CGEO INTERNATIONAL LIMITED

Model CGEO-IPIA /IPIB /IPID
MEMS In-place Inclinometer
Instruction Manual

（REV A）

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1. <u>INTRODUCTION</u>

The Model CGEO-IPIA /IPIB /IPID MEMS Horizontal In-Place Inclinometer system is designed for long-term monitoring of differential settlements beneath structures such as dams, landfills, embankments, storage tanks and the like. The basic principle is the utilization of tilt sensors to make accurate measurement of inclination, over segments, in boreholes drilled into the structure being studied. The continuous nature of the instrument allows for very precise measurement of changes in the borehole profile to be measured. The instrument is installed in standard grooved inclinometer casing.

CGEO-IPIA /IPIB /IPID MEMS Horizontal In-Place Inclinometer system is installed in Φ 70mm～80mm standard grooved inclinometer casing. Every inclinometer casing can install 12 pieces of instruments (the number is un-limited if changing the cable layout manner) and connecting through wheel assembly and joint casing, see the figure 1.

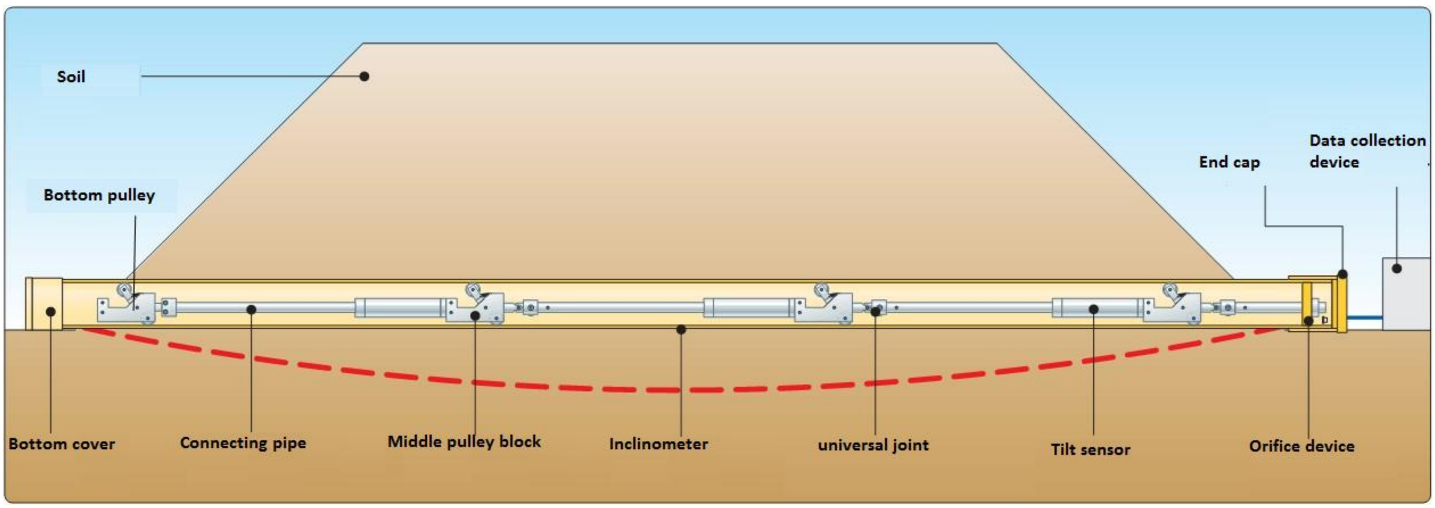

Figure 1-1 CGEO-IPIA /IPIB /IPID In-Place inclinometer horizontal installation diagram

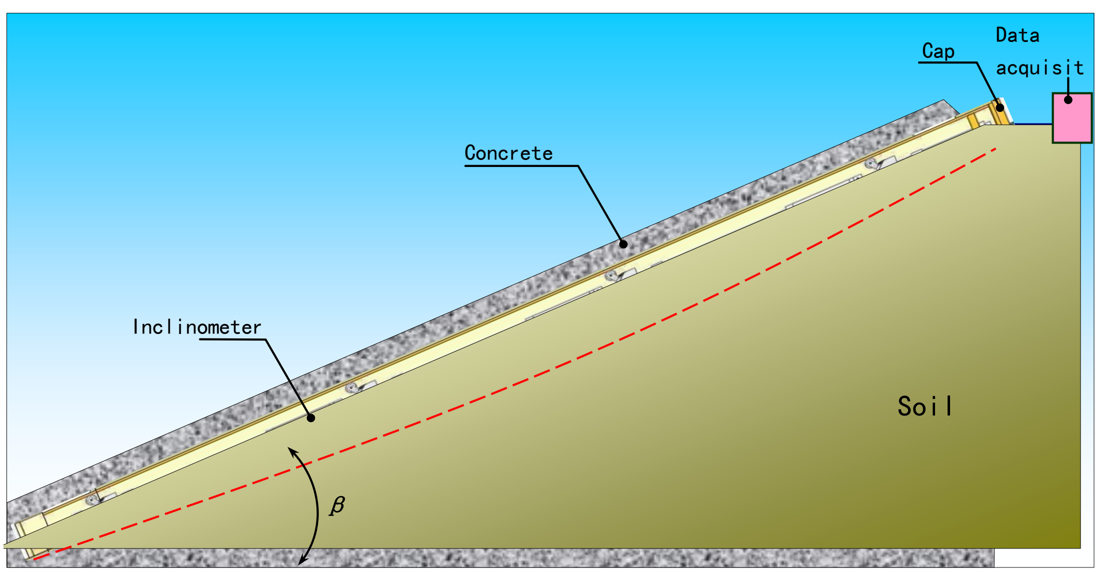

Figure 1-2 CGEO-IPIA /IPIB /IPID In-Place inclinometer slope installation diagram

In addition , also provide the In-Place Inclinometer installed in the slopes, which is derived from the Horizontal In-Place Inclinometer(the range is 0° ±10°), the inclinometer should lean to a preset angle β as a initial position (that is, β ±10°), basing on the obliquity as a standard to measure. The obliquity is provided by customers and customized, marked the installation angle behind the transducer model, like CGEO-IPIA /IPIB /IPID(35°), representing the transducer installation angle is 35 degree.

