Borehole Log Deletion from Database

7.5.3 Creating files from borehole database

Borehole files (CSV, DI1) can be created using create files button from database manager menu (figure 7-22 (a)). Select borehole logs whose files are to be created. Pressing on create files button will open save file formats menu. Figure 7-24 shows 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 to section § 7.5 to find created files in memory card.

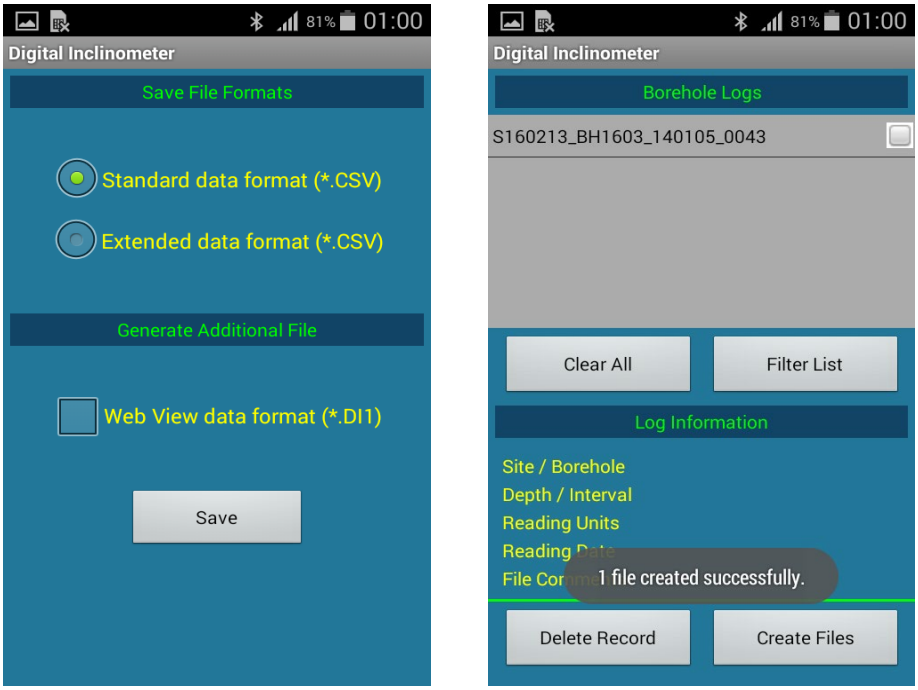
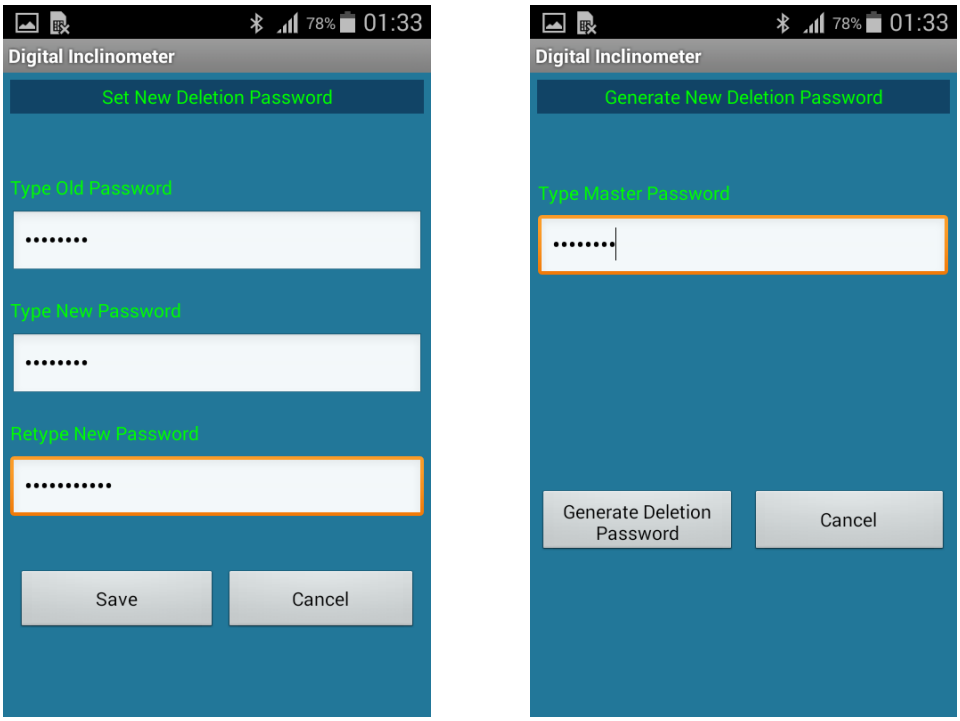


Figure 7-24 Extracting Borehole Log from Database

7.6 Setting database deletion password

Database deletion password is required when deleting borehole logs from database manager (refer to section § 7.6.2). This password can be set from option menu (refer to *figure 7-25 (a)*).



a) Changing Database Deletion Password **b) Resetting Database Deletion Password**

Figure 7-25

7.6.1 Change password

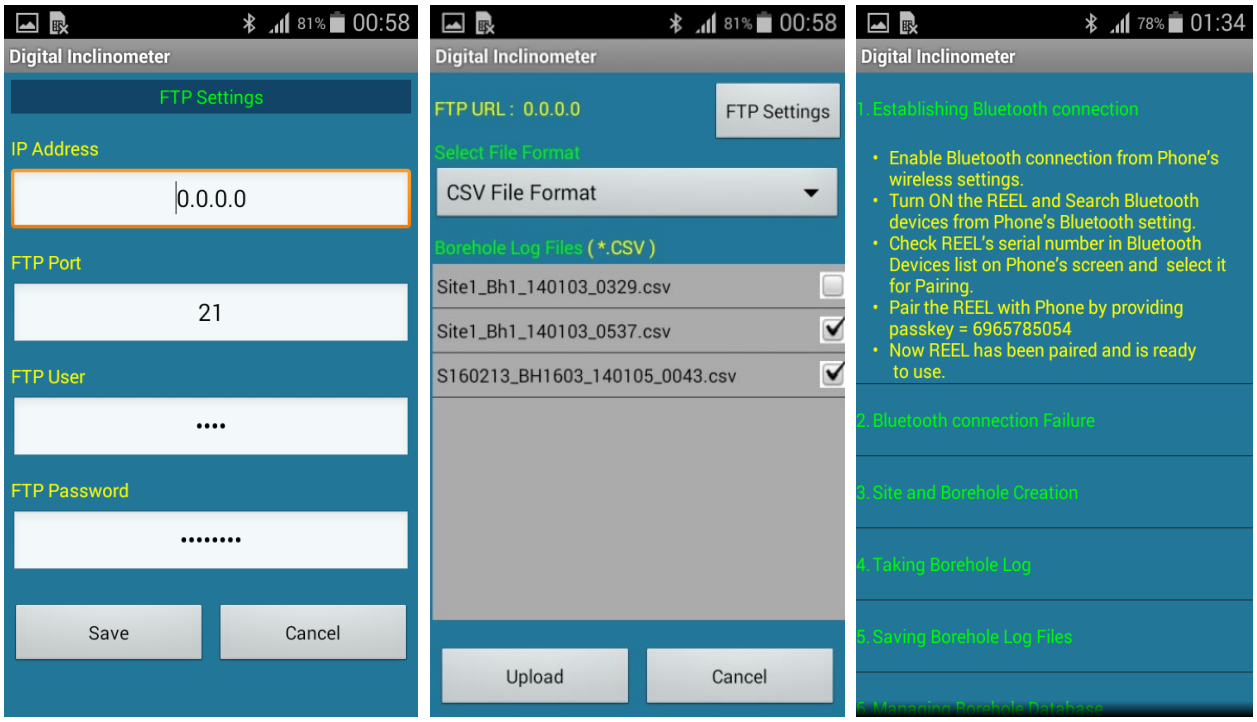
Database deletion password can be changed using change password menu. This menu can be opened by pressing change password button from option menu (see figure 7-3). Type old password, new password and retype new password. Password should be typed carefully. Letters are case sensitive. Press save button to save new password. Remember this password for use in future.

