

EN

INSTRUCTION MANUAL

Smart Inclinometer System

SI-200



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1. System Components

1-1 About Inclinometers

An inclinometer system is a survey instrument to measure displacement from inclinometer casing that installed permanently in a borehole that passes through a zone that expected suspected movement or already has. To correct surveying, it needs building and installation quality of the borehole and the casing. Displacement measurement compares its initial data, current data and latest data (right before-current). DAS inclinometer system SI-200 provides displacement that has been already calculated to millimeter distance. It does not need any secondary calculation by a factor.

1-2 System Components

An inclinometer system SI-200 includes as following:

- Inclinometer Probe
- Cable
- Bluetooth Reel
- End-cap
- Data Reader
(7inch tablet with Android OS)

Data from inclinometer probe is transmitted to the reader through the Bluetooth reel by wireless Bluetooth.

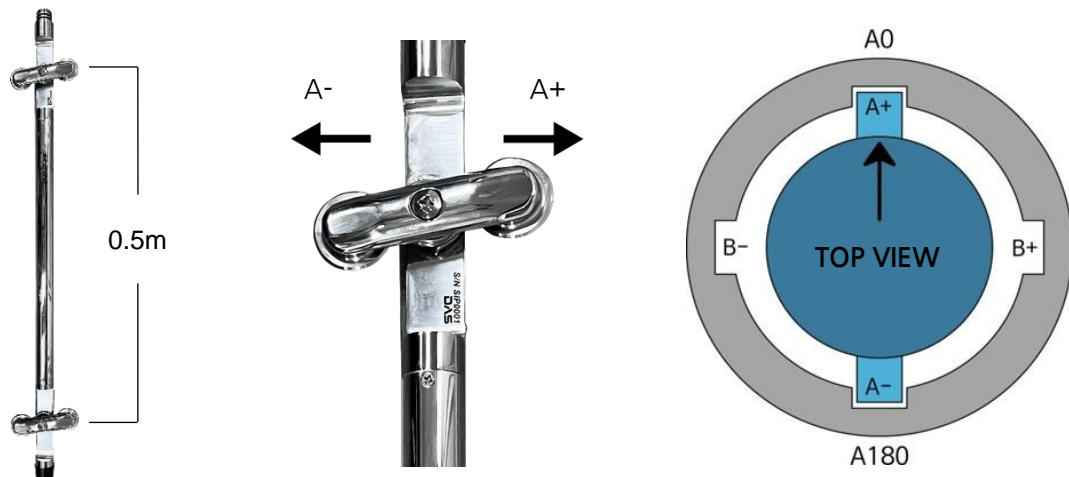


1-3 Inclinometer Probe

SI-200 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 the Probe

The inclinometer probe is a sensitive measuring instrument. Handle it with care.

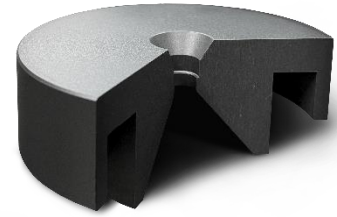
- Transport the probe in its carrying case as possible. With driving, transport the probe in its carrying case and put them into a luggage space.
- Avoid over-tightening when connecting the cable to the probe. It causes damages to the screw thread and the O-ring.
- When insert the probe into the casing, cup the wheels with hands to compress the springs and allow smooth insertion.
- When lower the probe into the borehole, do not allow it to strike the bottom.
- When withdraw the probe from the casing, cup the wheels with hands again to prevent them from snapping out.
- When rotate the probe, keep it upright and perform the rotation smoothly.
- Temperature between outside and inside of inclinometer casing may different by environment or seasons. Wait for around 10 minutes after insert the probe into the casing before start survey.
- Avoid using the probe in temperatures outside this range.

1-6 Data Cable

Data cable is used to control the depth of the inclinometer probe. And it conducts power and transmit / receive data between the probe and the reel. SI-200 data cable is made from 1-core stainless steel wire cable (with braiding shields) that designed strong for heavy weight. The cable has 0.5 meter graduations with labels every meter. The first graduation is 0.5 meters from the top wheels of the probe.

1-7 End-cap

End-cap is an assistant tool for accurate measurement. To accurate measurement, put cable graduations to the top of the end-cap during the survey. End-cap is designed for installation to both 50 and 60 millimeters of casing's internal diameter.



1-8 Bluetooth Reel

The Bluetooth reel provides a way to carry the probe and the cable. The reel transmits commands and readings between the reader and the probe. The reel includes internal Li-ion battery pack to supply power to the reel and the probe.

1-9 Front Panel

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



1-10 Power Button & Lamp

Press power switch to switch on and off. The power lamp blinks 1 time per second when power is 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 & Lamp

The Bluetooth lamp blinks 3 times per second when power is on and blinks 1 time per second when connecting Bluetooth during a survey.

1-12 Recharge Socket & Lamp

Insert the plug of the recharger into the recharge socket. The lamp glows green when the recharger is connected correctly, and it glows red while the battery is charging and glows blue when charging is finished. A full recharge takes 4 hours from fully discharged. The reel works over 25 hours from 1 charging. The reel beeps periodically when the battery charge is very low. The reel switches off automatically after 20 minutes from the first beeping without recharge.

