

EN

INTRODUCTION MANUAL

2 Core Sensor Smart Inclinometer System

SI-300



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1. System Components

1-1 System Overview

The passive underground inclinometer system is a device for measuring ground slope and ground displacement by inserting an inclinometer probe inside a casing installed in a measuring station borehole. For accurate displacement measurement, the bore hole and casing must be installed in good condition; if they are poor, measurement accuracy may be significantly reduced. Displacement measurement compares the current and previous measurement data from the initial measurement data. The underground inclinometer system SI-300 immediately converts and displays the length displacement for the slope, eliminating the need for secondary calculations through separate correction and conversion coefficients.

1-2 System Composition

The passive underground inclinometer system SI-300 consists of the following items, and the data measured from the inclinometer probe is wirelessly transmitted to the data reader via Bluetooth reel.

- Inclinometer Probe
- Cable
- Bluetooth Reel
- End-cap
- Data Reader

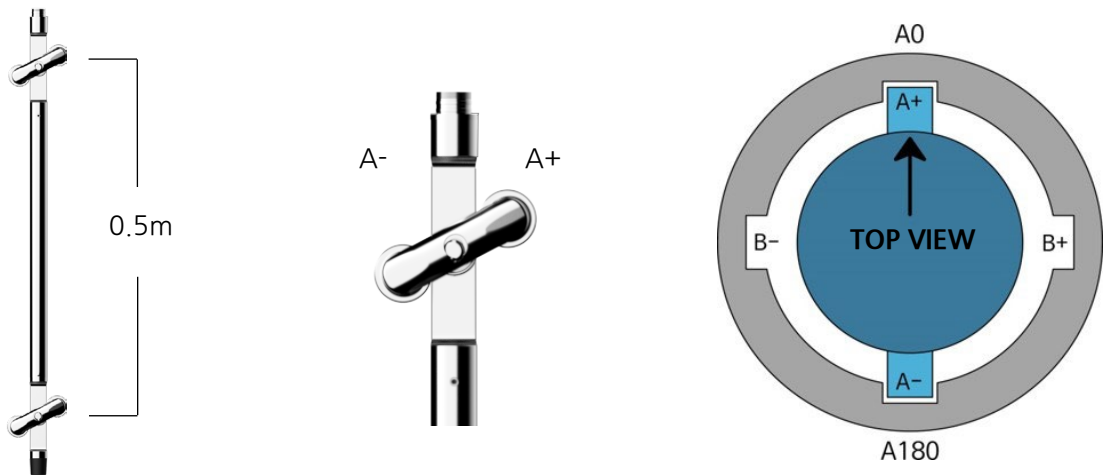


1-3 Inclinometer Probe

SI-300 inclinometer probe is supplied in metric and a gauge length is 0.5 meters (from the center of the bottom wheels to the top). The direction mark is marked on the body of the probe that used to orient the probe during a survey.

1-4 Measurement Axis

Inclinometer probe measures inclination of 2-axes. The A-axis measures tilt in the plane of the wheels and the B-axis measures tilt in the plane perpendicular to the wheels. When the top of the probe is tilted in the + direction, displacement values are positive and when the probe is tilted in the - direction, displacement values are negative. Set toward A+ to A0 direction to measure A0 and set toward A+ to A180 direction to measure A180. The picture as below shows directions of the probe.



1-5 Handling of Inclinometer Probe

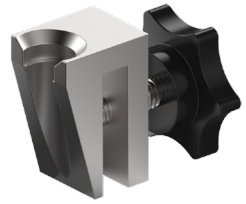
- The inclinometer probe is a sensitive measuring instrument. Handle it with care.
- If possible, transport the inclinometer probe by storing it in a storage case. When moving by vehicle, store it in the storage case and load it into the vehicle's cargo space.
- When connecting the inclinometer probe and cable, be careful not to overtighten. It may cause thread breakage or O-ring damage.
- When inserting the inclinometer probe into the casing, retract the wheel so that it can be inserted into the casing smoothly, and descend slowly to avoid hitting the bottom of the bore hole.
- When retrieving the inclinometer probe from the casing, be careful not to pop it out by closing the wheel as you did when inserting it.
- Depending on the season, the temperature inside the case may differ significantly from the outside temperature, so before starting measurement, insert the inclinometer probe all the way inside the casing and wait for at least 10 minutes to allow the temperature of the inclinometer probe to stabilize.
- The operating temperature range of the inclinometer probe is $-20^{\circ}\text{C}\sim+70^{\circ}\text{C}$. Do not operate in harsh environments outside of the temperature range.

1-6 Cable

The cable powers the inclinometer probe, transmits data, and allows handling of the probe inserted inside the casing. The SI-300's cable is designed to withstand high loads and is labeled every 0.5 m to indicate the current depth. (The first label is located 0.5 m from the center of the upper wheel.)

1-7 End-cap

The end-cap is a device installed on the top of the casing to assist in accurate measurement. Place the end-cap on the casing and secure it by tightening the fixing screw. For accurate measurement, you must place the label of the cable in the groove at the top of the end-cap. The end-cap is designed to be commonly installed on 50mm and 60mm internal diameter casings.



1-8 Bluetooth Reel

The Bluetooth reel is a device for transporting cables, and its role is to transmit data measured by the probe to the reader via Bluetooth. The top of the Bluetooth reel can conveniently hold an inclinometer probe and has a built-in lithium-ion battery.

1-9 Front Panel

The front panel has two buttons, three lamps and a connector.



1-10 Power Button / Power Lamp

Press power switch to switch on and off. The power lamp blinks 1 time per second when power in on and blinks 3 times per second when connection between the reel and the probe is lost. The reel switches off automatically after 20 minutes without a Bluetooth connection or no commands and readings between the reader and the probe.

1-11 Bluetooth Button / Bluetooth Lamp

When the power is turned on, the Bluetooth lamp blinks at a cycle of 3 times per second, and when measurement begins and Bluetooth is connected, it blinks at a cycle of 1 per second. If the Bluetooth connection is poor, you can press the button to retry the Bluetooth connection.

1-12 Power Socket / Power Lamp

You can charge the Bluetooth reel by connecting the charger to the charging terminal. When the charger is connected properly, the green light on the lamp turns on, a red light turns on during charging, and a blue light turns on when charging is complete. The Bluetooth Reel can be fully charged in 4 hours from a discharged state, and can be used continuously for about 25 hours on a single charge. When the battery is low during use, a warning sound will sound, and the power will automatically turn off 20 minutes after the first warning sound.

1-13 Data Reader (Tablet PC)

The data reader is provided as an 8-inch tablet PC based on Android OS, and the type and specifications of the tablet PC may change depending on the manufacturer's circumstances. The provided tablet PC is a service item, and DAS Co., Ltd. is not responsible for defects or malfunctions of the tablet PC. If you require repair, warranty, or technical support, please contact the manufacturer.