2. In-Place Inclinometer composition

2.1 CGEO-IPIA /IPIB /IPID MEMS model inclinometer transducer

The transducer is the core parts of In-Place 4 Inclinometer transducers including Micro-Electrical-Mechanical-Sensor, signal converter board and conductor packed in a sealed housing. There are two mounting holes used for the connection to the wheel assembly on a section of connecting plate on the transducer housing and the threaded hole on the bottom of transducer used for the installation of the wedge expansion plug so as to connection with the connecting tube.

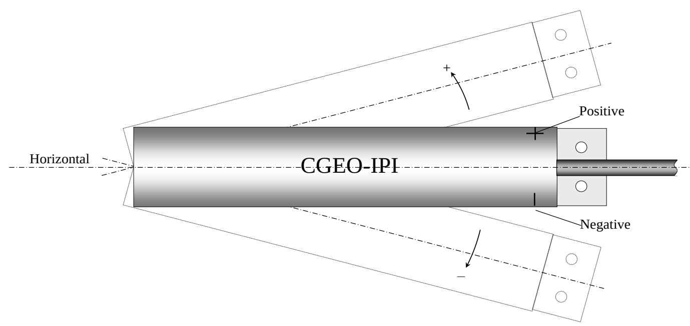

Figure 2-1 CGEO-IPIA /IPIB /IPID Horizontal In-Place Inclinometer Transducer

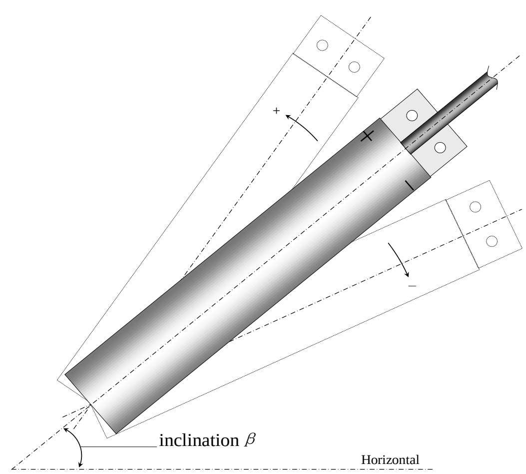

Figure2-2 CGEO-IPIA /IPIB /IPID Slope In-Place Inclinometer transducer

There are marks “＋” and “-” on the end of transducer near to the cable, when the transducer is in a level condition , the output reading should be near to 0. For the slope In-place inclinometer， output reading should be near to 0 when its initial position in the customized β slope, see figure 2-2.

The standard 8 core cable is used for the transducer’s power supply, the output of tilt and temperature signals.

2.2 CGEO-IPIA /IPIB /IPID MEMS In-Place inclinometer composition

1）Inclinometer transducer

The standard CGEO-IPIA /IPIB /IPID Horizontal In-Place transducer has a threaded hole on the its bottom, mounted a wedged connection parts, which is also possibly not mounted and placed in fitting parts package.

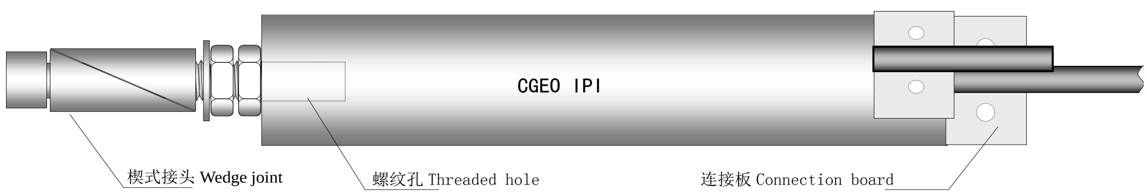

Figure 2-3 CGEO-IPIA /IPIB /IPID inclinometer transducer shape

2）middle wheel assembly

Shown as in the figure, the middle wheel assembly consists of the wheel brackets, stationary wheel, spring load wheel, the universal joint rotatable in axis direction and wedge-shaped expansion joint.

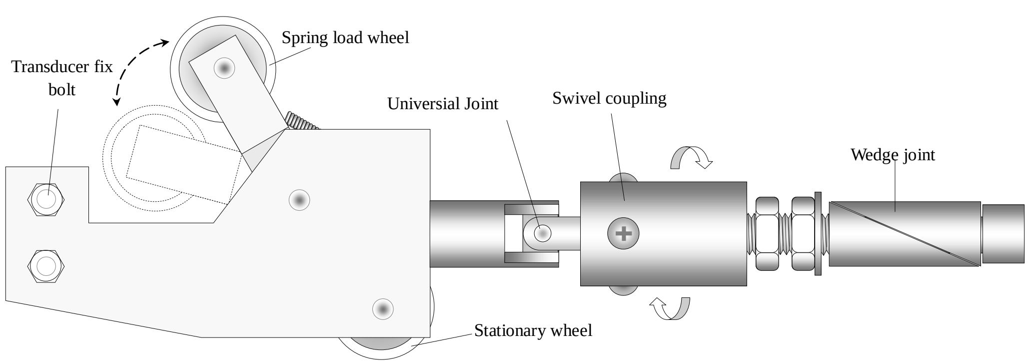

Figure 2-4 middle wheel assembly structure

The middle wheel assembly bottom has two mounting holes used for connecting the slope transducer, the top wedge-shaped expansion joint used for connecting with the tube. The middle wheel assembly and the slope transducer are used in pair so the number of both is same. The wheel assembly has a stationary wheel and spring load wheel, the spring load wheel is used for its locating inside inclinometer casing, the stationary wheel is adown and the spring load wheel is upwards.