1-13 Data Reader (Tablet PC)

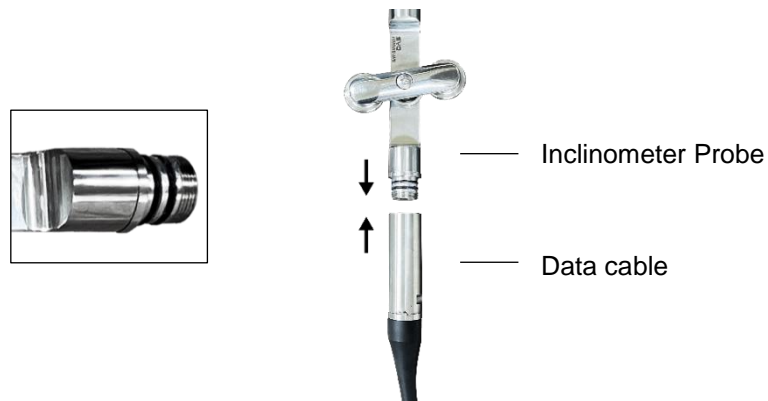
The data reader is supplied as 7in tablet PC with Android OS. A tablet PC may change without previous notice from supplier's conditions. The tablet PC supplied basically is a service part and DAS cannot guarantee any failure of the tablet PC. If it needs any repair services or technical supports, please contact the manufacturer (or supplier) of the tablet PC.

1-14 Reader App

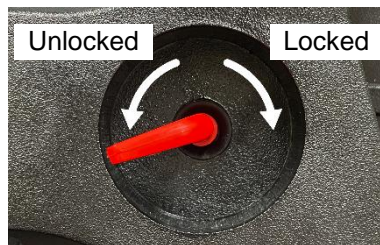
The reader application - Smart Tilt Reader is a software to operate fully Smart Inclinometer System SI-200 on a mobile device with Android OS. The application is installed on the tablet PC supplied basically and it also can be downloaded on DAS website (Downloads menu) <http://www.das-co.com>. Please notice the application may not support all Android OS device.

2. Assembling the System

1. Assemble the probe and the cable. Keep pushing them until O-rings of the probe are disappeared and rotate clockwise the probe. Do not rotate the connector of the cable. It causes damages to the cable.



2. Release counter-clockwise the locking brake to unwind the cable.



3. After measurement, remove and store in the reverse order of bonding.

3. Installing Reader App

The reader application - Smart Tilt Reader is installed on the tablet PC supplied basically and it also can be downloaded on DAS website (Downloads menu) <http://www.das-co.com>.

1. Install the application by a "File Manager" or "My Files" kind app.
(Installation File : SmartTiltReader_X.X.X.apk)
2. If "Unknown Source" kind warning is occurred, tap and go to the "Settings" Or go to the "Security Settings" on the mobile device.
3. Enable "Unknown Source".
4. Back to the installation.

4. Pairing Bluetooth Devices

To operate Smart Inclinometer System SI-200, Bluetooth pairing at the Android OS level between the reel and the data reader is necessary. The process is like pairing a Bluetooth headset and a mobile device. If the reader is changed to other device, pair it with Bluetooth again.

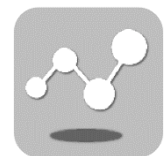
1. Switch on the Bluetooth reel.
2. Switch on the data reader (Android OS device).
3. Go to the "Bluetooth Settings".
4. Enable Bluetooth.
5. Enable "Search for devices".
6. After a short delay, it shows a list of available devices.
7. Tap the device which start with "SI-200C".
8. Enter the PIN : 0000
9. Confirm the message that the device is paired.

After the pairing, the reader connects to the reel automatically when starting a survey. Bluetooth settings may different each mobile device. contact the manufacturer (or supplier) of the device.

5. Reader App Overview

5-1 Run Reader App

Tap Smart Tilt Reader icon to open the app.



5-2 Overview

1. SURVEY

Tap to start survey. Add and manage sites and holes.

2. PLOT

Tap to show plots and data.

3. SEND

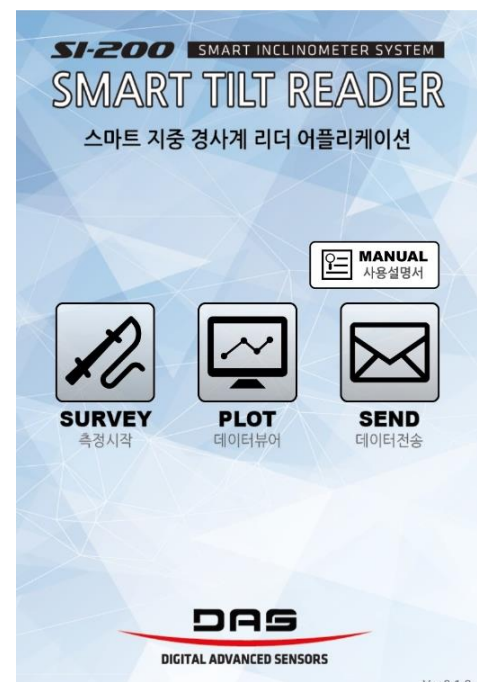
Tap to send surveys by e-mail, export to external USB storage with OTG (On the Go) or save to internal storage.

4. MANUAL

Tap to open PDF manual document.
(PDF viewer application is necessary.)

※ Back-button

Tap Back-button of Android OS to go back to previous page from any pages.



6. Survey



Tap SURVEY icon to start survey.

6-1 Site List

1. Tap this icon (on the low-right) to add a site.
2. Tap a site name to show a borehole list in the site.
3. Tap-and-hold a site name to rename or delete the site.