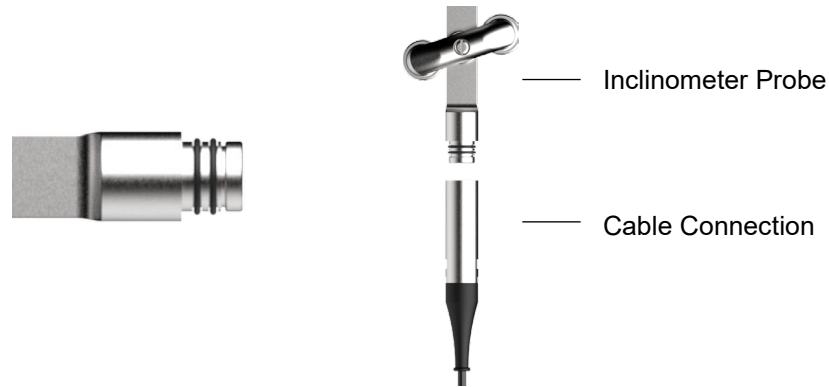
1-14 Reader Application (App)

Reader application Smart Tilt Reader is an application for operating the underground inclinometer system SI-300 on Android OS-based mobile devices. The reader application is installed by default on the provided tablet PC, and can be downloaded from the DAS Co., Ltd. website (Download>Software) at <http://www.das-co.com>. The reader application is not compatible with all Android OS-based devices.

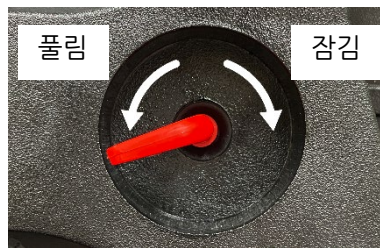
2. Assembling the System

1. Attach the inclinometer probe to the cable connection. Attach the inclinometer probe by rotating it clockwise while holding the two connections tightly until the double O-ring of the inclinometer probe connection is no longer visible. When combining, the inclinometer probe must be rotated to connect. If the cable connection part is rotated to connect, it may cause damage to the cable..

0.



2. Unscrew the lock on the back of the Bluetooth reel counterclockwise to release the cable.



3. After measuring, separate and store in the reverse order of assembly.

3. Installing Reader APP

The reader application is installed by default on the provided tablet PC, and can be downloaded from the DAS Co., Ltd. website (Download>Software) at <http://www.das-co.com>.

- Install the downloaded reader application through an app such as “File Manager” or “My Files” on your mobile device. (Reader application installation file: SI300.apk)
- If a warning such as “Unknown Source” occurs, tap “Settings” in the warning window to enter settings. Or, enter a menu such as “Lock screen and security” on your mobile device.

Enable “Apps from unknown sources” to allow installation.

4. Pairing Bluetooth Devices

To use the underground inclinometer system SI-300, a connection between a Bluetooth reel and a data reader is required. Bluetooth connection is similar to the connection method between a smartphone and a Bluetooth headset, and if you use a new data reader, you must reconnect the Bluetooth device.

1. Turn on the Bluetooth reel.
2. Turn on the data reader (Android OS mobile device).
3. Enter the “Bluetooth Settings” menu on your mobile device.
4. Change your mobile device’s Bluetooth to “Active” status.
5. Tap “Search” to search for connectable Bluetooth devices.
6. After a while, if a device name starting with “SI-300C” appears in the list of connectable devices, select it.
7. Enter the PIN number “0000”.
8. Check the Bluetooth device connection completion message.

Afterwards, when measurement is started from the reader application, it automatically attempts to connect to the Bluetooth reel. Bluetooth setup methods may vary depending on the mobile device, so please contact the manufacturer. After measurement, separate and store in reverse order of combination.



5. Reader App Overview

5-1 Run Reader App

Tap the SI-300 icon to run the reader application.



5-2 Home Screen Setting



-  icon
Open the Add Site pop-up window.
- Smartphone icon
Open the app's settings screen.
-  icon
Reload the site list.
- Go back
You can use the back button on your mobile device to return to the previous level of menus and functions at any stage.

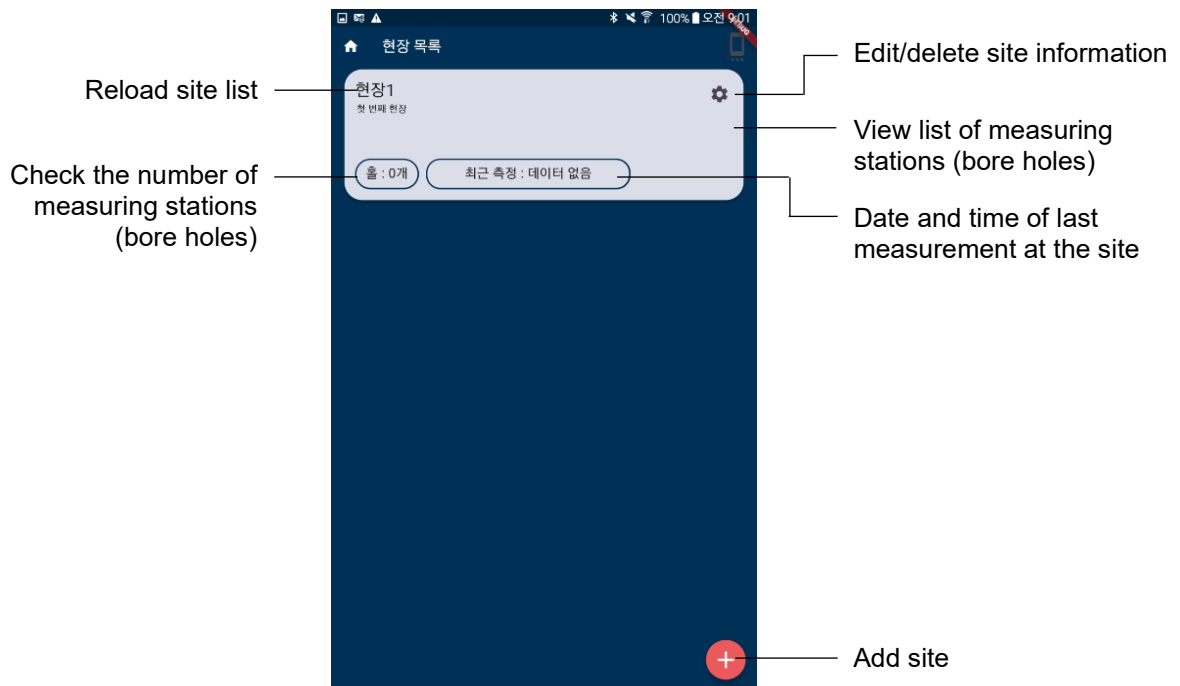


6. Measurement




Start the measurement by tapping the field hole on the application's initial screen.

