Model 1900

Magnetic Extensometer

Instruction Manual

GEOKON

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1. INTRODUCTION

The GEOKON Model 1900 Magnetic Extensometer is designed to measure movement between magnetic targets anchored in the ground. It is normally installed in a borehole or directly in fill as it is placed. The primary use of the magnetic extensometer is the measurement of vertical compression in embankments, foundations, and fills and the movement of settlements in soft ground due to the placement of fills and embankments. It may also be used to measure heave.

The figure below shows the basic arrangement of the Magnetic extensometer.

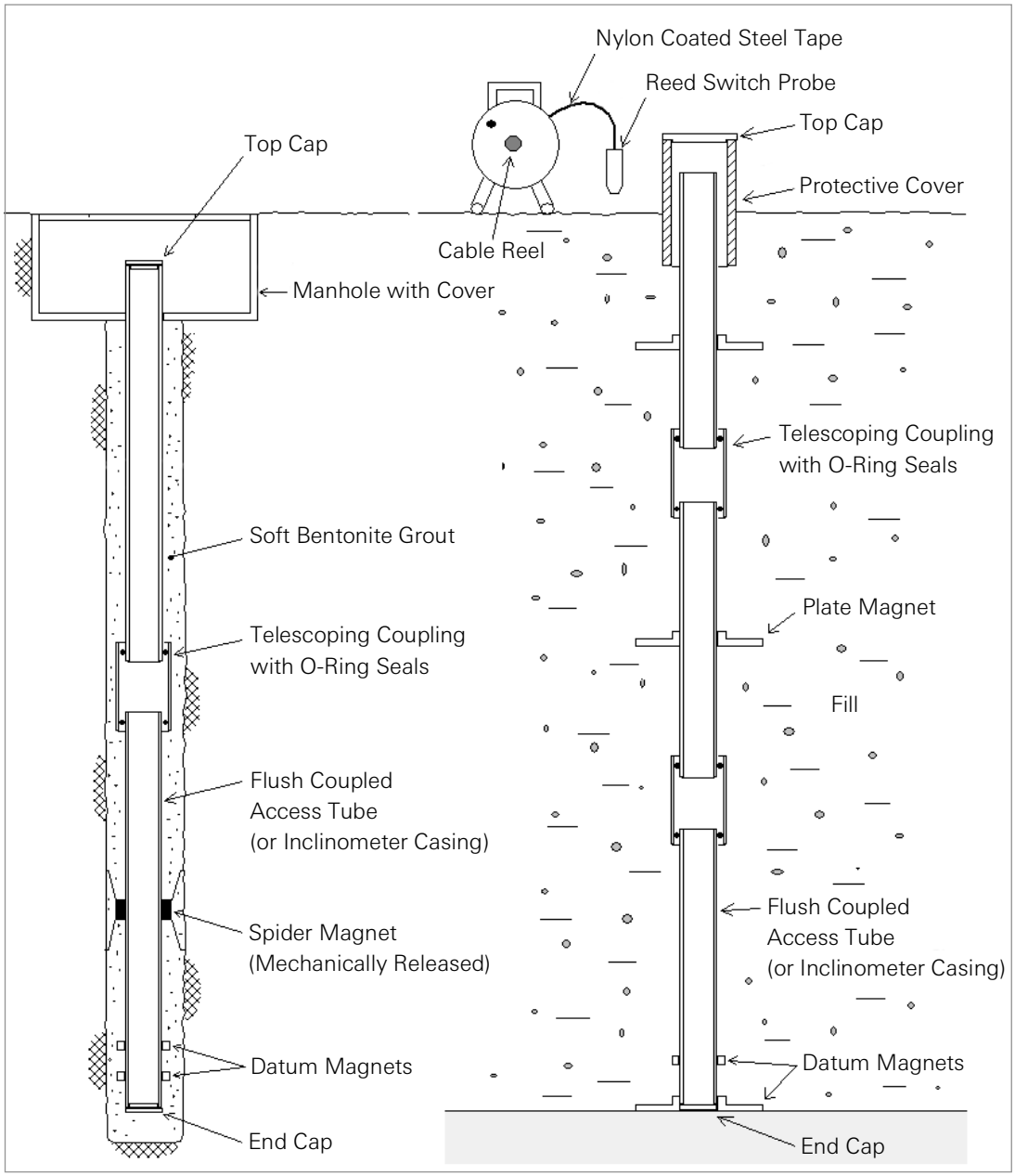

FIGURE 1: *Typical Magnetic Extensometer Installations in Borehole (Left) and in Fill (Right)*

Anchor points with permanent magnets are anchored in the ground with a continuous access tube passing through their center. A reed switch probe is lowered inside the access tube on the end of a graduated measurement tape, which also contains two electrical conductors. As the probe passes each anchor, the magnets in the anchor cause the reed switch to close, this sounds a buzzer on the tape reel at the surface.

When the buzzer sounds the depth of the anchor is measured by reading the graduated tape opposite the top of the access tube.

In most cases, the bottom of the access tube is deep enough to be located in solid ground. A datum magnet anchored to the bottom of the access tube provides a stable benchmark datum to which all the other anchor measurements are referred to in order to calculate the absolute settlement of each anchor point relative to the benchmark.

If the bottom of the access tube cannot be located in the solid ground then it will be necessary to reference the position of each anchor to the top of the access tube and to transfer this elevation to an external benchmark by normal level surveying techniques.

2. INSTALLATION

2.1 LIST OF SUGGESTED TOOLS

- Black electrical tape (for securing pull pins, packing pull cables, and protecting loops)
- Masking tape (to hold pull cables during installation)
- Small cutting tool (to cut cable ties)
- Measuring tape (to place the anchors on the access tube at correct depth)