Test Site

Site1 Hole Count : 0 Last : 19/07/31 10:24	Site2 Hole Count : 0 Last : 19/07/31 11:34	Site3 Hole Count : 0 Last : 22/12/20 15:36	Tap to show the borehole list
Site1 Hole Count : 0 Last : 19/07/10 13:43	Site5 Hole Count : 0 Last : 19/08/06 12:31	Site6 Hole Count : 0 Last : 19/08/14 10:19	

Tap to add a site

6-2 Borehole List

1. Tap this item to add a borehole.
2. Tap this item to add a survey.
3. Tap a borehole name to open/close a survey list in the borehole.
4. Tap-and-hold a borehole name to rename, delete the borehole or move to another site.
5. Tap a survey to check the data, resume the survey or start over it again.
6. Tap-and-hold a survey to set the data as an initial or edit the survey form.

Site1	
^ 2 20190712_150633 20190718_140456 20190725_100423 20190731_102417 +	Boreholes Surveys Tap to add a Survey
v 3 v +	Tap to add a borehole

6-3 Survey Info

Special characters cannot be entered.

- **Site Name** : Shows the name of the site.
- **Hole Name** : Shows the name of the borehole.
- **Description** : Input any description or note for the site/borehole.
- **Start Direction** : Choose a direction either A0 or A180 to start the survey.
- **Units** : Fixed in metric units.
- **Displacement Unit** : Shows the unit of displacements.
- **Depth Unit** : Shows the unit of the depth.
- **Interval** : Input the interval depth of the survey by the depth unit.
- **Top Depth** : Input the top (toward the surface) depth that end-point of the survey.
- **Bottom Depth** : Input the bottom (toward underground) depth that start-point of the survey.
- **START Button** : Done input or modify and start the survey.

Add Survey

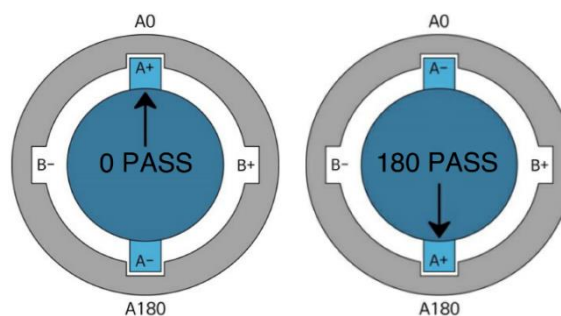
Site Name	Site1
Hole Name	1
Inclinometer	
A0 Derection	<input checked="" type="radio"/> A0 <input type="radio"/> A180
Unit	<input checked="" type="radio"/> Metric <input type="radio"/> English
Displacement Unit	mm
Depth Unit	m
Interval	0.5
Top Depth	0.5
Bottom Depth	6.0

START

7. Survey Basics

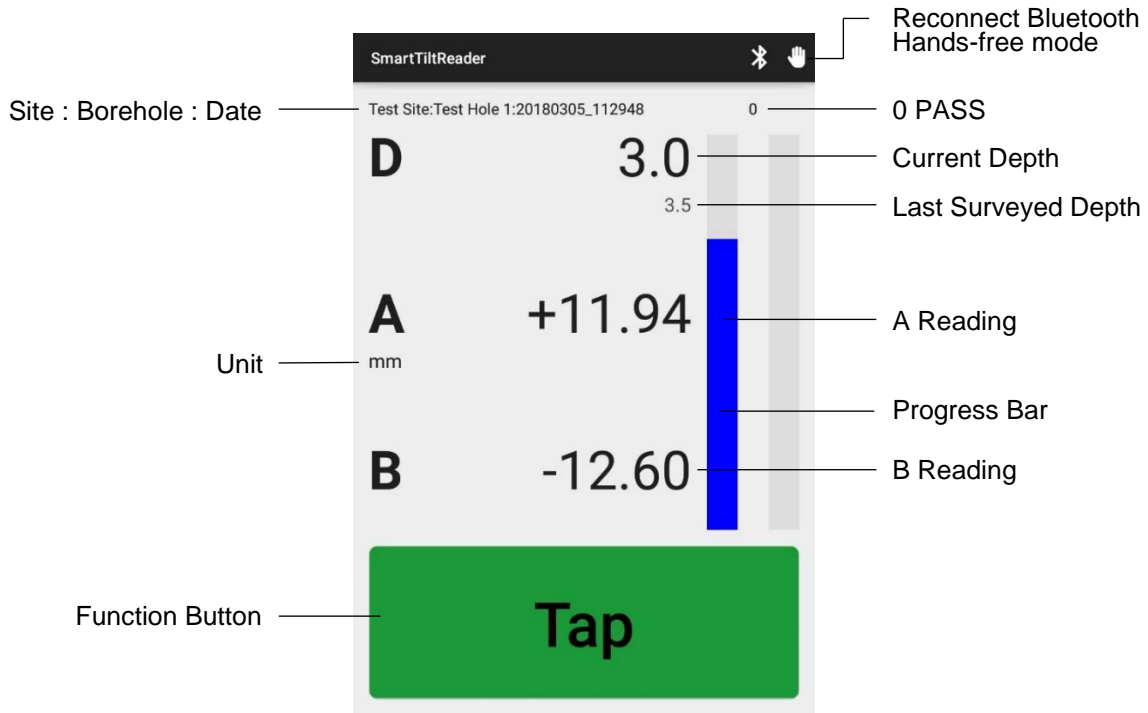
7-1 Inclinometer Surveys

During a survey, the probe is drawn from the bottom to the top of the inclinometer casing. This is called a "PASS". A complete survey consists of two passes, a 0 PASS which A+ direction of the probe towards A0 direction and a 180 PASS which A+ direction of the probe towards A180 direction.