The end of the wheel assembly is installed a universal joint and swivel coupling which accommodate any spiraling of the casing, and prevents the wheel assemblies from running out of the casing grooves.

3）Bottom wheel assembly

The bottom wheel assembly is used for installing in the end (hole bottom), is same as the middle wheel assembly except without universal coupling and is not used in place of middle wheel assembly .

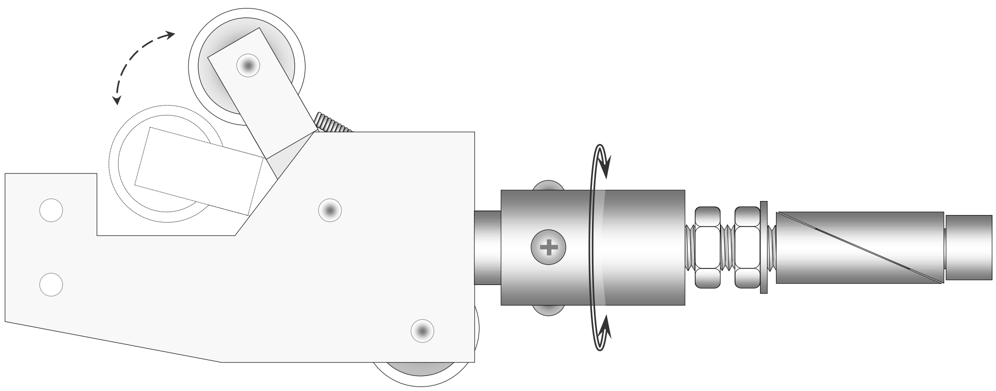

Figure 2-5 Bottom wheel assembly structure

Every group of Horizontal In-Place Inclinometer only configures one bottom wheel assembly.

4) Orifice fix component

The orifice fix component is installed in the orifice of the inclinometer casing and connected with the nearest middle wheel assembly, its function is to prevent the whole in-place inclinometer system to sliding to the hole bottom. The orifice fix component is suit to the inclinometer casing of diameter 58-86mm.

The orifice fix component consists of the wedge-shaped coupling used for connection, orifice pendent and suspension link. Every Horizontal In-place inclinometer system is configured one set of orifice fix component.

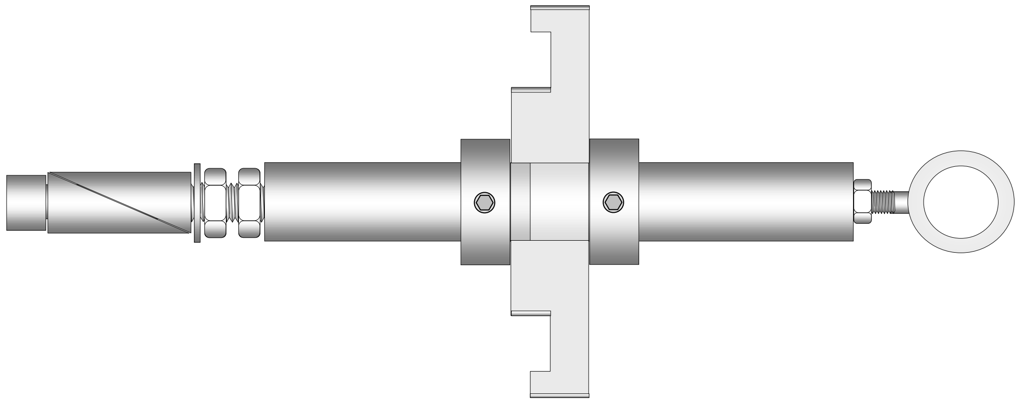

Figure 2-6 orifice pendant and fix component

5）Tubing

The tubing is special stainless steel tube of diameter 20mm and the standard length 2m and also configured shorter tubing basing on the length customers ordered.

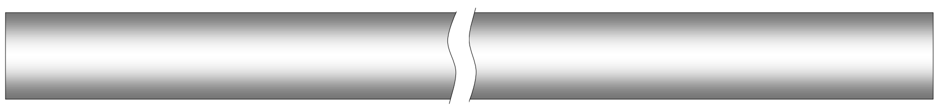

Figure 2-7 tubing

In field sometimes need to make some fine adjustment basing on the actual length, so normally the configured connecting tubing length has some surplus and need to cut some in field.

6）Wedge-shaped coupling

There are kinds of wedge-shaped couplings, one end connecting and two ends of connecting respectively. The one end of wedge-shaped coupling is normally installed in transducer, wheel assembly and orifice fix component but the two ends of coupling is used for lengthening the tubing.

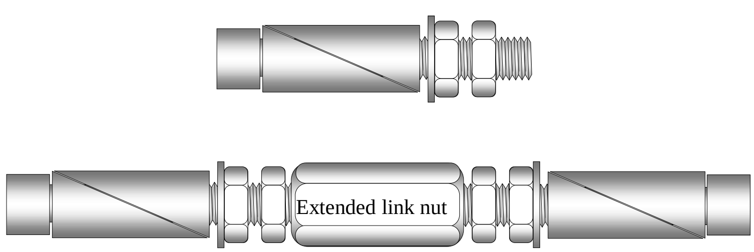

Figure 2-8 one direction and double directions coupling

The wedge-shaped coupling consists of connecting threaded rod, wedge-shaped expansion tube, locknut, plain cushion and extended connecting threaded rod. A qualified wedge-shaped coupling can bear not less than 500kg weight

7) Inclinometer casing (optional)

The inclinometer casing is not included in the components of Horizontal In-Place inclinometer system but purchased by customers. There are several types of inclinometer casing, glass fiber, like aluminum alloy, ABS engineering plastics and PVC basing on their materials. Thereamong, the functions of the glass fiber inclinometer casing is best, its pressure-resistance and corrosion resistance is good. They have the diameter 60mm, 70mm, 80mm and other specifications, the CGEO-IPIA /IPIB /IPID model is best suit to install inside ϕ70mm and 80mm inclinometer casing which has the vertical pair of grooves. The installation of the Horizontal In-Place Inclinometer requires only one of pairs of grooves plane locates in vertical direction.