7.6.2 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 7-3). On pressing forgot password option application will open new password generation menu (figure 7-25 (b)). 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 to section § 7.7.1)

7.7 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 7-4*). *Figure 7-25 (b)* shows an example of upload files menu.



a) FTP Settings **b) Uploading Borehole Log Files to FTP Server** **c) Help Menu**

Figure 7-26

7.7.1 URL settings

On pressing FTP settings button from upload files menu (figure 7-26 (b)) application will open URL settings menu. Figure 7-26 (a) shows 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

7.7.2 Uploading multiple files to server

Upload files menu can be opened on pressing upload files button from main menu (*figure7-4*). *Figure 7-26 (b)* shows an example of upload files menu. Back end FTP server URL address showing on top of the screen.

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 '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 to section § 10 to view archive folders.

7.8 Help menu

Help information can be seen by pressing Help button from option menu (refer to *figure 7-3*). Help information is very useful while working on site. It may be helpful while troubleshooting. *Figure 7-26 (c)* shows an example of Help information screen.

8 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 m (or 2.0 ft). Displacement is calculated from inclination and interval. Readout unit displays the angular displacement in terms of meters / 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-

8.1 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-)

8.2 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

8.3 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.

8.4 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.

9 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.

9.1 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    : -15.0"
"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
-10.0,0.0058,0.1620,-0.0057,-0.1617
-10.5,0.0056,0.1622,-0.0054,-0.1622
-11.0,0.0059,0.1621,-0.0058,-0.1621
-11.5,0.0061,0.1625,-0.0059,-0.1625
-12.0,0.0065,0.1624,-0.0063,-0.1623
-12.5,0.0064,0.1623,-0.0062,-0.1621
-13.0,0.0061,0.1626,-0.0060,-0.1626
-13.5,0.0058,0.1630,-0.0057,-0.1622
-14.0,0.0056,0.1632,-0.0055,-0.1620
-14.5,0.0057,0.1630,-0.0056,-0.1623
-15.0,0.0056,0.1628,-0.0054,-0.1625
```

9.2 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    : Rajesh"
"DEPTH OF TUBE    : -12.0"
"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
-10.0,0.0058,0.1620,-0.0057,-0.1617
-10.5,0.0056,0.1622,-0.0054,-0.1622
-11.0,0.0059,0.1621,-0.0058,-0.1621
-11.5,0.0061,0.1625,-0.0059,-0.1625
-12.0,0.0065,0.1624,-0.0063,-0.1623
```

9.3 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.

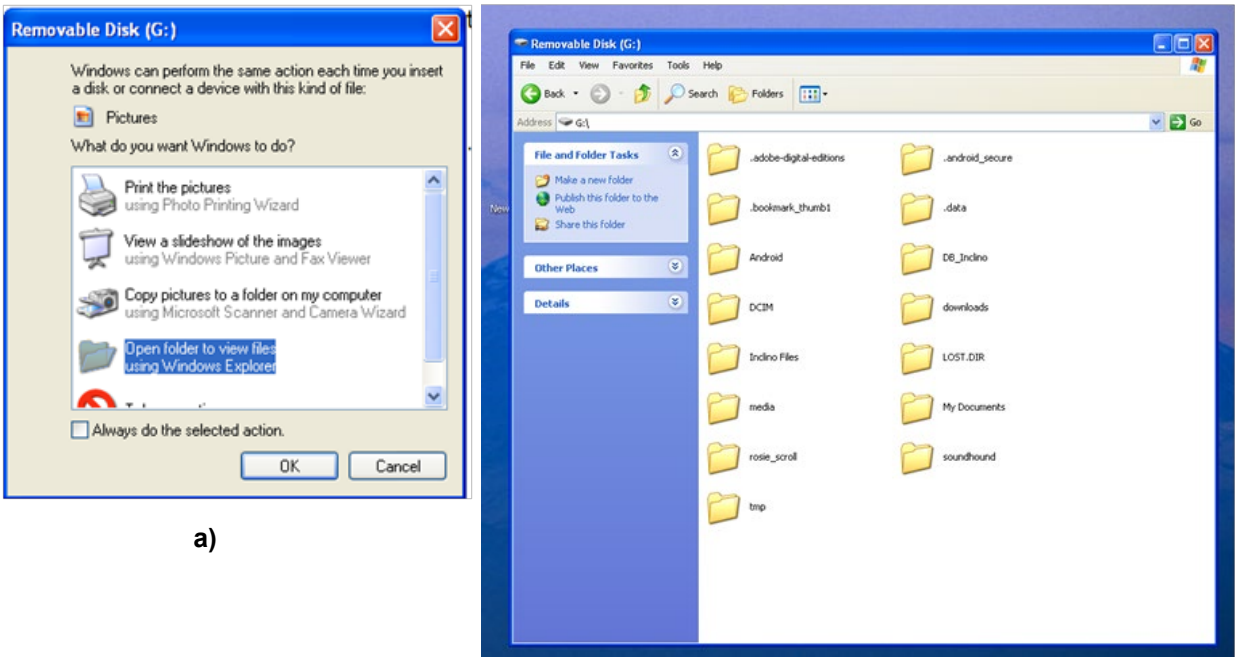
10 INCLINOMETER DATA BACKUP

The inclinometer data can be backs 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.