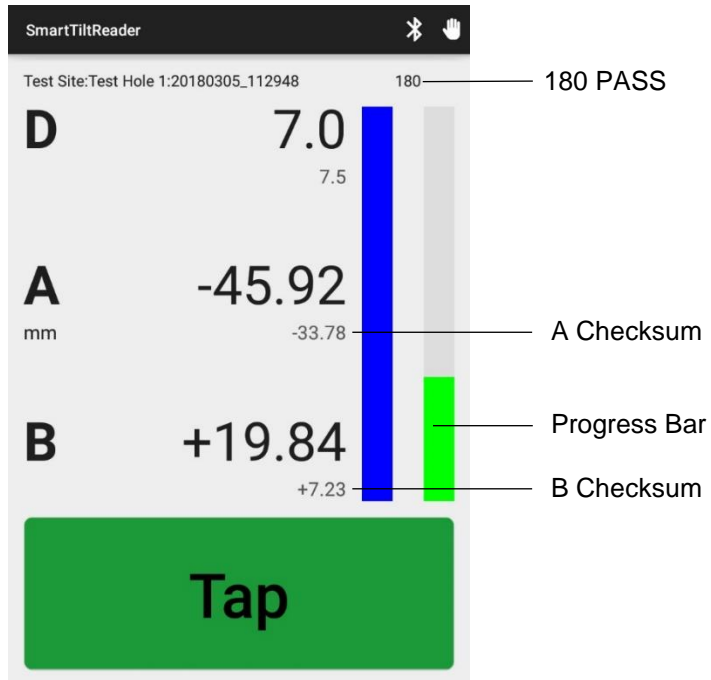


7-2 The Survey Screen

- **0 PASS Screen** : The elements of the survey screen are explained below.



- **180 PASS Screen** : The 180 PASS screen adds checksums.



7-3 Function Button

The function button has multiple colors and functions. Tap this button to operate displayed function.

Start & End

The function button is orange at the start and end of each pass.
(At 180 PASS, it shows Start 180 Pass / End 180 Pass.)



Start 0 Pass



End 0 Pass

Wait

The function button is yellow when readings are not stable. The system will record the data automatically when reading is stable.



Wait

Tap or Pull

The function button is green when readings are ready to record. Tap the button or pull the cable (hands-free mode) to record the readings. The button cannot be tapped on hands-free mode.



Tap



Pull

OK

Tap OK button to resume the survey when the survey is stopped by a connection problem, changing depth, resuming an interrupted survey or etc.



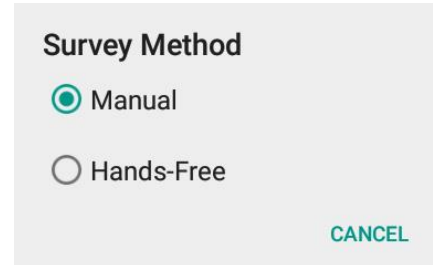
OK

7-4 Hands-free mode

Tap the hands-free mode icon to change survey mode.



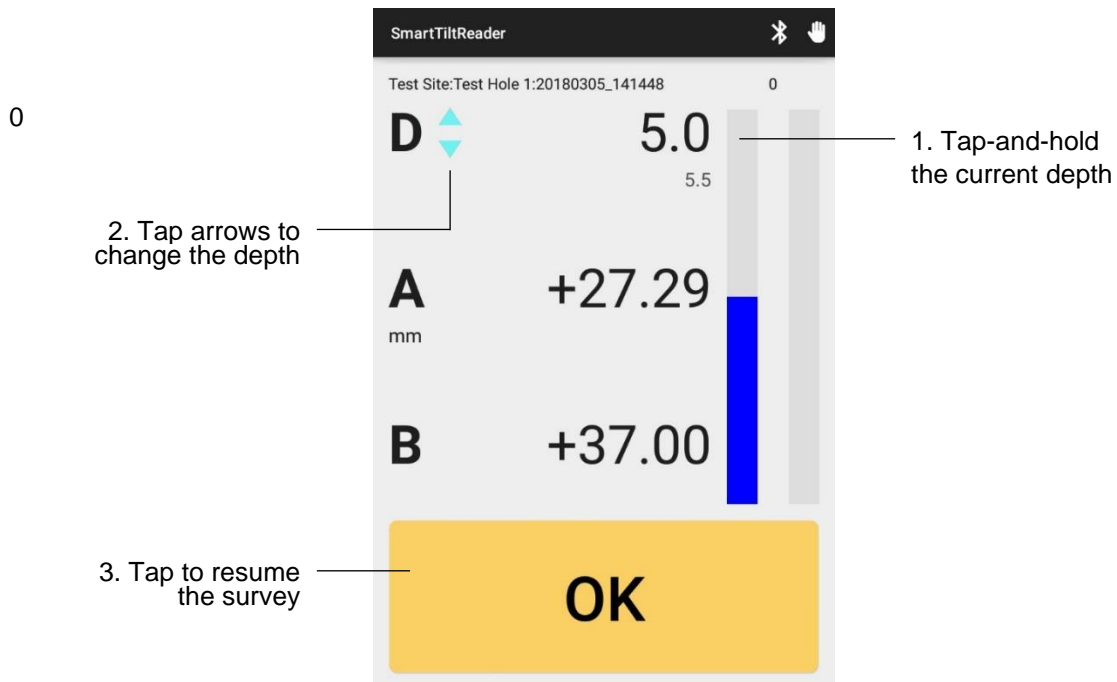
In Hands-free mode, system automatically records the readings when pull the cable (pull the probe) without any tapping the button during the survey. Hands-free mode is recommended to an expert as hands-free mode may get less accurate data than manual mode relatively.