3. Installation

3.1 Preparing for installation

Installation tools: 2 pieces of small pipe clamp, 2 pieces of fixed wrench of mouth breadth 16mm, Hacksaw, rasp and the tools and materials required for the connection of inclinometer casing, these tools are self-provided by customers.

3.2 Use of connection parts and installation essentials

The wedge-shaped expansion joint is to use of wedge-shaped expansion tube to connect with the tube and consists of threaded bolt, a pair of wedge-shaped expansion tube, plain cushion and two nuts. Under any circumstance must the expansion end connect with the connecting tube in the installation of wedge-shaped expansion joint and then connect the threaded end with other related parts after fixed. Shown as the figure below, first adjust wedge-shaped expansion joint and insert in the connecting tube, note to place the plain cushion correctly.

Insert the nut close to the connecting tube end and screw down with hand, stick the connecting tube with a pipe clamp and screw down the nut close to the connecting tube end with a spanner (recommend to use a thin bayonet fixed spanner).The connection strength of a qualified connection between the wedge-shaped expansion joint and connecting tube can bear not less than 500kg pull.

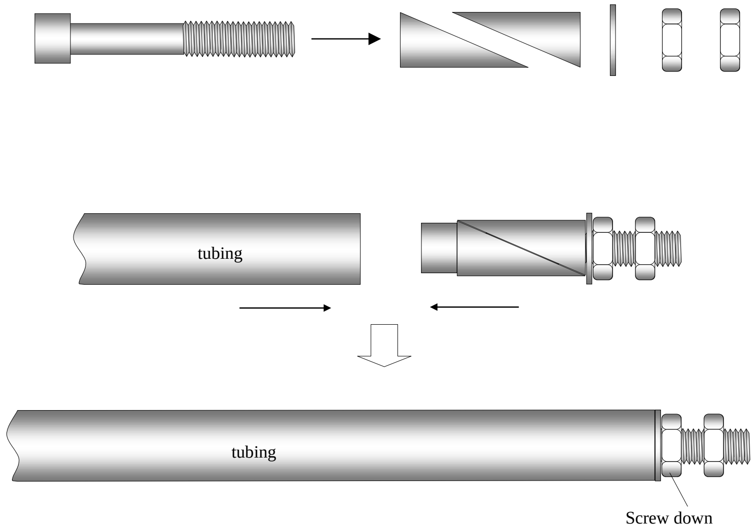

Figure 3-1 connection between connector and connecting tubing

After completion of the expansion end connection, screw a nut of thread end into the connecting end, screw the thread part into a transducer or similar parts(like middle wheel assembly, middle joint, orifice fix parts etc), screw down the nut of thread end to the connected end direction with a spanner to lock out the thread rod. Note to not touch the nut in the connecting end during screwing the nut, that is, avoid loosing the nut of connecting end.

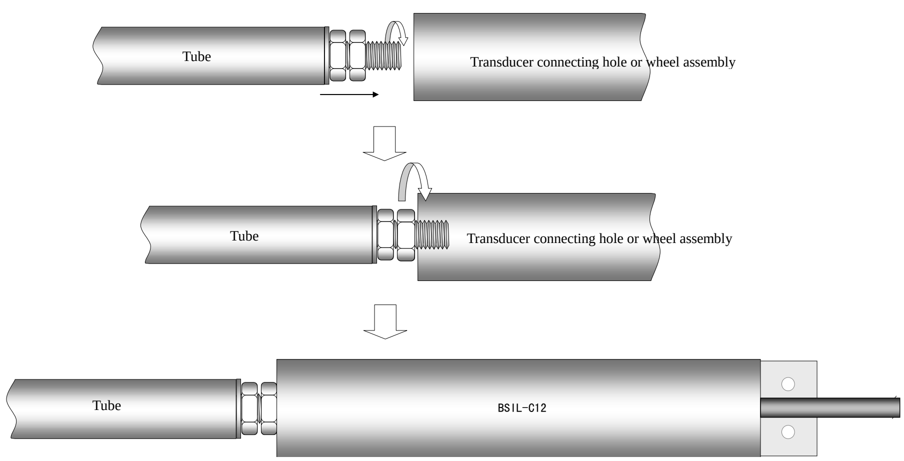

Figure 3-2 connection of the connecting tubing and transducer

As to the double end joint connection, first connect expansion end and then thread end, see the figure below