10.1 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 10-1 (a)*). Select "open folders to view files" option and the click on "OK". Explorer will open the contents of phone's SD card. *Figure 10-1 (b)* shows an example of phone's SD card contents.



a) **b)**

Figure 10-1

10.2 Backing up the inclinometer database

Open folder "DB_Inclino" to view database folder contents. Figure 10-2 shows 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..).

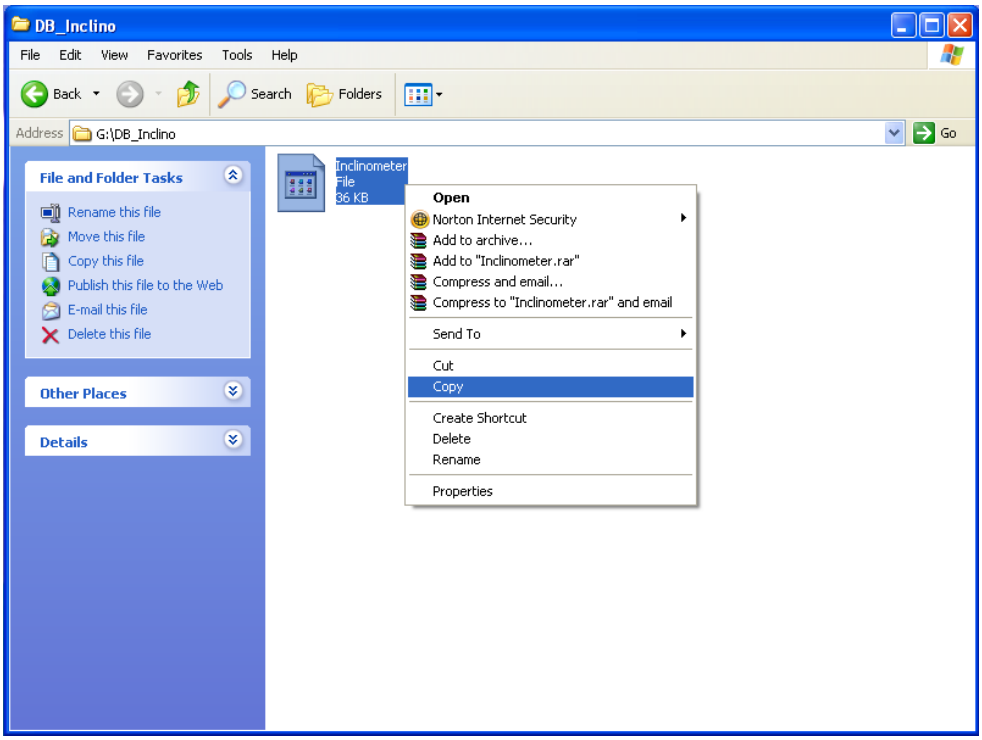


Figure 10-2

10.3 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 10-3).

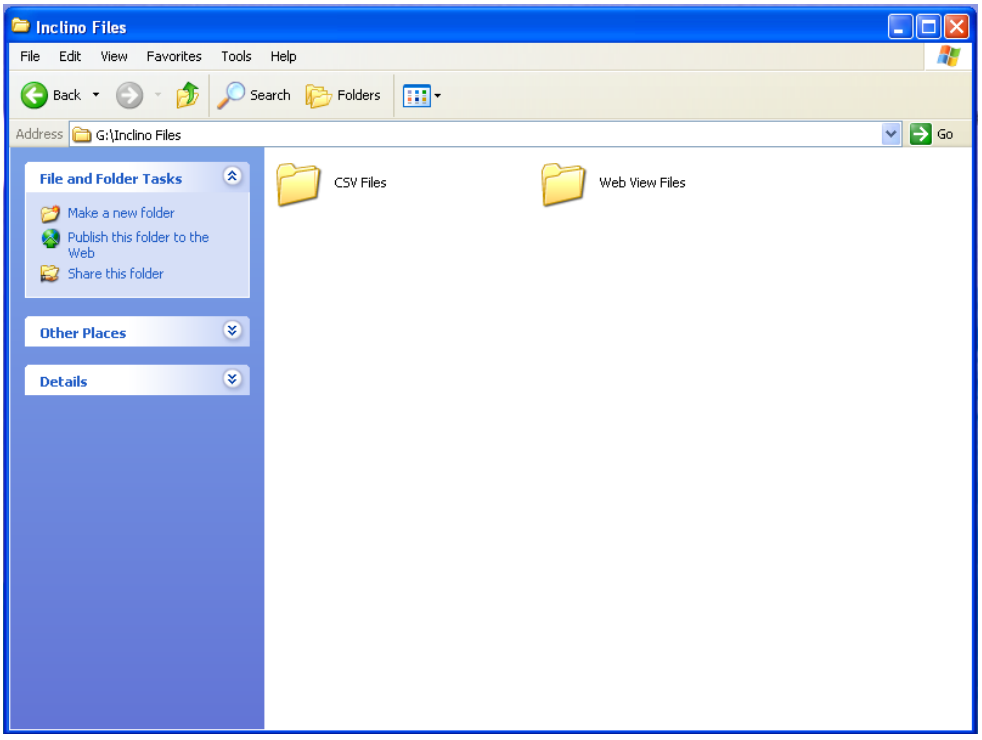


Figure 10-3

Open folder "CSV files" to view CSV files folder contents. Figure 10-4 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.).

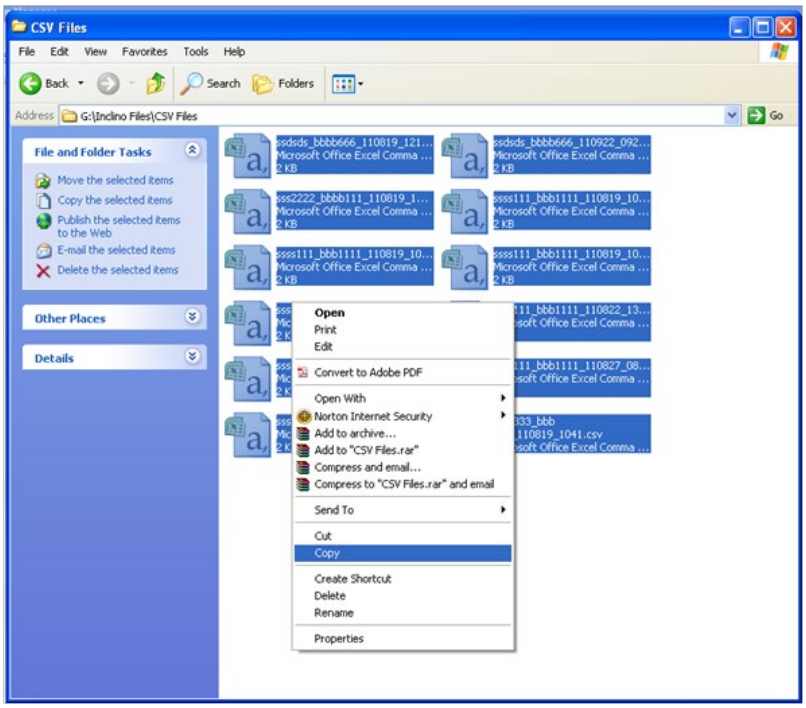


Figure 10-4

Open folder "Web view files" to view Web view files folder contents. Figure 10-5 shows 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.).