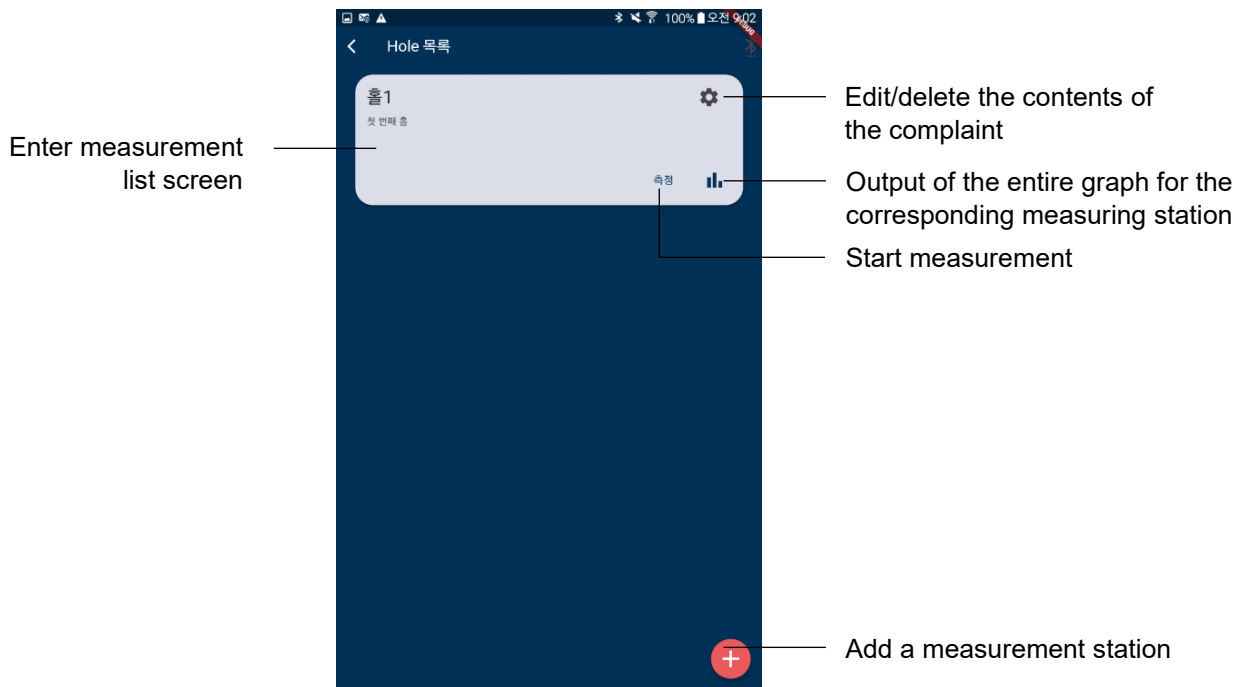
6-1 Site List

- Click the  at the bottom right to add a site.
- Tap on the site name and a list of measurement stations (boreholes) will appear.
- Change the site contents or delete the site by clicking the  to the right of the site name.






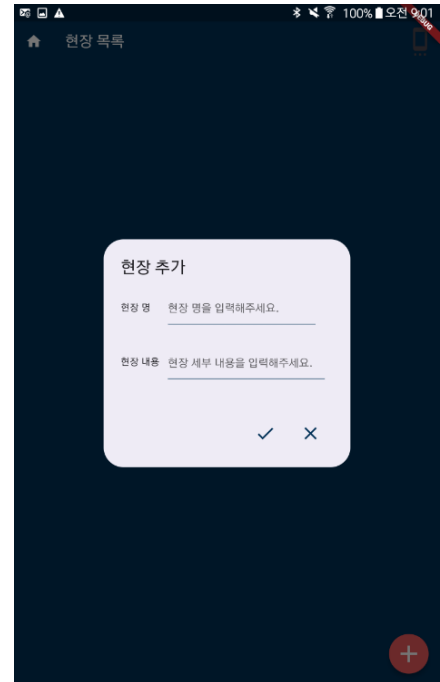
6-2 Measuring Station (bore hole) List

- Tap the  at the bottom right to add a measuring station.
- By tapping on a measuring station, you can move to the measurement list screen.
- Change or delete the contents of the hole by tapping the  to the right of the measuring station name.
- Tap the “Measure” text to start measuring.
- Tap the  to display all measurement information from that measuring station in a graph.






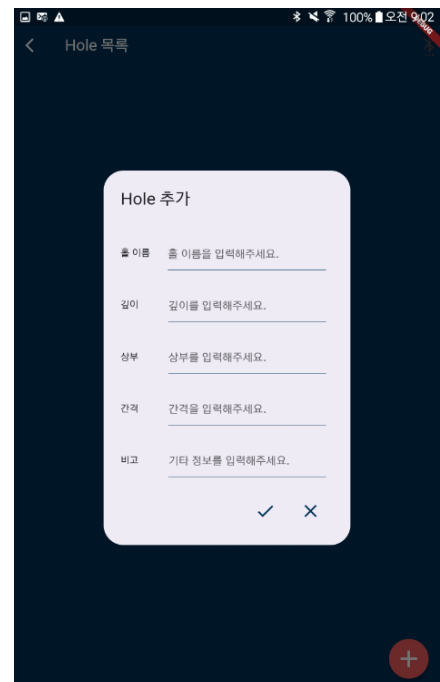
6-3 Field Information

- Tap the  at the bottom right, the Add Site window will appear.
- Pop-up window
 - A. Site name : Shows the site name in the site list.
 - B. Site contents : Shows the contents (remarks) of the site at the bottom of the site name in the site list.
 - C.  : Apply the site name and site details.
 - D.  : Returns to the site list screen without applying the content.



6-4 Measuring Station Information

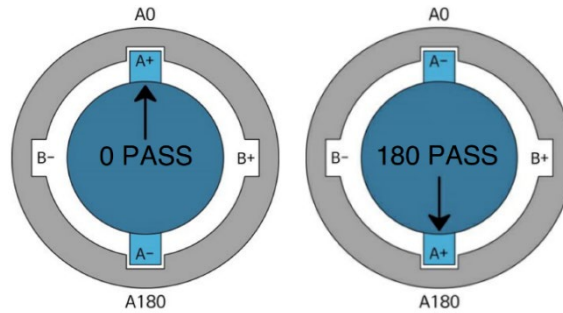
- Tap the  at the bottom right, the Add Measuring Station window will appear.
- Pop-up window
 - A. Hole Name : Shows the hole name in the measuring station list.
 - B. Depth : Set the measurement starting point at the bottom (in the direction of the ground).
 - C. Top : Set the measurement end point at the top (ground direction).
 - D. Interval : Set the measurement interval. (0.5 meter increments)
 - E. Remarks : Additional information about the hole is displayed at the bottom of the hole name in the measuring station list.
 - F.  : Apply the contents.
 - G.  : Returns to the measuring station list screen without applying the contents.