7-5 Changing Current Depth

If cable depth and the current depth get out of sync :

1. Tap-and-hold the current depth until arrows appear.
2. Tap the arrow to change the depth.
3. Move the probe to the new depth. (Synchronize cable depth and the changed depth)
4. Tap OK button to resume the survey. The new readings overwrite the previous readings.



7-6 Interrupting a Survey

Tap BACK button of the mobile device to call the Exit Survey-dialog during a survey.

- **Abort** : Deletes the current survey and interrupts. The survey name in a borehole list won't be deleted.
- **Bookmark** : Sets a bookmark at the last recorded reading and interrupts. A bookmarked survey can be resumed later.
- **Done** : Saves the current survey as is. This is useful to correcting a few readings and stop. This cannot be resumed later because a "Done" survey is saved as a complete survey.

7-7 Resuming an Interrupted Survey

A bookmarked survey can be resumed later. If a survey has a bookmark, the bookmark lets the survey resume from the last recorded depth.

- **Use Bookmark** : Resume the survey from the last recorded depth.
- **New** : Abandon the bookmarked survey and start new.

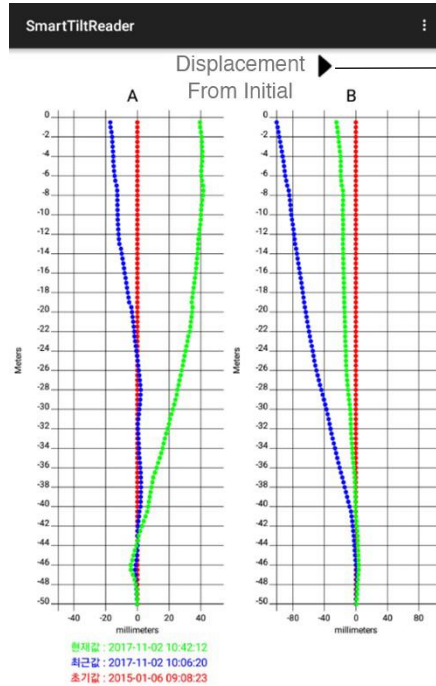
8. Plotting Inclinometer Surveys

Tap PLOT icon to display plots and tables for validating the survey. Choose the data as same way on the Survey menu.



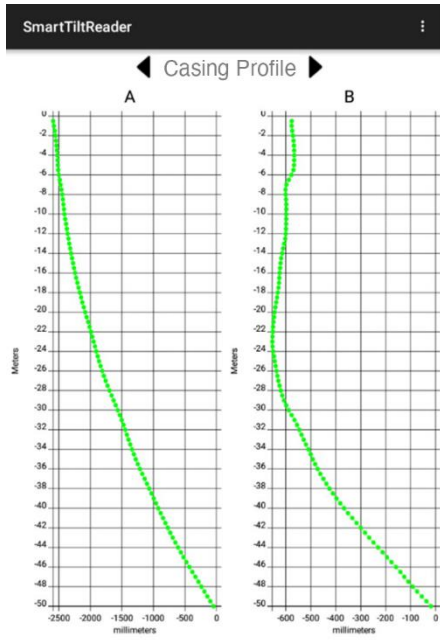
8-1 Move the Screen

Tap left or right arrow beside titles to move the screen.



Tap left or right arrow to move the screen

1. Displacement from Initial : Initial value is the origin(0) of the plot.
2. Casing Profile : Plot by surveyed raw values for validating the shape of the inclinometer casing.
3. Data Table : Show a data table. This table is same as .csv file which is sent or exported by Sending Data functions.



The figure shows the 'Data Table' interface in SmartTiltReader. It includes site information and a data table.

Site Information:

- SiteName: 다스 시내 천공
- HoleName: 다스2홀 (60)
- CreatedTimeStamp: 1.5095869E12
- SurveyName: 20171102_104212
- Init SurveyName: 20150106_090823
- Description:
- A0 Direction: 0.0
- Units: METER
- Display Unit: mm
- Depth Unit: m
- Interval: 0.5
- Top Depth: 0.5
- Bottom Depth: 50.0
- Bookmark: true
- PhaseState: FIRST_PHASE