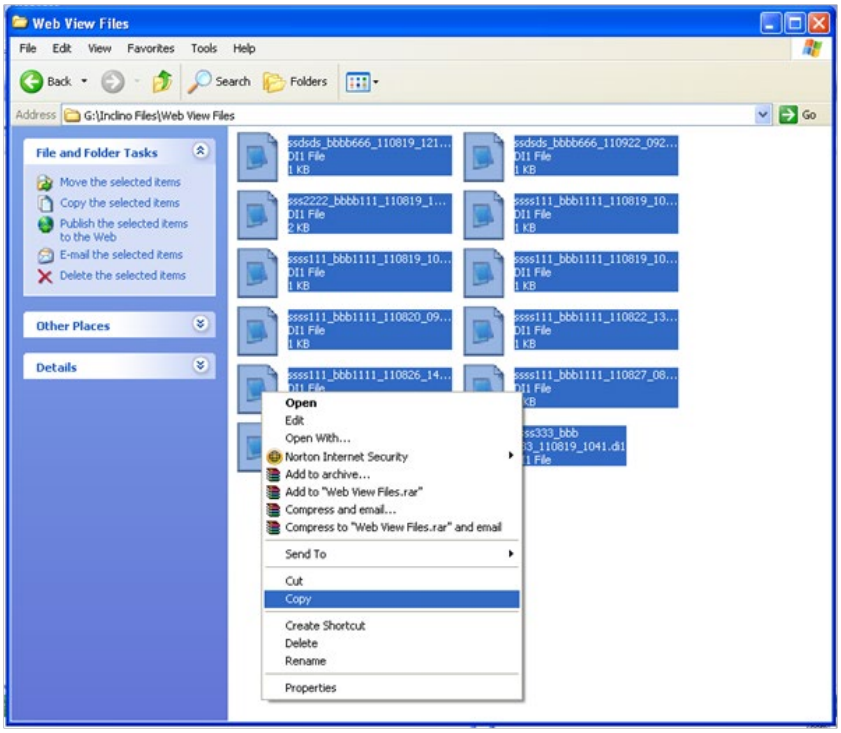


Figure 10-5

11 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 § 14.

11.1 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 11-1*.