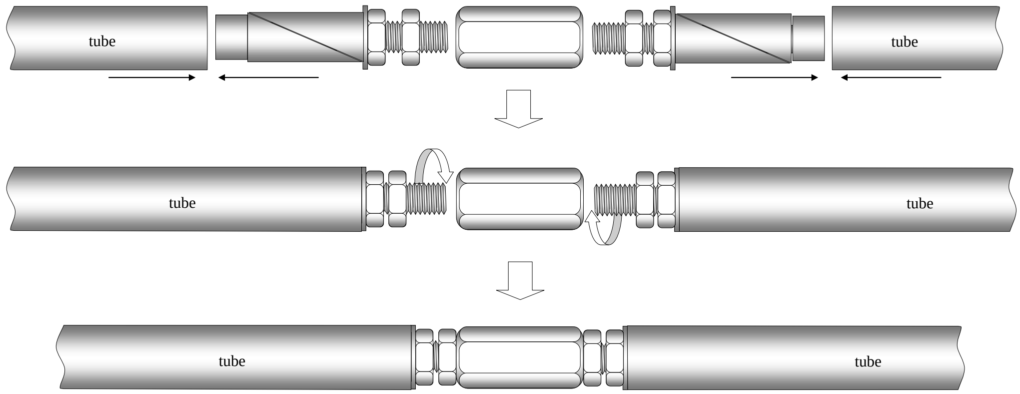

Figure 3-3 connection extension of connecting tubing

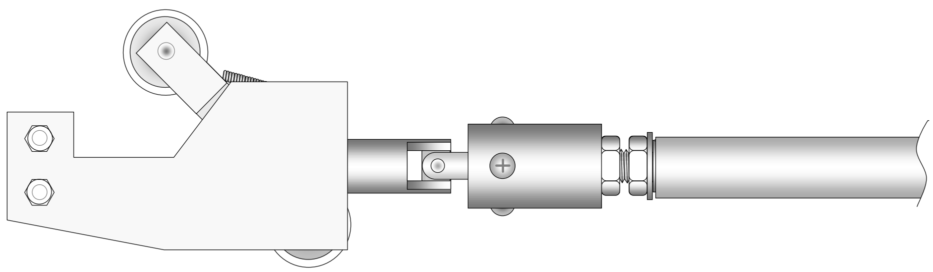

Figure 3-4 connection between the connecting rod and wheel assembly

3.3 Installation steps

The installation of the Horizontal In-Place Inclinometer and inclinometer casing are simultaneously carried out, the installation zone is preserved in installation profile and should be compacted to dense and maintained smooth. Installing in the rockfill zone, transition material bedding layers and the coarse sand bedding should be set.

The installation of inclinometer casing starts from the deepest end, the tubing cap should be put on the end. Some quantity of compression space should be reserved in the connection of inclinometer casing, the connection of the inclinometer casing depends on its materials (riveting or bonding).The first end is generally installed 8 m length and then assemble the inclinometer.

The in-place inclinometer should start from the bottom wheel, connect with corresponding connector and tube, while connecting first transducer, determine the central distance between two neighboring wheels basing on the design size, cut the surplus tube with a hacksaw, rasp the orifice burrs and connect the transducer and wheel assembly.

When completing the connection of the two neighboring wheel assemblies, you should measure the central distance between two wheels and record the length L, shown as in the figure below, the distance L will be a important parameter to this position inclinometer calculation.

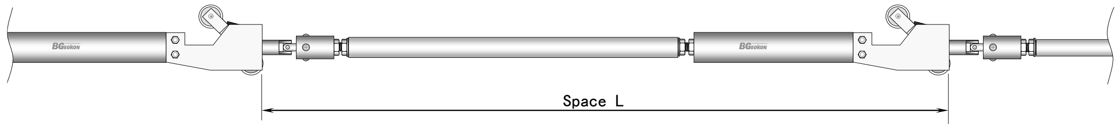

Figure 4-1 size determination of the installation space

Note the installation direction when installing the transducer, keep the spring load wheel and the plus mark “+” on the transducer in same direction, that is, keep the positive direction of the transducer upwards and fix with a bolt lastly.

After completing the first section of installation, push the wheel assembly and transducer into the inclinometer casing and keep the stationary wheel on the wheel assembly adown, that is, maintain same direction.

The rest installation is first to install in-place inclinometer components and then set into the inclinometer casing.

All instruments cable should be marked well, including transducer series number, cable length, and same time record the instrument position, installation depth, space L and other relative data.

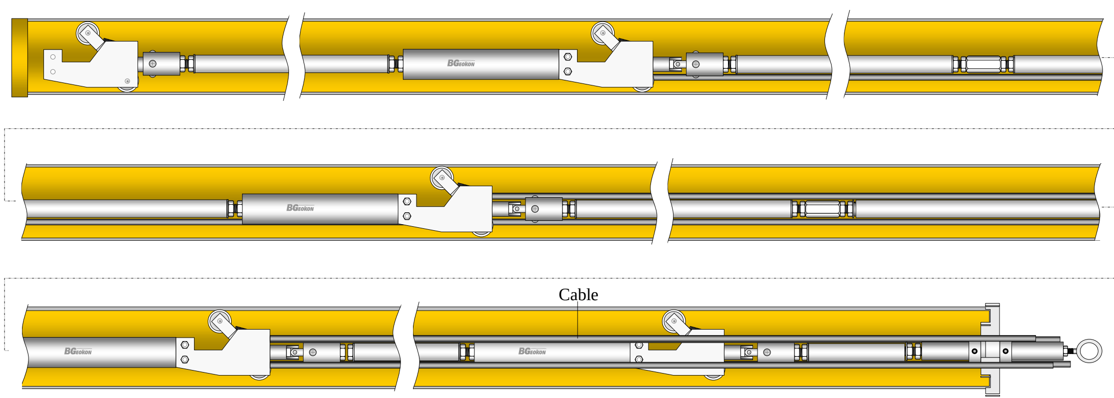

Figure 4-2 CGEO-IPIA /IPIB /IPID whole structure diagram of horizontal in-place inclinometer

Cable route: all instrument cable should be parallel routed, more than two cables should wrapped onto the connecting tube, prevent from crossing and avoid occupying too much space. Recommend to use nylon ties to tie the cables, the space not more than 1m. The cable should reserve some bending and tensile surplus whole passing the universal joint in case the cable breakage because of deformation.