7. Measurement Method

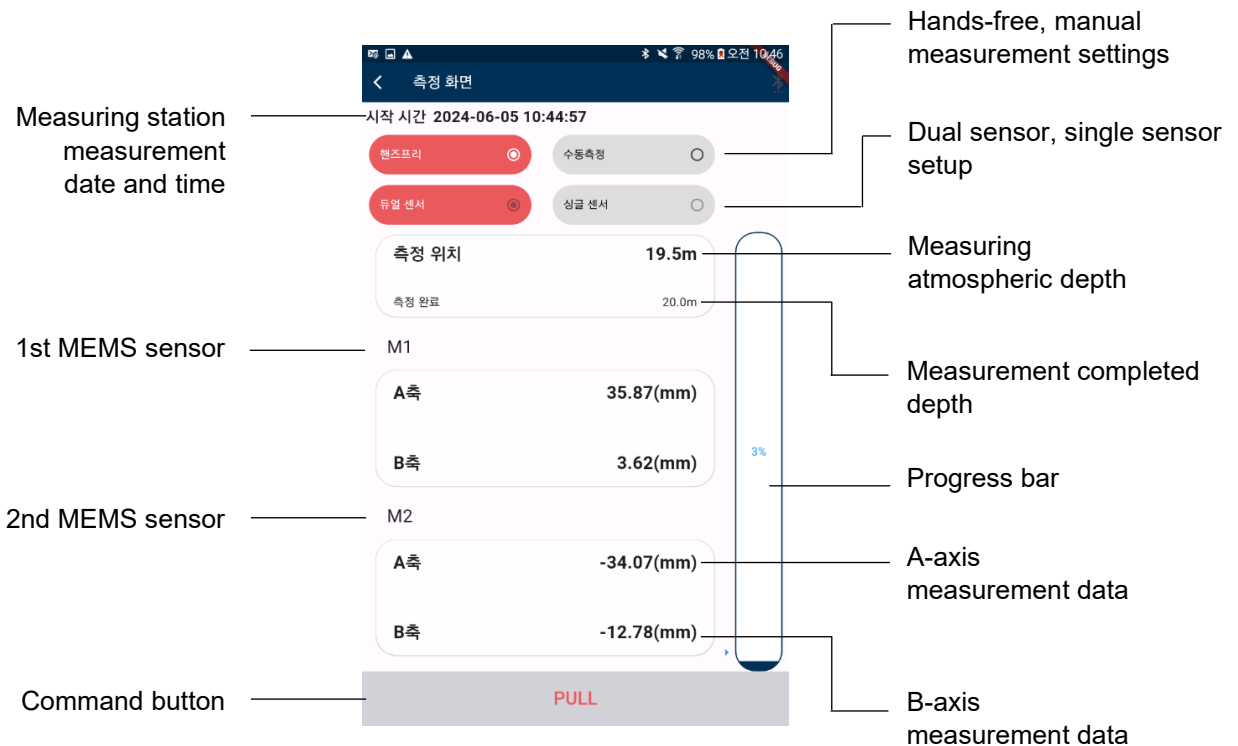
7-1 Before Start

During the measurement, the inclinometer probe is pulled along the casing from the lowest measurement start point to the uppermost measurement end point and measures the inclination. This is called "PASS", and measurements are made as 0 PASS, where the A+ direction of the inclinometer probe is toward the A0 direction, and 180 PASS, when the A+ direction is toward the A180 direction. In the case of SI300, when measuring in dual sensor mode, 0PASS and 180PASS are performed simultaneously.



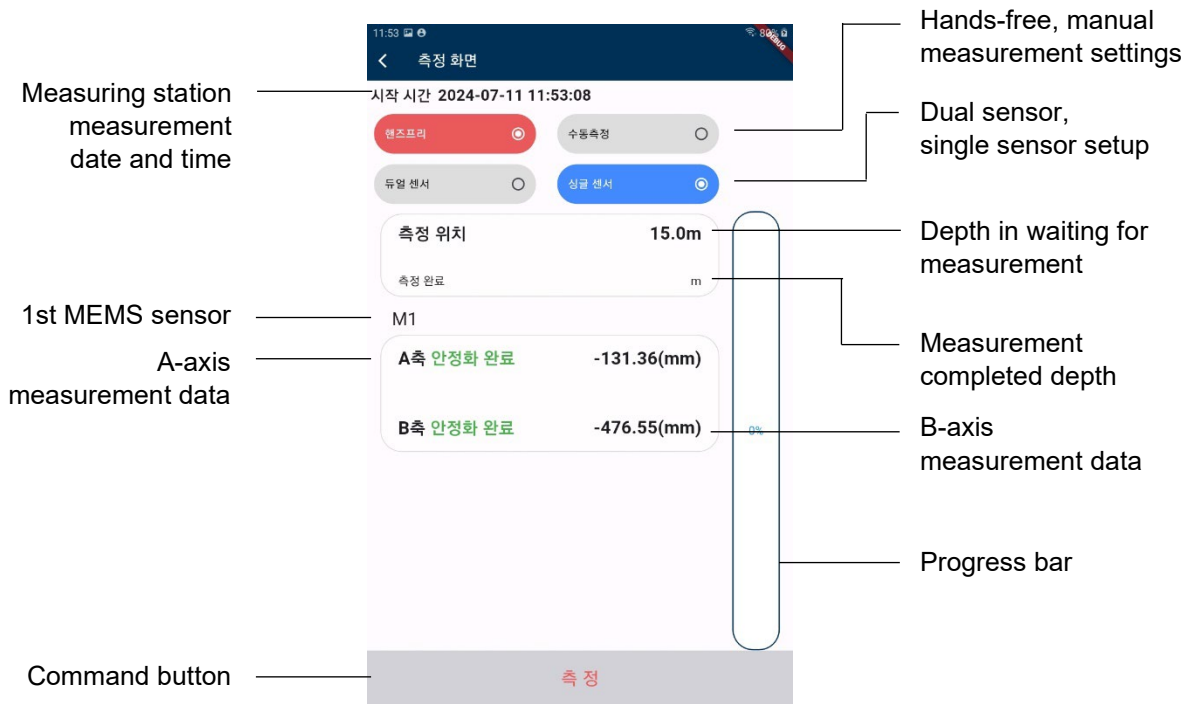
7-2 Dual Sensor Measurement Screen

- Dual Sensor (0 PASS & 180 PASS) : Detailed description of the dual sensor measurement screen.