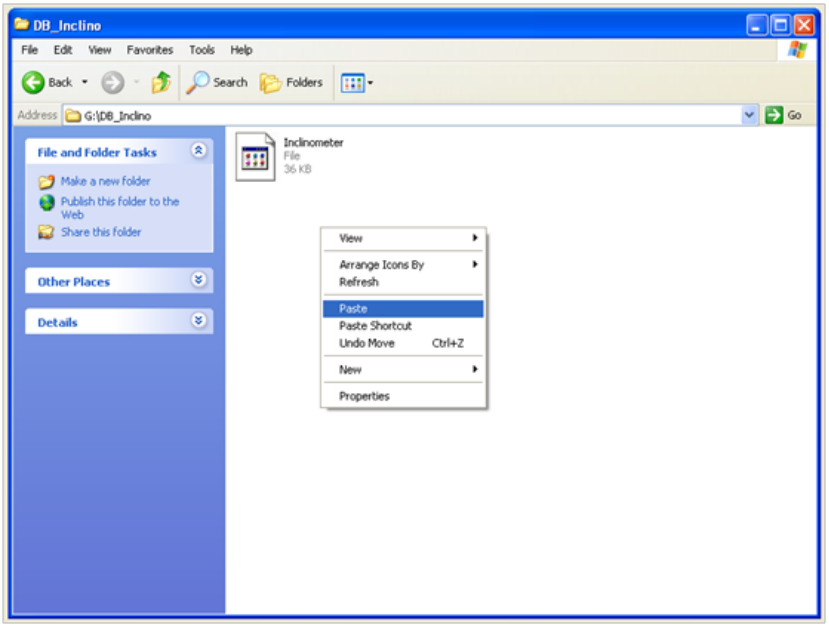


Figure 11-1

11.2 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 11-2.*

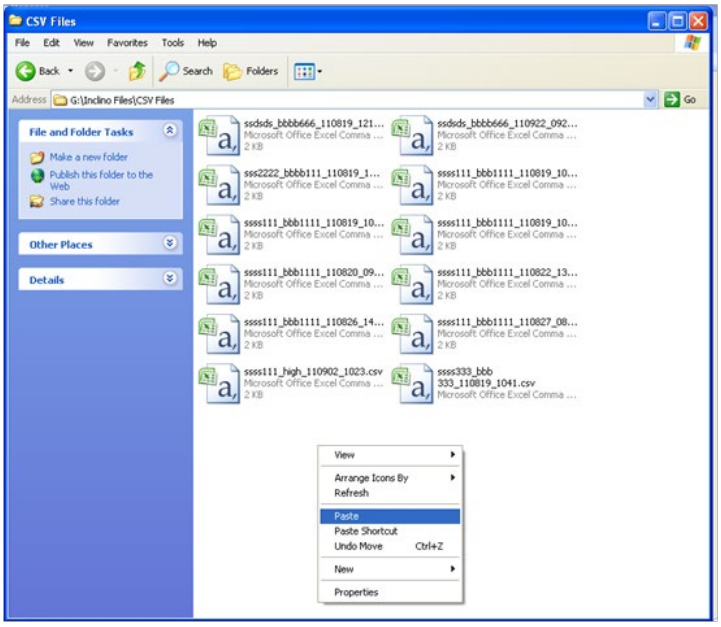


Figure 11-2

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 11-3.*

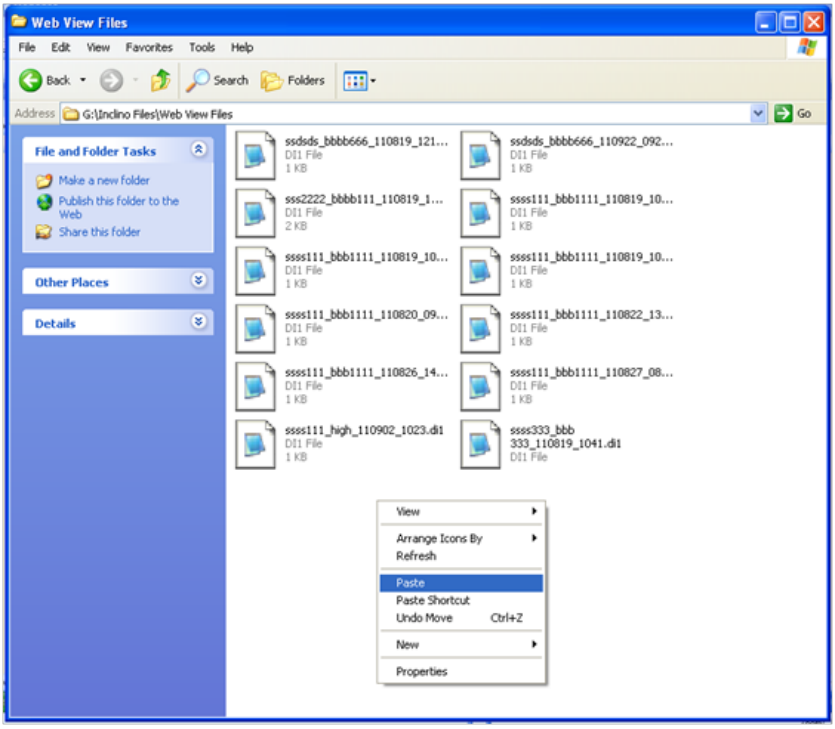


Figure 11-3

12 INSTALLING NEW DI SOFTWARE IN PHONE

Encardio-rite's Digital Inclinometer software can be installed in any compatible mobile phone device. Mobile phone must meet basic requirements for use.

12.1 Downloading application software

Connect mobile phone with Desktop PC (or laptop) via Bluetooth. Explore the CD shipped with EAN-26 Digital inclinometer system and find digital inclinometer application (DI.apk) file (see figure 12-1). Send "**DI.apk**" file to the mobile phone through Bluetooth (see figure 12-2).

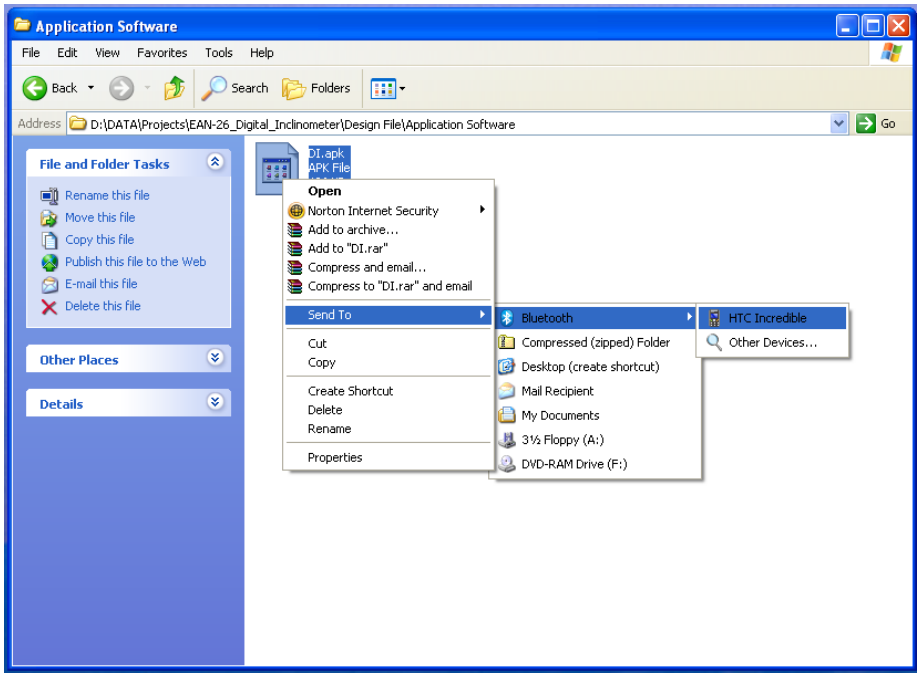


Figure 12-1

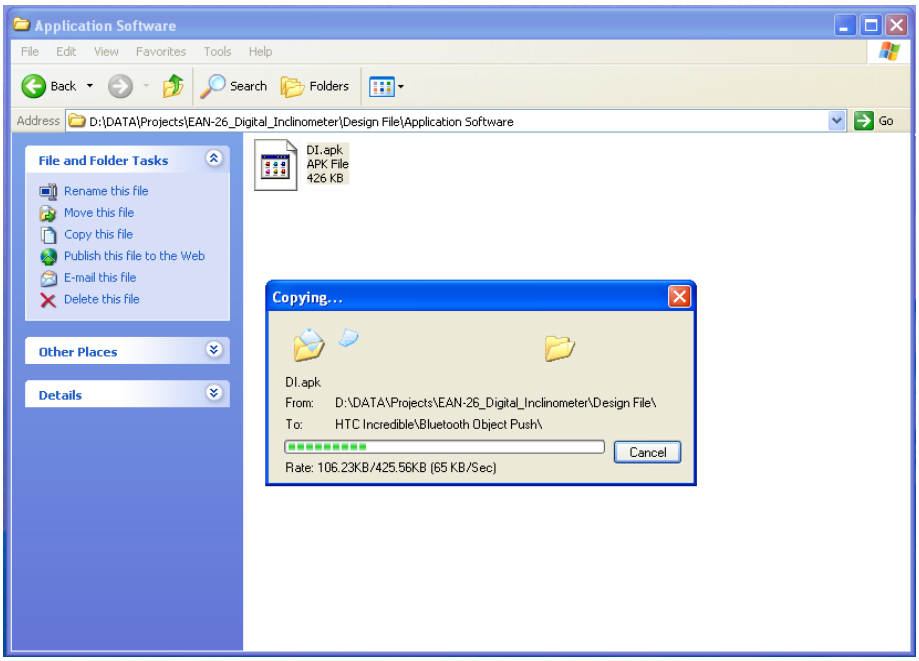


Figure 12-2

NOTE: Alternate method for downloading DI.apk file is through USB data cable. USB data cable is shipped with mobile phone (readout unit). Connect the mobile phone with PC through USB data cable. Explore the CD and copy DI.apk file to a folder in memory card of mobile phone.

12.2 Installing the application software

Open the Encardio-rite's Digital Inclinometer application file "DI.apk" from memory card of mobile phone. Click on DI.apk to open software installation wizard. Figure 12-3 shows the software installation wizard. Click on install button to install the application. Once install button is pressed application installation starts and will complete within 2-3 seconds. Figure 12-3 shows an example of application installation progress screen. Press on Done button to complete the installation.