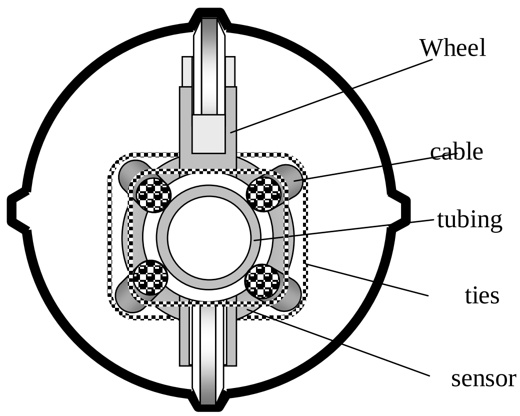

Figure 4-3 cable route profile of in-place inclinometer in inclinometer casing

Regarding the In-place inclinometer system more than 9 transducers, the inclinometer casing can not accommodate too many cables, and can lead part of transducer cables out of the inclinometer casing and protected with steel pipe to lead to the orifice of the inclinometer casing, the diameter of protection steel pipe depends on the number of the cables, normally 1.5″ ～2″ .

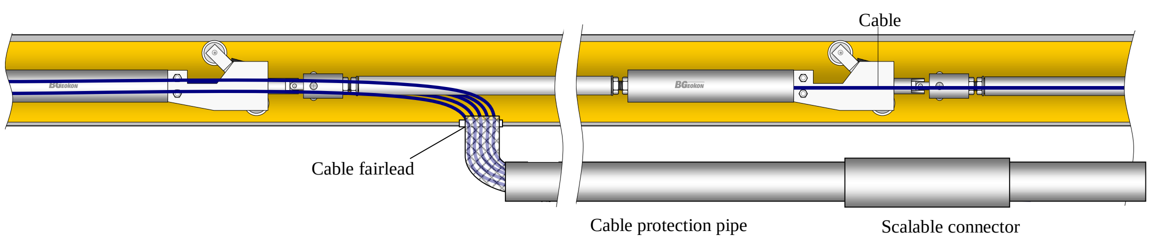

Figure 4-4 Multi-transducer cable laying and protection

Note to wrap the cable with soft materials in the orifice of the inclinometer casing in case the orifice burrs damaging the cable. In addition, the connection of the cable protection pipe can not use the connector with buckles and recommend to use a steel pipe (length 30~50cm) little bigger than the protection pipe, also please note to maintain about 10cm space between the protection pipes for compression.

All the instruments are lead to the observation station or observation room and connected with the corresponding data acquisition equipment.

The installation of the In-place Inclinometer mounted in a slope is similar to that of Horizontal In-Place Inclinometer, that is, maintain the mark on the transducer upwards and the stationary wheel downwards to the bottom of the inclinometer casing.

3.4 Backfill methods and recommendations

The backfill instruction is only the case of rockfill, the installation of other fill materials can refer to this method. The backfill materials should be same as the site materials, for example, the burry in earth dam should use the same clay backfill and the burry in rockfill should use coarse sand, transitional materials backfill one layer by one layer, the thickness of the coarse and transitional materials cover are not less than 50 and 30cm. First compact with hand and only the thickness of the cover is over 1m and then roll with a roller.

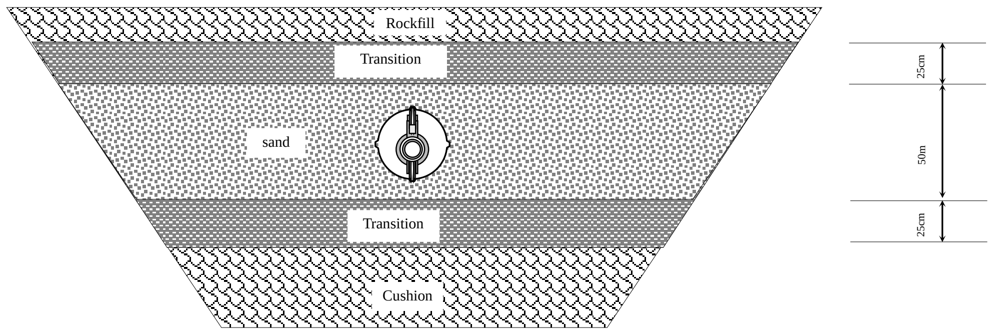

Figure4-5 laying backfill diagram of horizontal in-place inclinometer installed in the inclinometer casing

4. Taking readings

4.1 Function definition of the cable cores of transducer

CGEO-IPIA /IPIB /IPID In-Place inclinometer uses an 8 core cable, the 8 core cable consists of 4 twisted pair and another shield wire, the 8 core wire definition as the following:

core color	function definition	
	double axes	uni-axis
Red	12V power (+)	12V power (+)
Black, red black twisted pair	12V power (−)	12V power (−)
White	A axis signal (+)	A axis signal (+)
Black, white black twisted pair	A axis signal	A axis signal
Green	B axis signal (+)	empty
Black, green black twisted pair	B axis	empty
Blue	thermistor	thermistor
Black, blue black twisted pair	thermistor	thermister
naked wire	shield	shield

Thanks to the voltage signal of transducer output, the transducers can connect with most data acquisition equipments. Use CGEO-PR-MEMS readout to take readings on site manually, also can use most commercially available dataloggers to automatically or remotely acquire data.

Regarding the use of CGEO-PR-MEMS readout please refers to its manual instruction or consult to CGEO Company.

4.2 Preliminary test

Prior to installation, the sensors need to be checked for proper operation. Each tilt sensor is supplied with a calibration sheet, which shows the relationship between output voltage and inclination. The tilt sensor electrical leads are connected to a datalogger or CGEO-PR-MEMS readout box and the current reading compared to the calibration readings. Carefully hold the sensor in an approximately horizontal position and observe the reading. The sensor must be held in a steady position. The readings should be close to the factory horizontal reading. The temperature indicated by the thermistor, and readout on the green and white wires using an ohmmeter, should be close to ambient.