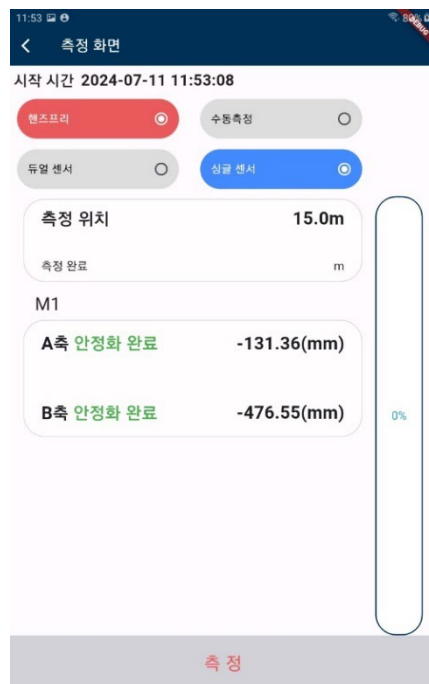


7-3 Single Sensor Measurement Screen

- Single Sensor (0 PASS) : Detailed explanation of the single sensor measurement screen.



- Single Sensor (180 PASS) : In 180 PASS, the progress is reset after completing 0 PASS. After completing 0PASS, a pop-up window with instructions for proceeding to 180 PASS will be displayed.



7-4 Command Button

Command buttons are displayed with different letters depending on their function, and tapping them performs the current display function.

- **Start & End**

The command button appears as a “Measure” button when starting/ending measurement of each PASS.



- **Wait & Delay**

The command button appears while receiving and recording measurement data from the inclinometer. If the inclinometer is unstable, it maintains a delay until it stabilizes and then records the data.



- **Measurement Command**

The command button appears when a measurement is available and displays the command “Measure” (manual measurement) or Pull (hands-free measurement) depending on the measurement method. In the Pull state, you cannot give commands manually by tapping the button.

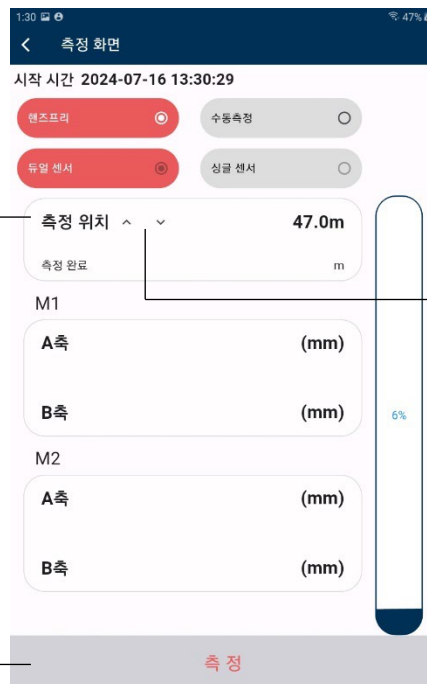


7-5 Change Current Depth

If the measurement depth displayed in the reader application and the actual cable depth display are different due to a mistake made by the measurer, the current depth (measurement target depth) can be changed in the reader application.

- Tap and hold the current depth until the up/down arrows appear.
- Tap the up/down arrows to change the current depth.
- Verify that the changed current depth matches the depth markings on the actual cable.
- Tap the command button to resume measurement. Existing data will be overwritten with new data.

1. Tap and hold the measurement location, up/down arrows will appear.



2. Tap the up/down arrows to change the current depth.


3. Resume measurement.

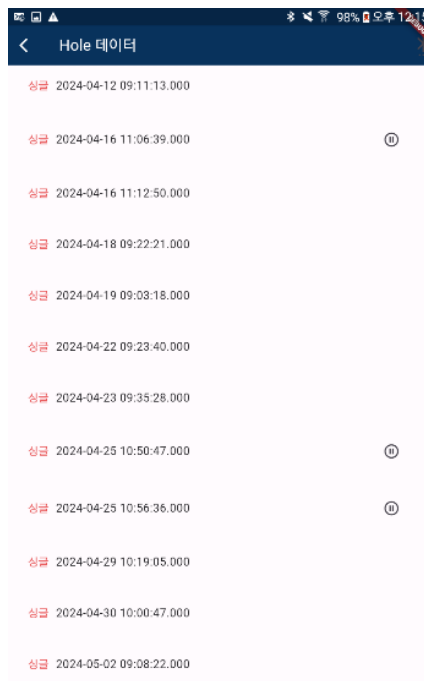
7-6 Measurement interruption

When you need to stop measurement, tap the back button on your mobile device and select the End menu.

- Delete : Deletes all data being measured and stops measurement. Measurement records created in the measuring station list are not deleted.
- Save : Saves and stops the data measured to date. You can continue measurements from the point of interruption by selecting the corresponding measurement record from the measuring station list.

7-7 Resume Interrupted Measurement

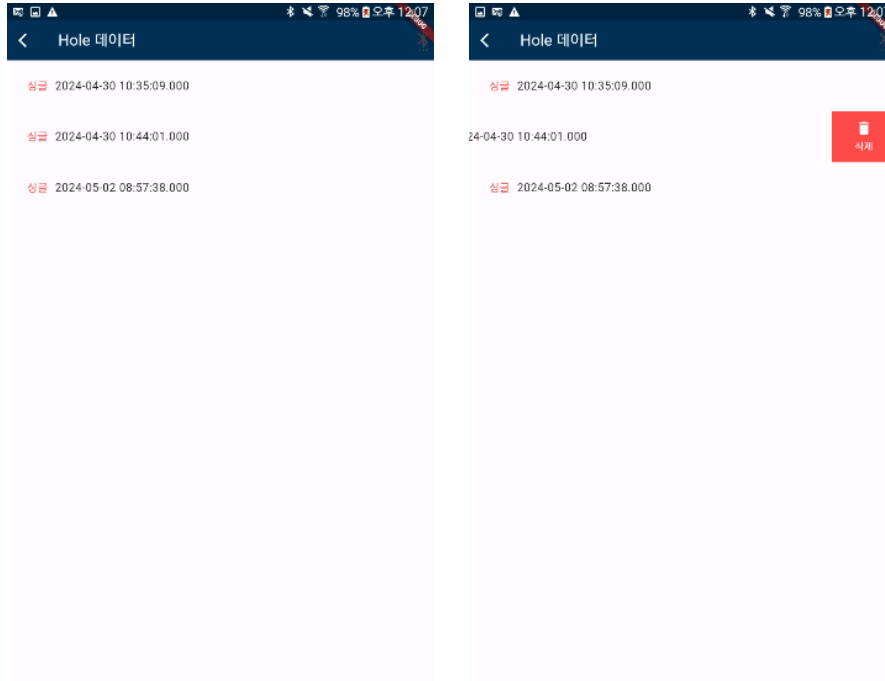
Tap the hole in the measuring station list and tap the  icon for the interruption date to start measurement.



If the 0 PASS measurement is completed with the dual sensor and a 180-degree measurement is required, tap the relevant date and time and tap “180-degree measurement” in the displayed pop-up window to continue the measurement. In this case, start the measurement in single sensor 180 degree measurement mode.