Depth	A0	A1	A_MEAN	A_CS	A_SUM	A_SUM_INIT	B0
-0.5	-14.417039	13.181817	-13.799428	-1.235222	2592.1921	39.515526	-0.07155
-1.0	-12.842465	11.954366	-12.398416	-0.888099	2578.3928	39.627197	-2.80298
-1.5	-11.211056	10.233896	-10.722476	-0.977159	2565.9944	40.111397	-3.47055
-2.0	-9.719126	8.17214	-8.945633	-1.546986	2555.272	40.629665	-2.61885
-2.5	-8.52203	6.931353	-7.726692	-1.590677	2546.3264	40.726086	-1.98792
-3.0	-7.58491	5.995935	-6.790422	-1.588975	2538.5996	40.822207	-1.28805
-3.5	-7.199234	5.56923	-6.384232	-1.630004	2531.809	40.996593	-0.42149
-4.0	-5.266434	3.337917	-4.302176	-1.928516	2525.425	41.13883	-0.00261
-4.5	-4.022068	3.489758	-3.755913	-0.53231	2521.1228	40.927654	0.437201
-5.0	-6.445322	5.723682	-6.084502	-0.72164	2517.367	40.58951	2.58133
-5.5	-10.962407	9.99309	-10.477749	-0.969317	2511.2825	40.371807	7.726264
-6.0	-14.231238	13.414736	-13.822987	-0.816502	2500.8047	40.35524	10.47201
-6.5	-14.159708	13.318777	-13.799243	-0.840931	2486.9617	40.822395	9.12233
-7.0	-14.658665	13.418223	-14.038445	-1.24044	2473.2424	41.421707	2.874541
-7.5	-13.19403	11.645529	-12.41978	-1.548501	2459.2039	41.678173	-1.14406
-8.0	-10.491277	8.984471	-9.737874	-1.506805	2446.7842	41.3602	-1.97919
-8.5	-8.501962	6.98458	-7.743271	-1.517381	2437.0464	40.969765	-1.89978

8-2 Screenshot

Capture the screen (plots) to save an image file. Captured file path : Android Internal Storage > Documents > SmartTiltReader > ScreenShot

8-3 Checksum

Checksums are the sum of the 0 PASS and 180 PASS readings at each depth. Technically the verticality from the earth and the verticality of the probe cannot be exact same. That's the reason the inclinometer system uses checksums for. The ideal checksum is 0 (zero-sum). In practice, checksums are typically some small non-zero value by human errors, technical tolerances, moving of the probe in an inclinometer casing etc. If any rapid change of the checksum is occurred, the probe, surveying or installation quality of the casing may have a problem or needs to be checked there is any construction activities causes displacements near the site such as blasting, excavating.

8-4 Initial

An initial value is automatically set as the first surveyed data in the borehole. If necessary, another survey in the borehole can be set as the initial value. This plot uses values that minus initial values from each value to shows the change in profile. This plot does not show actual profile of the casing.

8-5 Latest

A latest value is the data surveyed right before in the borehole. (If surveys 4 times, the 3rd survey is the latest value and the 4th survey is the current value.)

8-6 Current

A current value is the data surveyed at last (or surveyed now).

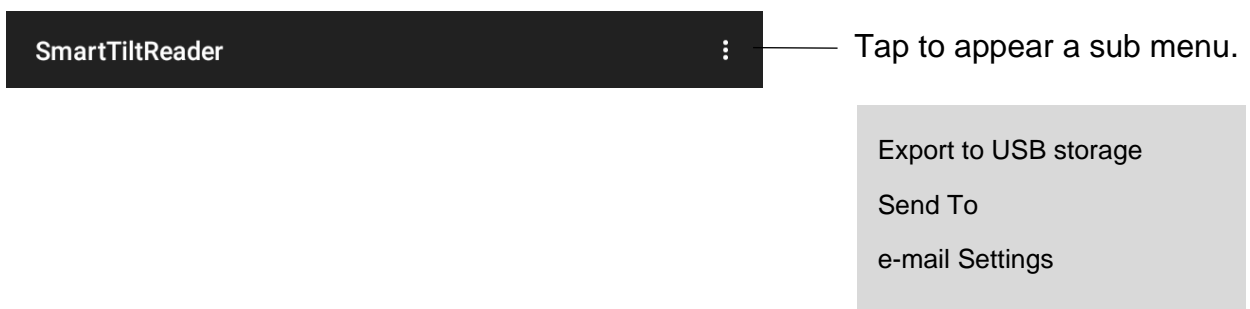
9. Sending Data

Tap the SEND icon to send or export data. Data can be exported to external USB storage, saved to internal storage or emailed.



9-1 Exporting to External USB Storage

1. Data is exported by a unit of a site.
2. Tap and choose the site on the list to export.
3. Connect an external USB storage to the USB port (Micro USB-B or USB-C) of the reader. If the USB drive is USB type-A, accessories like OTG cable may necessary.
4. Tap Export to USB storage to export.
5. Export data of all boreholes and surveys in the chosen site.



9-2 Send to

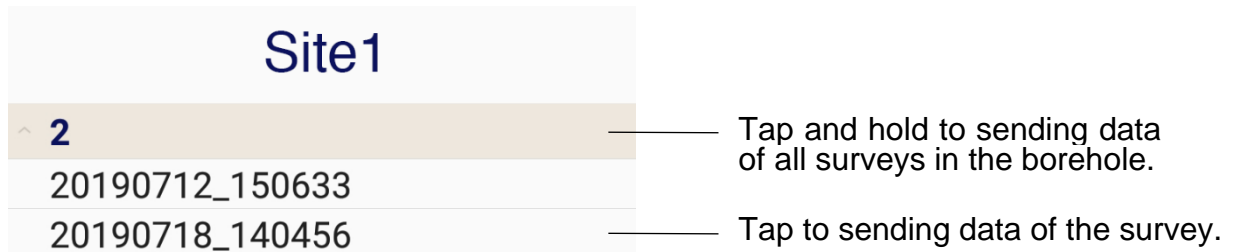
1. Tap SEND TO choose to save to internal storage or send by e-mail.
2. e-mail : Send data in the chosen borehole(s) to the address.
3. Internal Storage : Save data in the chosen borehole(s) in the internal storage. Saving path : Android Internal Storage > Documents > SmartTiltReader > Result.