Inclination		measured vales			average	accuracy	
θ	**sinθ**	1	2	3		linear	polynormal
-12.0	-0.2079	-1.6712	-1.6712	-1.6712	-1.6712	-0.03%	0.01%
-9.0	-0.1564	-1.2580	-1.2579	-1.2580	-1.2579	-0.01%	-0.01%
-6.0	-0.1045	-0.8415	-0.8415	-0.8413	-0.8414	0.00%	-0.01%
-3.0	-0.0523	-0.4227	-0.4226	-0.4225	-0.4226	0.02%	0.00%
0.0	0.0000	-0.0025	-0.0022	-0.0021	-0.0022	0.02%	0.00%
3.0	0.0523	0.4180	0.4182	0.4182	0.4181	0.03%	0.01%
6.0	0.1045	0.8378	0.8380	0.8379	0.8379	0.02%	0.01%
9.0	0.1564	1.2556	1.2559	1.2558	1.2557	0.00%	0.00%
12.0	0.2079	1.6705	1.6708	1.6709	1.6707	-0.05%	-0.01%
/		/	/	/	/	/	/

formula — linear: $D(mm) = G \times L (R_1 - R_0)$

polynomial: $D(mm) = L (AR_1^2 + BR_1 + C)$

Linear coefficient 0.1244497644 sinθ/Volt

Polynomial -0.000093110144 **B** =0.124449683838

C = 0.0002870555690215

R_1---current readings R_0-initial readings

L-distance between two inclinometers (mm)

Note: readout display is half of output voltage of transducer

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Figure 4-6 sample calibration sheet of in-place inclinometer

Detecting steps: connect the instrument with power and CGEO-PR-MEMS or other data acquisition equipment according the core wire definition; please note the power supply is 12V stabilized voltage supply. The reading ranges of A and B axis is ＋1.9999～1.9999, changing the inclination of inclinometer to see if the reading is normal, the inclinometer should have a stable readings. There are normally marks "＋" and "-" on the cable end; the inclinometer readings will increase （0～1.9999）when the inclinometer incline upwards to "+" otherwise the readings will decrease （0～-1.9999）; The readings of the inclinometer will be near to zero when it is in a level position.

It must be explained that, using CGEO-PR-MEMS to read , the display values are the 1/2 output voltages of inclinometer transducer.

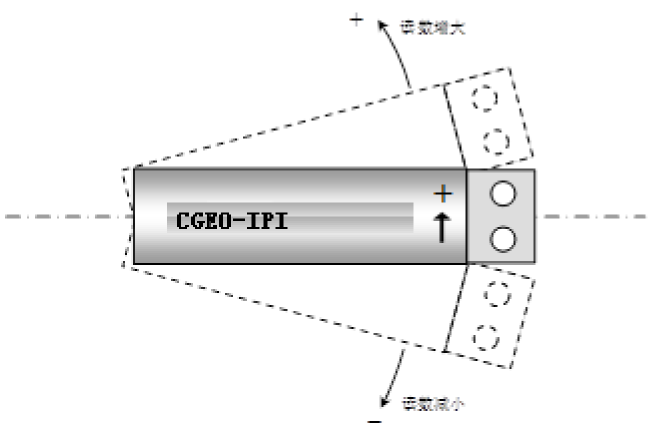

Figure 4-7 diagram of the transducer inclination direction and reading variation tendency

The temperature sensor is independent, use CGEO-PR-VW to read and display the degrees directly; the value should be close to the ambient temperature. Or use the CGEO-PR-MEMS ohm grade or other digital multimeter to measure the thermistor resistance. The resistance of the temperature sensor at 25℃ is about 3000 ohms. Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

Equation B-1 Convert Thermistor Resistance to Temperature

Where; T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance
A = 1.4051×10^{-3} (coefficients calculated over the −50 to +150° C. span)
B = 2.369×10^{-4}
C = 1.019×10^{-7}

See the appendix B.

4.3 Insulation test

Different from the regular instruments, this transducer contains some Precision Electronic Components and works in low voltage range, so you can not use a traditional insulation resistance meter to test the insulation resistance of the instrument, otherwise will damage the instrument. When measuring , you must twist all cable core conductor together and only allow to use 50V megameter or digital multimeter to test the insulation resistance between core wires and shield wire or outside shell, its insulation resistance should be bigger than 2 megaohms. The factory shall not repair or exchange if mis-using 50v over megameter and damage the instrument.

5. Data reduction

5.1 Settlement calculation principle

Shown as in the figure, supposed the length of a inclinometer is L, when inclining (rotating) angle θ related to o point, and then A point displaces to A', then D=L×sin θ .

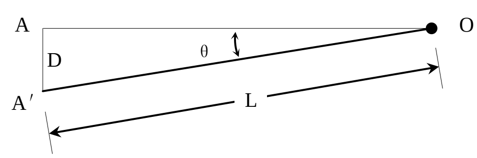

Figure 5-1 vertical displacement transition principle

If multi-instruments in series, the accumulation displacement of these instruments will get the vertical deformation curve of the whole profile.

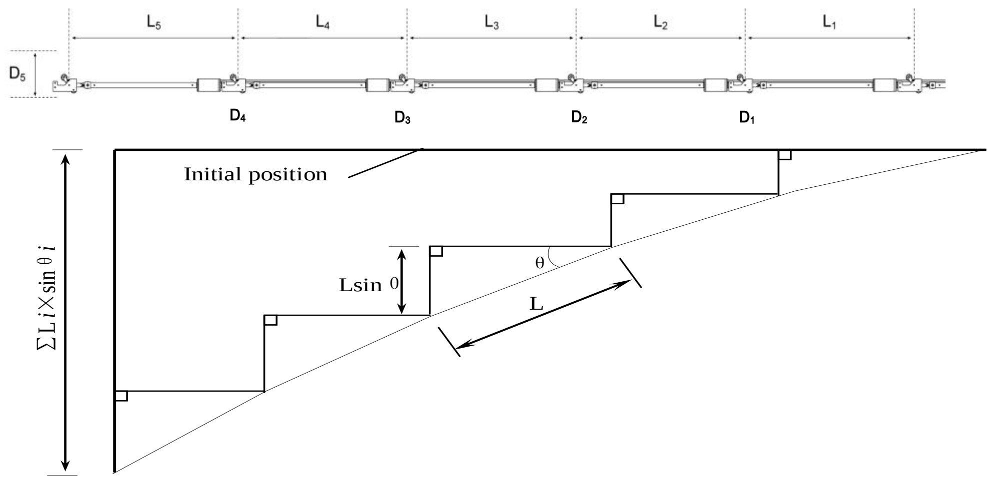

Figure 5-2 transition diagram of incline and settlement

Supposed installing 5 points of horizontal in-place inclinometers (see figure 22), L end as a benchmark, the total vertical displacement generated in L end is:

$$D5 = D1 + D2 + D3 + D4 + D5$$

5.2 CGEO-IPIA /IPIB /IPID settlement calculation

The output of the inclinometer is a voltage signal and the calculation methods are a little different when using different display instrumentation and data acquisition devices

1）If using CGEO-PR-MEMS readout box, you directly use the formula supplied in the calibration sheet.

$$\mathbf{D(mm) = G \times L\ (R_1 - R_0)}$$

Where: D-the vertical offset related to the inclinometer length L(mm);

G-instrument coefficient, given in the calibration sheet (sinθ/V, using CGEO-PR-MEMS to measure);

L-single transducer inclinometer length or the central distance between the neighboring wheels (mm);

R1-current readings (the readings measured by CGEO-PR-MEMS, unit 1/2 V);

R2-initial readings (using CGEO-PR-MEMS readout）

2）when using other data acquisition equipment, its display result is the actual output voltage of transducer, taking this voltage value half, that is, calculate as the following formula:

$$\mathbf{D(mm) = 0.5 \times G \times L\ (R_1 - R_0)}$$

Where：D-the vertical offset related to the inclinometer length L

G-instrument coefficient, given in the calibration sheet（sinθ/V）;

L-the single transducer inclinometer length or the central distance between the two neighboring wheels (mm);

R1-current readings (unit, V)

R2-Initial readings (unit, V)

The reading range is ±12°when calibrating CGEO-IPIA /IPIB /IPID in the factory, its measurement range can reach±15°when using, the corresponding transducer output is ±12°@ ±4V.

5.3 Temperature compensation

Although the temperature dependence of the MEMS tilt meter is practically zero, and does not require compensation, it sometimes happens that temperature effects can cause real changes of tilt, therefore each MEMS tilt sensor is equipped with a thermistor for reading temperature. This enables temperature-induced changes in tilt to be distinguished from tilts due to other sources. The thermistor gives a varying resistance output as the temperature changes. The temperature property of CGEO-IPIA /IPIB /IPID is that the signal output will decrease 0.0005Vevery 1℃ rising (the variation in CGEO-PR-MEMS is 0.00025V), then the temperature corrected readings are:

$$RT = R + 0.0005\ (T1 - T0)$$

When using CGEO-PR-MEMS readout, the corrected displacement variation is:

$$D(mm) = G \times L\ (R1 - R0 + 0.00025\ (T1 - T0))$$

When using datalogger to read, the corrected displacement variation is:

$$D(mm) = 0.5 \times G \times L\ (R1 - R0 + 0.0005\ (T1 - T0))$$

5.4 Environmental Factors

Since the purpose of the CGEO-IPIA /IPIB /IPID MEMS installation is to monitor site conditions, factors that may affect these conditions should be observed and recorded. Seemingly minor effects may have a real influence on the behavior of the structure being monitored and may give an early indication of potential problems. Some of these factors include, but are not limited to: blasting, rainfall, tidal or reservoir levels, excavation and fill levels and sequences, traffic, temperature and barometric changes, changes in personnel, nearby construction activities, seasonal changes, etc.

6. TROUBLESHOOTING

Maintenance and troubleshooting of the vibrating wire tilt sensors used in the Model CGEO-IPIA /IPIB /IPID MEMS Horizontal Inclinometer are confined to periodic checks of cable connections. The sensors are sealed and there are no user-serviceable parts.

Consult the following list of problems and possible solutions should difficulties arise. Consult the factory for additional troubleshooting help.

Symptom: Tilt Sensor Readings are Unstable

- ✓ Is there a source of electrical noise nearby? Most probable sources of electrical noise are motors, generators and antennas. Make sure the shield drain wire is connected to ground whether using a portable readout or datalogger.
- ✓ Does the readout work with another tilt sensor? If not, the readout may have a low battery or be malfunctioning.

Symptom: Tilt Sensor Fails to Read

- ✓ Is the cable cut or crushed? This can be checked with an ohmmeter. The nominal resistance of the thermistor is 3000 ohms at 25 degrees C. If the approximate temperature is known, the resistance of the thermistor leads can be estimated and used as a cable check. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7Ω/1000' or 48.5Ω/km, multiply by 2 for both directions). If the resistance reads infinite, or very high (megohms), a cut wire must be suspected. If the resistance reads very low (<20Ω) a short in the cable is likely.
- ✓ Does the readout or datalogger work with another tilt sensor? If not, the readout or datalogger may be malfunctioning.

Symptom: Thermistor resistance is too high.

- ✓ Is there an open circuit? Check all connections, terminals and plugs.

Symptom: Thermistor resistance is too low.

- ✓ Is there a short? Check all connections, terminals and plugs.
-]✓ Water may have penetrated the interior of the tilt sensor. There is no remedial action.

APPENDIX A - THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

Equation B-1 Convert Thermistor Resistance to Temperature

Where; T = Temperature in °C.

LnR = Natural Log of Thermistor Resistance

A = 1.4051×10^{-3} (coefficients calculated over the −50 to +150° C. span)

B = 2.369×10^{-4}

C = 1.019×10^{-7}

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	**3000**	**25**	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table B-1 Thermistor Resistance versus Temperature