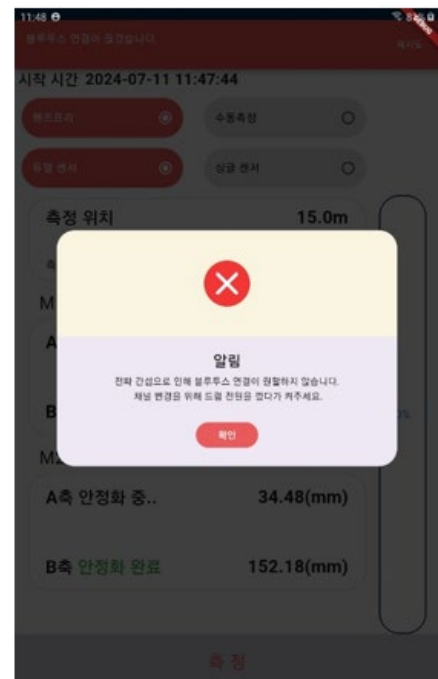
7-8 Delete Measurement

When you need to delete measured data, tap the corresponding hole on the measuring station screen to enter the Hole data screen, then drag the date and time you want to delete from right to left, and a deletion window will appear.




7-9 Notes

- Bluetooth reel data processing may not be smooth due to radio wave interference during measurement.
- If this problem occurs, a notification window will be displayed and the Bluetooth connection will be disconnected.
- After the Bluetooth connection is disconnected, the measurement location is changed from the last measurement location to the two previous measurement locations to ensure the integrity of the measurement data.
- To proceed with the measurement, turn the Bluetooth reel off and on, then press the Bluetooth reconnect button in the reader application.

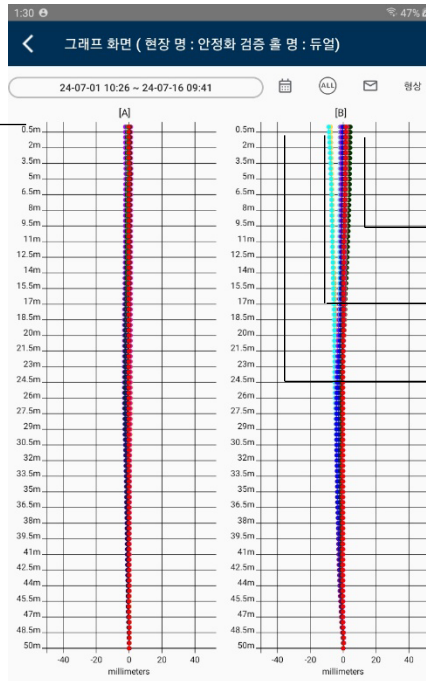


8. Data Viewer

- Tap the  icon on the reader application measurement station screen to check the measurement data.
- Tap the hole on the measuring station screen, click the date and time on the hole data screen that appears, and then tap “Graph” to check the measurement data.

8-1 Data Item

Tap the date and time to print a single graph.



Settings to apply calculation method and hole shape.

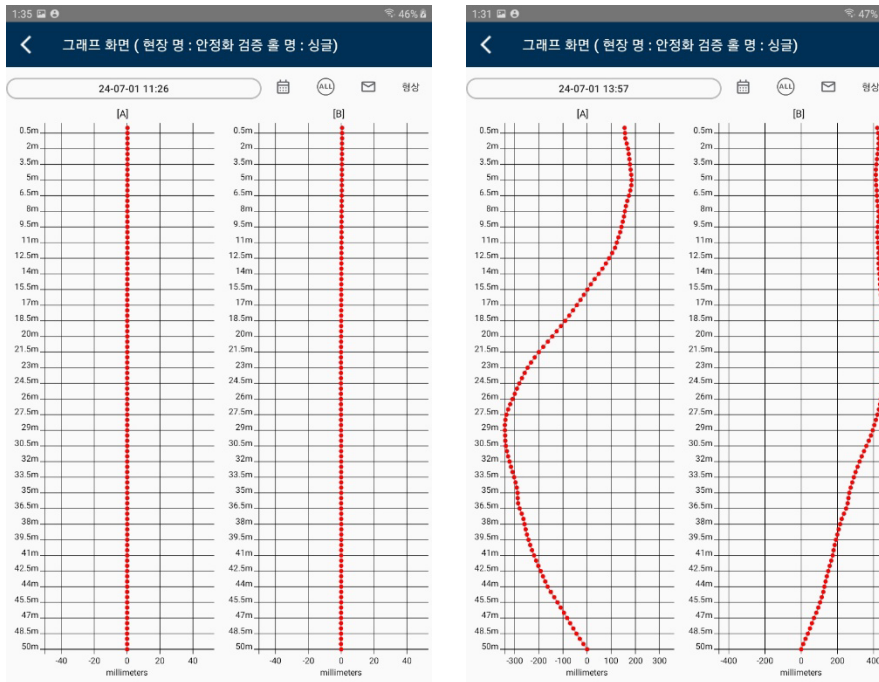
Data transfer function

Full graph output

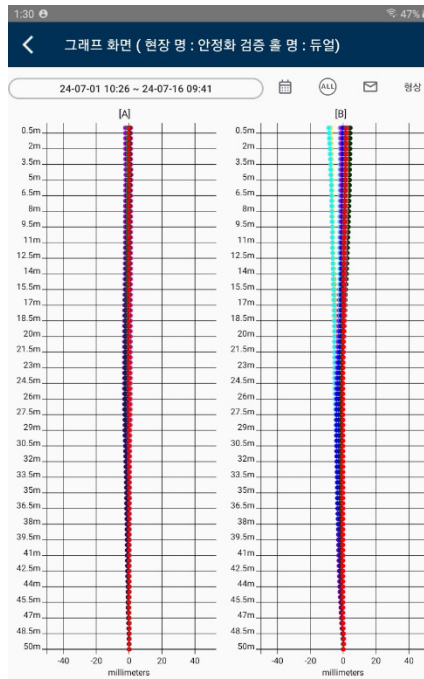
Graph output by period


- Graph : Shows a graph of the displacement of the current value compared to the initial value. This graph is a graph of relative displacement compared to the initial value with the initial value as the origin.

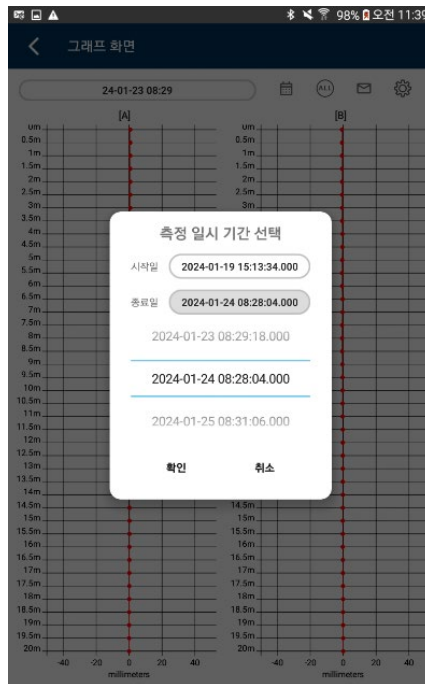
- Hole shape : Absolute displacement graph of the current value, allowing you to check the shape of the actual inclinometer casing.