9-3 E-mail Address List

1. To sending data by e-mail, e-mail address list is necessary.
2. Tap e-mail Settings.
3. Add valid e-mail address to the list.
4. Tap OK to save the list.
5. The address list is automatically input as address when sending the e-mail.

9-4 Choosing Data

1. Data is sent by a unit of a borehole.
2. Tap and choose the site on the list.
3. Tap and hold a borehole name to sending data of all surveys in the chosen borehole.
4. Tap a survey to sending data of the chosen survey.



9-5 E-mail App Setting

At the first time to sending data by e-mail, settings of e-mail app are necessary.

1. Choose data to sending.
2. At the first time to sending by e-mail, Android OS default app settings dialog appears.
3. Choose an e-mail application such as E-mail or Gmail.
4. Input account information of e-mail to use.
5. Sending an e-mail screen appears after complete input information.
If account information is already input, step 2-4 will be skipped.
6. To clear account information, go to the settings of the device and clear application data and cache.
7. To change e-mail application, go to the settings of the device, clear setting of default application for e-mail and go back to step 1.

9-6 Notes

- Sending e-mail requires a mobile internet (Wi-Fi, Hotspot, CDMA, LTE or etc.) connection.
- Sent data file has .csv (Comma-Separated Values) extension. The data file can be opened in a spreadsheet (such as MS Excel) or Notepad program on a PC.
- Accessories such as OTG cable, USB flash drive are not provided by default.
- To access an e-mail account by an e-mail application, IMAP4 or POP3 settings is necessary on the account. If necessary, contact the e-mail provider.
- E-mail or application settings may different each mobile devices. If necessary, contact the manufacturer (or supplier) of the device.

10. MAINTENANCE

10.1 Inclinometer Probe

- If wheel does not turn freely, clean the wheel and lubricate wheel bearings with light machine oil. Do not use WD-40 or any other spray that contains chlorinated solvents.
- If spring of the wheel assembly does not return to fully extended position, clean the wheel assembly and the spring. If problem persists, repairing wheel assembly may necessary.
- Lubricate regularly with O-ring lube or silicone-based grease to smoothen assembly of the probe and the cable and protect O-rings. Do not use WD-40 or any other spray that contains chlorinated solvents.
- Replace O-ring if flattened or split.
- Store probe in dry place with it carrying case. Clean the probe before store if necessary.
- Do not use electrical contact cleaners or sprays.

10.2 Cable

- Check any damages of the cable before use. Damages cause lower tensile strength of the cable. If there any damages of the cable, repair the cable immediately otherwise may losing the probe in an inclinometer casing during a survey.
- Avoid any sharp materials or edges of surfaces. It causes damages of the cable.
- Avoid pulling with twists of the cable. It causes damages of the core wire.
- Wipe off the cable after use. Do not use WD-40 or any other spray that contains chlorinated solvents. It may cause lower strength and durability of the cable.

10.3 Bluetooth Reel, Date Reader and Others

- Clean and wipe off after use and store in dry place.
- (use only for End-cap if necessary.)
- Check frequently state-of-charge of batteries of the reel and the reader.

11. Warranty

- 12 months warranty is provided after released.
- Warranty provided only in case of using for designed purpose correctly.
- Warranty provided only for malfunctions, defects or design deficiencies of the product during the warranty period.
- The manufacturer has not any responsibilities for not manufacturing products such as a mobile device as data reader.

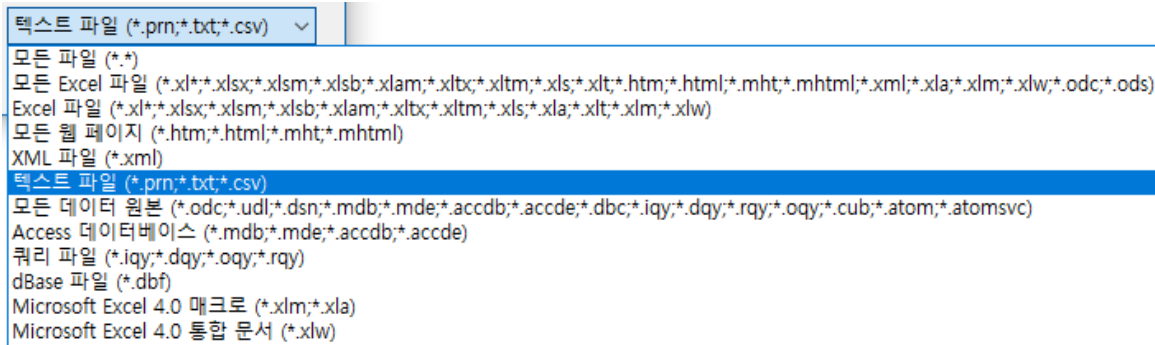
- Damaged by any kind of natural disaster, user's carelessness, abnormal power sources, disassembling or converting the product or in case of warranty termination is excluded from this warranty.
- ※ All data in this manual are owned by DAS Co., Ltd., and may not be reproduced, modified or redistributed without permission.

*A-1. Data File Descriptions

Data file that exported, saved or sent by the app can be opened in a spreadsheet program (such as MS Excel) on a PC.