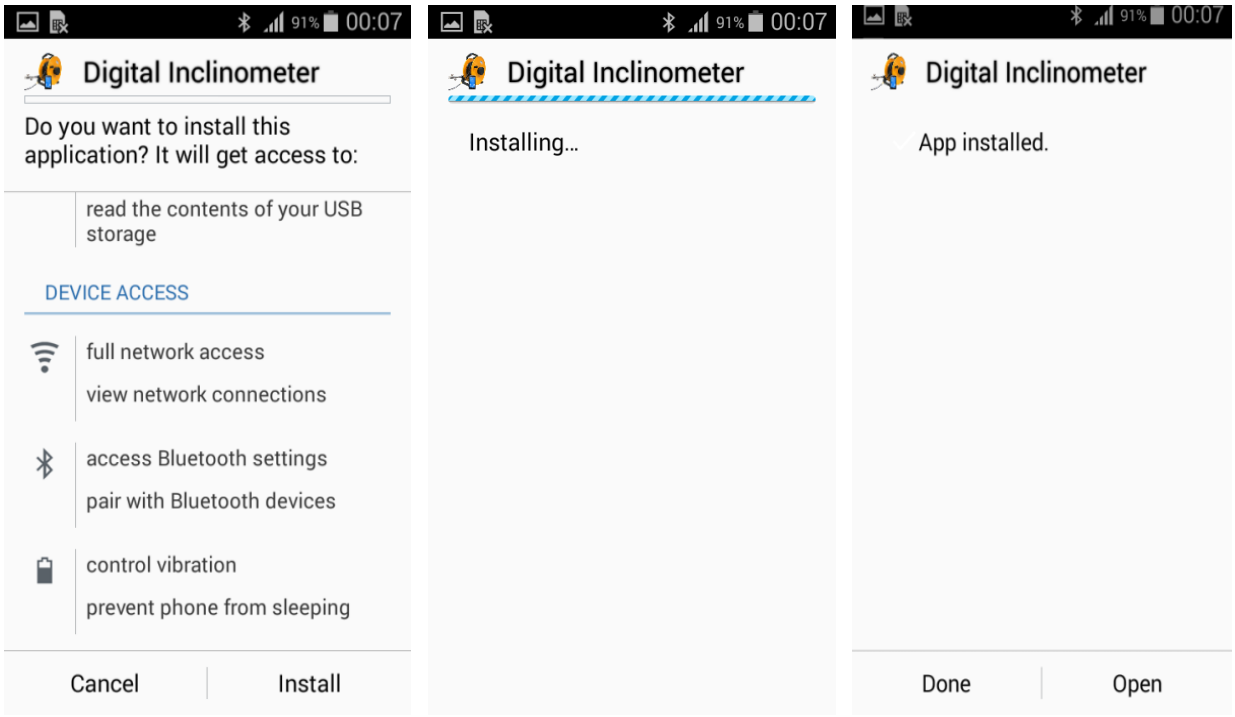


Figure 12-3 Digital Inclinometer Android Application Software Installation

13 UNINSTALLING THE DI SOFTWARE

Encardio-rite's Digital inclinometer application software must be uninstalled before installing new software (same or upgraded). Software must be uninstalled if it gets corrupted for any reason and then install a fresh copy of the application.

13.1 Clearing application data

Application data must be cleared before uninstalling DI application. Open the mobile applications menu and go to "Settings" menu (refer to *figure 13-1*). Press "*applications*" button from settings menu. Press "*manage applications*" button to manage the application we want.

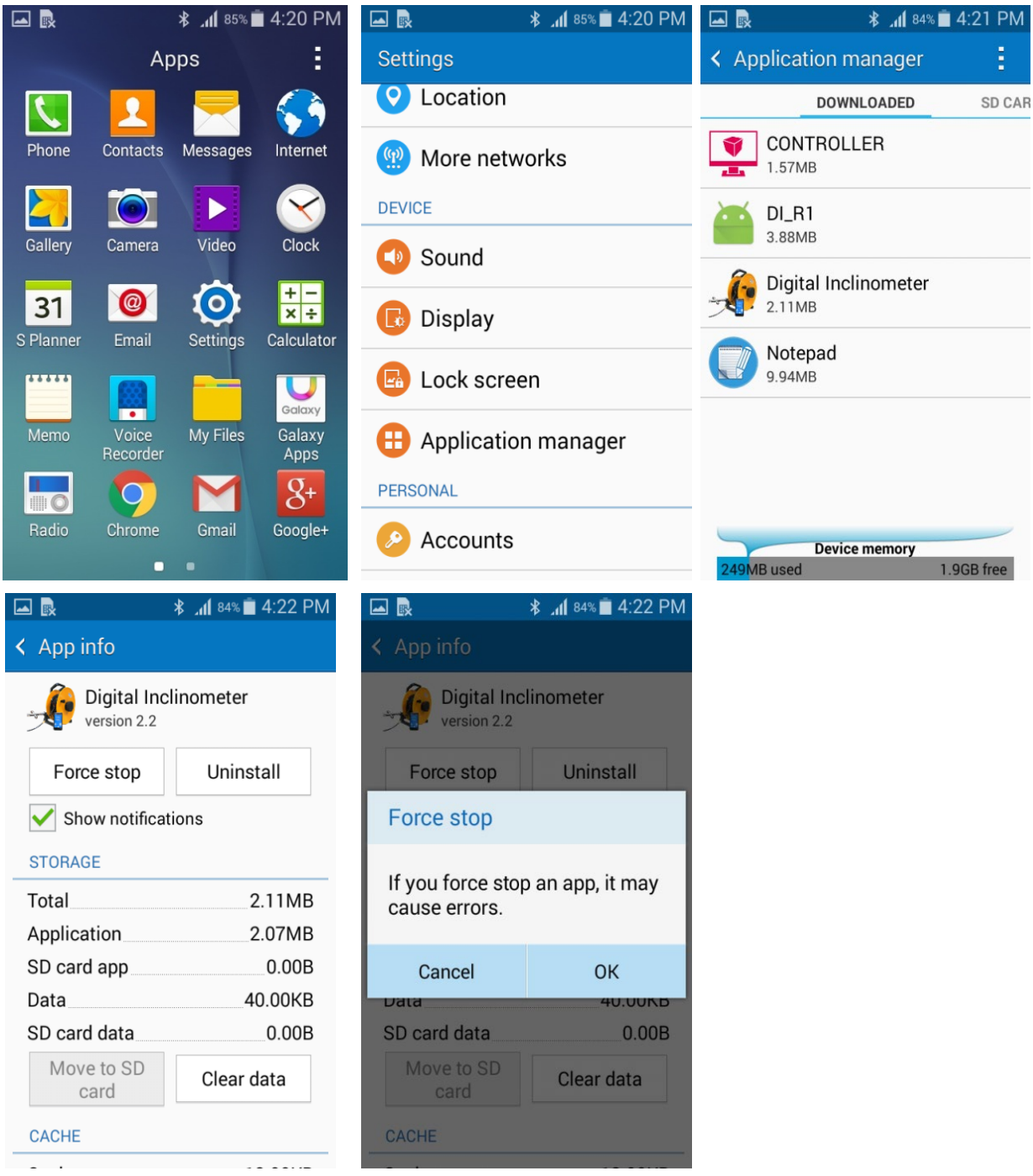


Figure 13-1 Clearing Data settings for Digital Inclinometer Android Application

Figure 13-1 shows an example of *manage applications* menu. Pressing on Digital Inclinometer button will open *application info* menu. Now press on clear data button to clear application data. Delete confirmation window will appear on phone's screen. Press *OK* button to clear application data.