- Data transmission function : Transmits all data of the application. Data verification is possible for each site and hole in the PC program.
- Full graph : If the graph is created as a graph by period or a single graph, tap the **ALL** icon to output all data for the hole as a graph.



- Graph by period : When you click the  icon, a pop-up window that allows you to print a graph for a specific date will be displayed on the screen. You can specify the period by tapping the date and time next to the start and end dates and then scrolling the date and time below the end date.



8-2 Initial Value

The initial value is automatically set to the data first measured at the relevant measuring station, and if necessary, you can compare data by setting other measurement data as the initial value. Since the graph uses the result of subtracting the initial value from each data to make the initial value 0, the graph does not represent the actual shape of the bore hole and casing.

8-3 E-mail Setup

If this is your first time attempting to transfer data, you will need to set up your mobile device's email preferences for data transfer.


- If you are attempting data transfer for the first time, the Android OS's default task settings window will appear.
- Select an email application such as Email or Gmail.
- Once the selection is complete, the email sending screen appears.
- Enter basic email information.

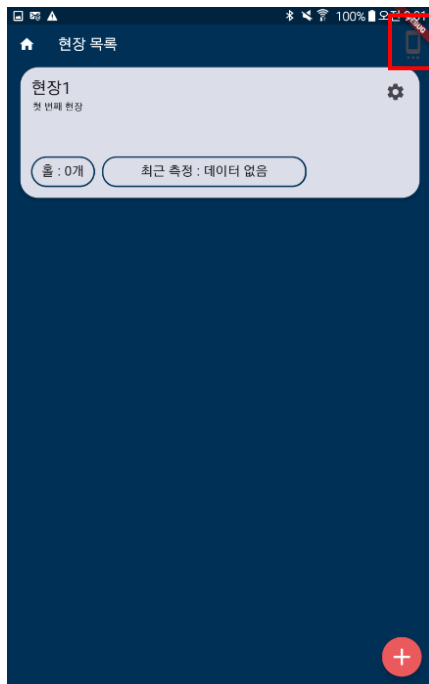
8-4 Caution

- To send email, the data reader must be connected to a wireless network via Wifi, LTE, or mobile hotspot.
- The transmitted data file has a .db(database) extension file, and the file can be opened on a PC using a PC program dedicated to SI-300.
- OTG cable, USB data cable, and external USB storage device are not provided as standard.
- To connect your email account to an email application, you must enable IMAP4 or POP3 on your account. Please refer to help and technical support from your email service provider (Naver, Daum, etc.).
- Dual graphs may have a deviation of about 0.02% between the A-axis and B-axis.

9. Setting Screen

9-1 Setting List

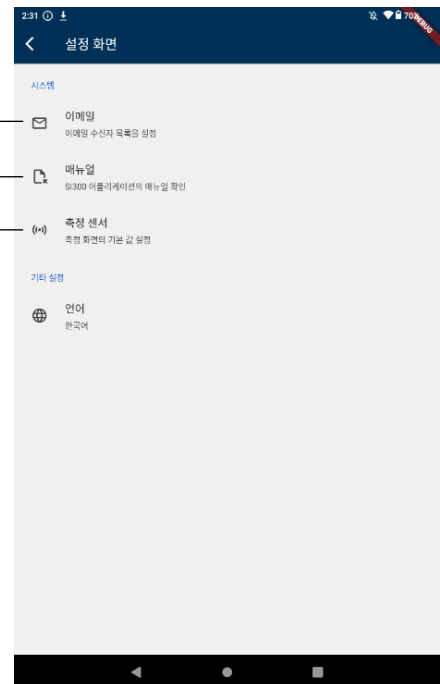
Click the  icon in the upper right corner of the site list to enter the settings screen.



Set up email receiving list

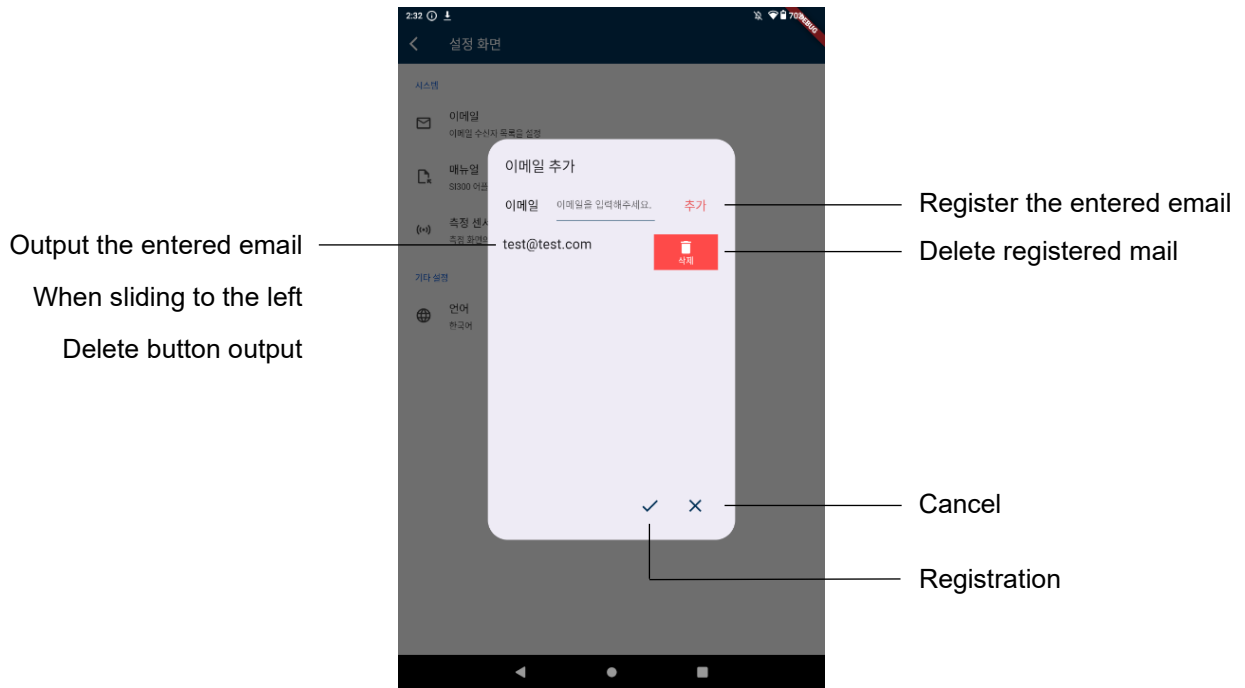
Open manual

Set measurement screen defaults



9-2 E-mail

When you click the Add Email button, the entered email will be displayed in the list. When you drag the printed mail from right to left, the delete button is activated.