1. Open file

Data file is .csv (Comma-Separated Values) extension file. Double-click a file to open or click Open files to open a file on the program. (MS Excel ; Change the option as below if the file is not appeared on the file list.)



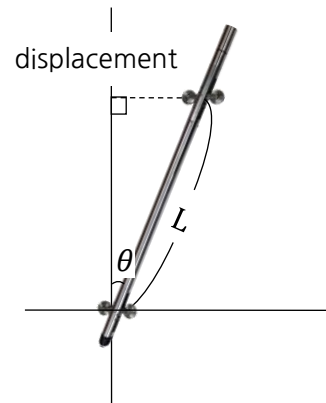
2. Data Unit

All data in data file means displacements (as distances) by the unit of mm (millimeter).

- Formula to converting angular to displacement.

$$\sin \theta = \frac{\text{displacement}}{L}$$

※L = 500mm (gauge length), θ = angular data



∴ **displacement = 500mm · sin θ**

3. Data Descriptions

The data table as below is for A-axis. (for B-axis is equally same.)

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** : Depth of each recorded data.
- **A0** : Recorded data of A0 direction at each depths.
- **A1** : Recorded data of A1 direction at each depths.
- **A_MEAN** : Actual displacement at each depths. A_MEAN is a basis of calculating A_SUM.

$$\therefore A_{MEAN} = \frac{(A0 - A1)}{2}$$

- **A_CS** : Checksum of A0 and A1. Checksum is a barometer that denotes a measuring accuracy.

$$\therefore A_{CS} = (A0 + A1)$$

- **A_SUM** : Accumulated displacement of recorded data. A_SUM is accumulation by A_MEAN.

e. g.) at total depth is 10 meters, $A_{SUM} = A_{MEAN}@10m + A_{MEAN}@9.5m + A_{MEAN}@9m + \dots$

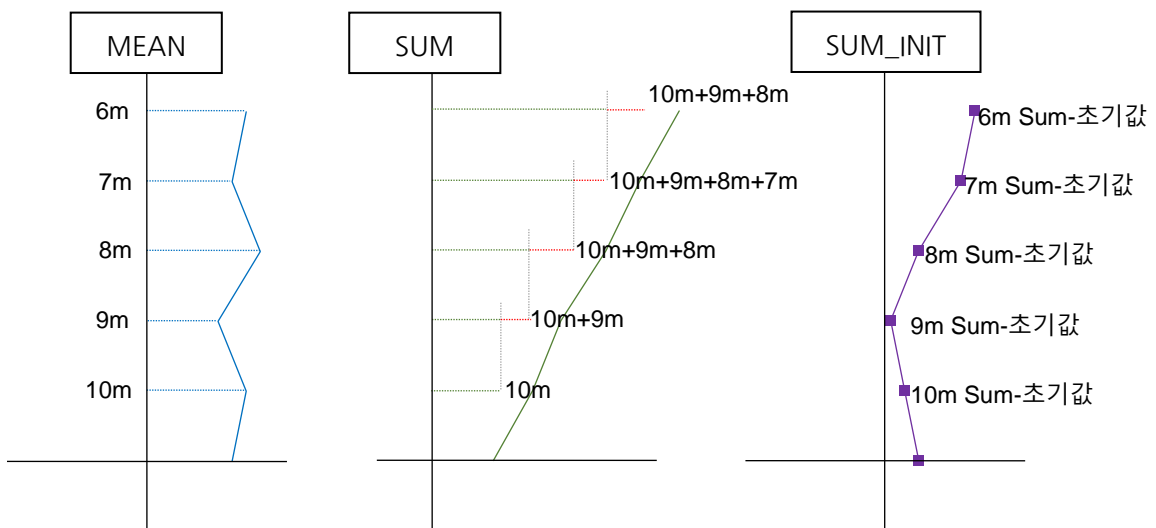
A chart as displacement from initial in plotting menu is built from A_SUM_INIT data.

- **A_SUM_INIT** : Accumulated displacement from Initial Value set on the app. At a data table of initial value, A_SUM_INIT is always zero(0).

$$\therefore A_{SUM_INIT} = A_{SUM\ of\ initial\ value} - current\ A_{SUM}$$

A chart as displacement from initial in plotting menu is built from A_SUM_INIT data.

4. Date Concept



A-2. Run-Through

Before operating the system as RUN-THROUGH, be well-acquainted with whole instruction manual.

1. Turn on power of the reel and the reader. And check Bluetooth pairing. Refer to **4. Pairing Bluetooth Device**.
2. Connect the probe and cable. If possible, install End-cap on top of the casing.
3. Run the app and tap SURVEY to start survey.



4. Choose or add a new site and a borehole. Input a survey info and tap START. Refer to **6. Survey**



5. Insert the probe for A0 direction into the lowest of the casing.

6. Tap Start 0 Pass to start the survey.



7. Pull the cable as each 0.5 meters and tap **Tap** button to record the data.



8. Repeat surveying to the top of the casing.

9. End 0 Pass button is appeared when finish surveying 0 PASS. Rotate the probe for A180 direction and insert the probe again.



10. Wait button may appear if vibrations or any instabilities are occurred in the casing or underground. The probe stands by until the casing is stable. Refer to **7. Survey Basics**.



11. Tap End 180 Pass to complete the survey. Start other surveys or go back to the start-up screen.



★ Refer to each content in the manual for other things to operate the system. ★