13.2 Uninstalling the application

Follow the steps explained in section § 13.1 to reach following screen as shown in *figure 13-2*. Pressing on Uninstall button will open application uninstall wizard. Press on OK button to confirm un- installation. Now application has been uninstalled from mobile phone.

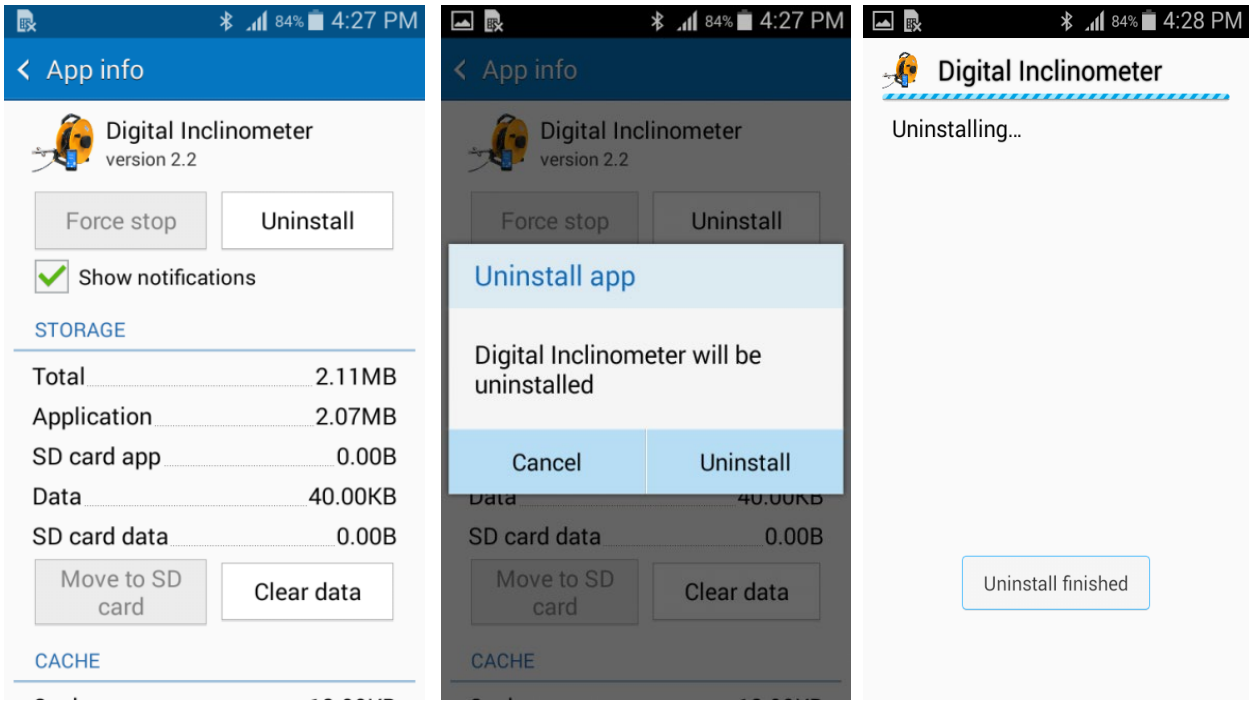


Figure 13-2 Uninstalling the Digital Inclinometer Android Application Software

14 TROUBLESHOOTING

14.1 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.

14.2 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.

14.3 Files not uploading on FTP server

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

14.4 Inserting new SD card

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

15 PUSH BUTTON AND STATUS LED INDICATOR

There is a push button with LED indicator given on Reel's disk. Main function of push button is to turn ON and turn OFF the Reel. By pressing once it will change Reel's power state ON to OFF or OFF to ON.

Reel power become auto OFF if it is kept idle (not connected to readout) for more than 5 minutes. This feature is given to save battery power.

LED indicator is given to show the various status indications for diagnostic purpose. Status indicator modes are given below.

LED continuous OFF : Reel power is OFF

LED continuous ON : Reel power is ON but Reel is not connected to Readout (mobile)

LED blinking at 1 Hz : Reel is connected to Readout

LED blinking at 2 Hz : Readout is taking Reading from Probe

LED double blinks : Probe is not connected / Probe is not responding

16 INCLINOVIEW APPLICATION SOFTWARE FOR PC

Encardio-rite's InclinoView software has been designed to process and analyses borehole data from Encardio-rite's EAN-26M Digital Inclinometer. It is suitable for plotting mean deviations, absolute borehole profile, cumulative deviation against depth and time vs deviation and vector plots at each depth.

InclinoView can also plot checksums for assessment of quality of data. Plots can be easily switched between top or bottom reference. The plots can be viewed along inclinometer casing grooves or along a skew angle. Spiral correction can also be applied if such data is available.

InclinoView allows inclinometer data for the same borehole to be automatically correlated for excavation or fills and benchmark elevation or fill levels with date can be annotated on the plots.

Sub soil stratigraphy layers can also be marked on the plots together with user comments.

InclinoView allows data from a large number of boreholes from different sites to be organized and stored on the users' PC.

InclinoView can run on both Microsoft Windows (XP and later operating systems) and Linux platforms.