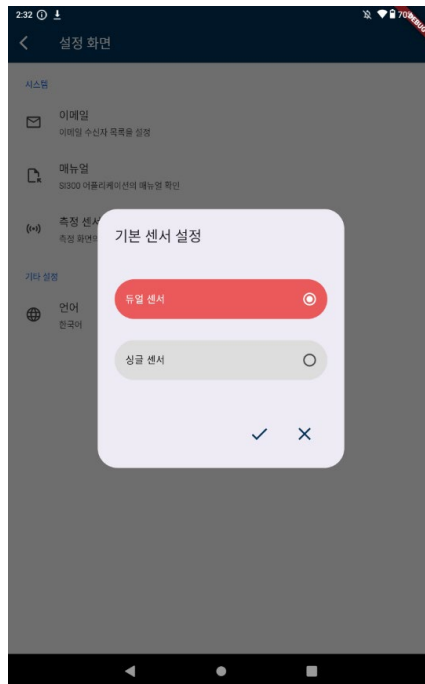
9-3 Manual

Can check the manual for SI-300.



9-4 Measurement Sensor Setup

You can select the default measurement mode on the measurement screen. Choose between Dual Sensor and Single Sensor. If no separate settings are made, the default sensor setting is “Dual Sensor.”



10. Daily Inspection and Management

10-1 Inclinometer Probe

- If the wheel does not rotate smoothly, clean the wheel of any contamination and foreign substances, or inject lubricant (grease or Teflon oil, etc.) into the wheel bearing. Do not use rust preventives such as WD-40 as they are cleaning agents, not lubricants..
- If the spring of the wheel assembly does not return to its original position, check whether the spring is contaminated and clean it. If spring abnormalities persist, repair of the wheel assembly is required.
- Periodically inject O-ring-specific lubricant or silicone-based grease into the O-ring of the connection. It provides a smooth connection between the inclinometer probe and the cable and prevents damage to the O-ring. Do not use rust preventives such as WD-40 as they may cause O-ring hardening and damage.
- If the O-ring of the connection is broken or damaged, the O-ring must be replaced.
- After use, be sure to separate it from the cable and store it. After cleaning and drying any moisture, contamination, and foreign substances, store it in a storage case and store it in a dry place.
- Do not clean the metal terminals of the connection with conductive substances.

10-2 Cable

- Check the cable for damage before use. If the cable is damaged, the tensile strength of the cable may decrease and the inclinometer probe may be lost within the casing, so it must be repaired immediately before use.
- The cable is made of a high-strength and high-elasticity polyurethane sheath, but it can be damaged by sharp objects or terrain, so be careful when using it, and be careful not to damage the cable core wire by pulling it in a tangled or twisted state.
- After use, unplug the cable, clean it of any contamination and foreign substances, and then store it. Do not use rust inhibitors such as WD-40 as they cause hardening and damage to rubber and plastic.

10-3 Bluetooth Reel, Data Readers and Other Accessories

- After use, wash away moisture, contamination and foreign substances and store in a dry place.
- Do not use rust preventives such as WD-40 on rubber, plastic, and bearings.
- It is okay to clean the end-cap using a rust preventive such as WD-40.
- Frequently check the charging status of the Bluetooth reel and data reader to prevent them from discharging during use.

11. Warranty

- The quality guarantee is 12 months from the date of delivery of the product, and the product will be exchanged or repaired free of charge for quality problems arising from design or manufacturing defects within the warranty period. If the system is arbitrarily disassembled or modified, used for purposes other than those intended, or used differently from the user manual, the warranty becomes void, and the warranty does not cover products not manufactured by the manufacturer (data readers, tablet PCs, etc.).
- All materials in this document are owned by DAS Co., Ltd. and may not be copied, modified, or redistributed without permission.

*Attachment 1. Data File Description

Measurement completed and recorded data can be saved to a storage device or sent by email to be checked and managed in the SI300 PC program.

1. Open File

The saved or transmitted data file has a .db (DataBase) extension, and opens the file by loading it in the SI300 PC program.

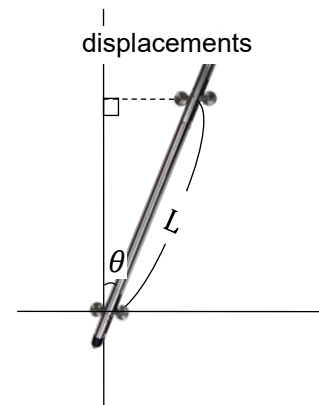
2. Data Unit

All data in the data file are length displacements, and the unit is mm.

- Length Displacement Conversion Formula

$$\sin \theta = \frac{\text{displacement}}{L} \quad \text{※ } L = 500\text{mm}(\text{wheelbase}), \theta = \text{slope}$$

$$\therefore \text{Displacement} = 500\text{mm} \times \sin \theta$$



3. Data Description

It is based on the A-axis, and the B-axis data is also in the same format.

Depth	A0	A1	A_MEAN	A_CS	A_SUM	A_SUM_INT
0.5	30.769898	-30.505107	30.637503	0.264792	149.436354	-0.373685
1	31.070392	-30.838708	30.95455	0.231684	118.798851	-0.385009
1.5	30.833482	-30.616599	30.725041	0.216883	87.844301	-0.34146
2	29.514676	-29.320409	29.417543	0.194267	57.119261	-0.314458
2.5	27.628446	-27.5204	27.574423	0.108046	27.701718	-0.324912
3	25.926578	-25.81677	25.871674	0.109808	0.127296	-0.307921

- Depth : Indicates the measured depth.
- A0 : Data measured and recorded in the A0 direction at the corresponding depth.
- A1 : Data measured and recorded in the A180 direction at the corresponding depth.
- A_MEAN : The average value of the difference between data [A0] and [A1] displacements, represents the actual amount of displacement at each point, and serves as the basis for calculating the accumulated displacement (A_SUM).

- $$\therefore A_{MEAN} = \frac{(A0 - A1)}{2}$$
- A_CS : Checksum value of data [A0] and [A1], which is an indicator of measurement accuracy.
- $$\therefore A_{CS} = (A0 + A1)$$
- A_SUM : Represents the cumulative displacement of the corresponding measurement records, calculated by accumulating A_MEAN data from the bottom (direction underground).

Ex) If the total depth is 10m, $A_{SUM} = A_{MEAN}@10m + A_{MEAN}@9.5m + A_{MEAN}@9m + \dots$

When you create a chart with A_SUM data in a spreadsheet, you end up with a "cumulative displacement graph."

- A_SUM_INIT : This is the displacement amount for the accumulated displacement from the initial value data set in the reader application. Therefore, all values appear as 0 in the initial data.

$$\therefore A_{SUM_INIT} = \text{Initial } A_{SUM} - \text{Current } A_{SUM}$$

When you create a chart with A_SUM_INIT data in a spreadsheet, it becomes a "graph of cumulative displacement versus initial value."

4. Data Concept Map