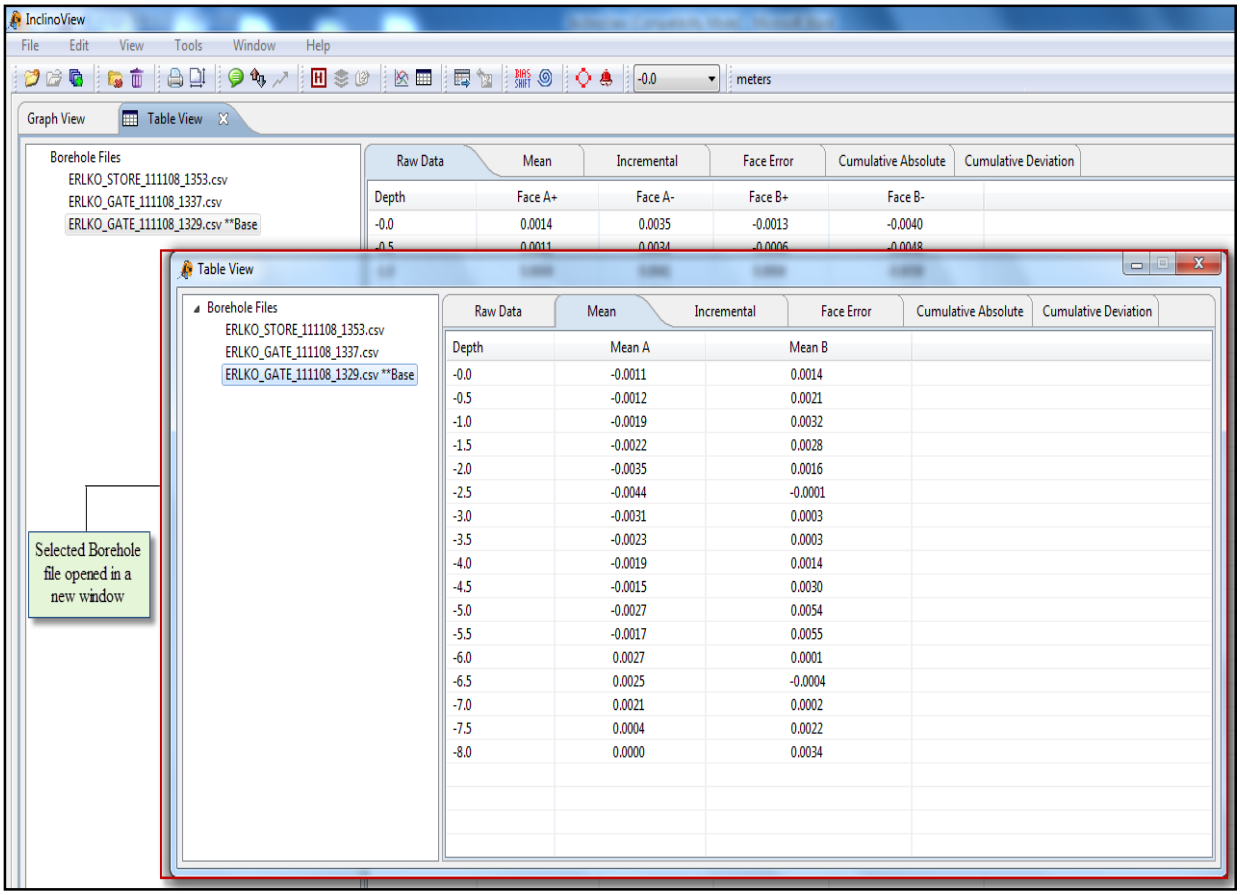


Figure 16-1 Data Represented in Tabular Form

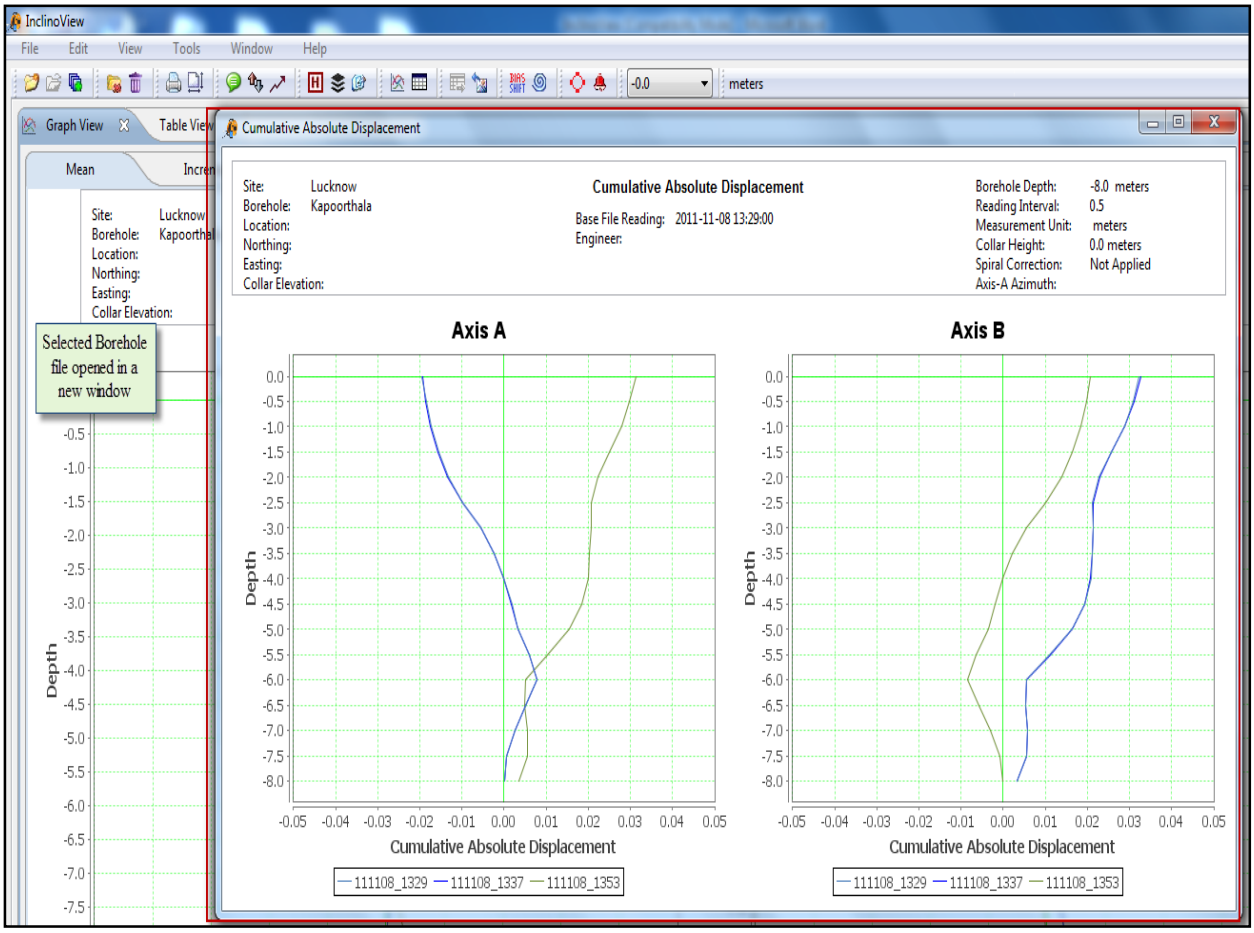


Figure 16-2 Data Represented in Graphical Form