- Pen or Marker (to identify anchor location on access tube)
- PVC glue (for bottom cap)
- Steel saw (to cut access tubing)
- Long pushrod, typically threaded water pipe (extensible to reach the bottom of the hole)
- ID numbers (or colored tape) to identify pull cables
- Small and medium plastic cable ties or cable clamps/grips (for making loops with the cable)
- Medium cutting tool (to cut pull cable)
- Small cutting tool (to cut cable ties)
- Measuring tape (to place the anchors on the access tube at correct depth)
- 300' tape (to measure pull cable length)
- Working gloves (to hold anchor legs closed when working with the chain and the access tube)
- Grease for telescopic sections (and possibly for anchors)
- Clear water (to clean threads)
- Pipe wrench (for threaded water pipe)

2.2 INSTALLATION IN BOREHOLES

Boreholes may be open, cased, grouted, or not grouted. In cased boreholes, it will be necessary to pull the casings after the string of access tubes and anchors have been installed inside it. In holes that are to be grouted using a soft bentonite grout there are two options: Pre-grout the borehole, or grout the borehole through a tremie pipe after the extensometer string has been lowered into position.

2.2.1 PREPARING THE ACCESS TUBE ANCHOR STRING

It is advisable to prepare the entire access tube string on a stretch of clean, level ground prior to installing it. In this way, there will be a minimum of delay during the actual installation since everything will be ready. Do not screw the sections together; just arrange them in their correct order with the anchors attached.

1. Cement the end cap onto the bottom section of the access tubing using PVC cement (not supplied by GEOKON).
2. Using three set screws, tighten the datum magnet onto the bottom section of the access tube about 1 m (3.28') above the bottom end cap.

Note: Do not put the datum magnet too close to the bottom in case the access tube silts up.

FIGURE 2: *Datum Ring Magnet Secured*

3. Select further sections of access tube and/or telescoping couplings. Position the spider anchors along the sections of access tubing in their desired locations. The spider anchors are attached to the access tube as shown below.

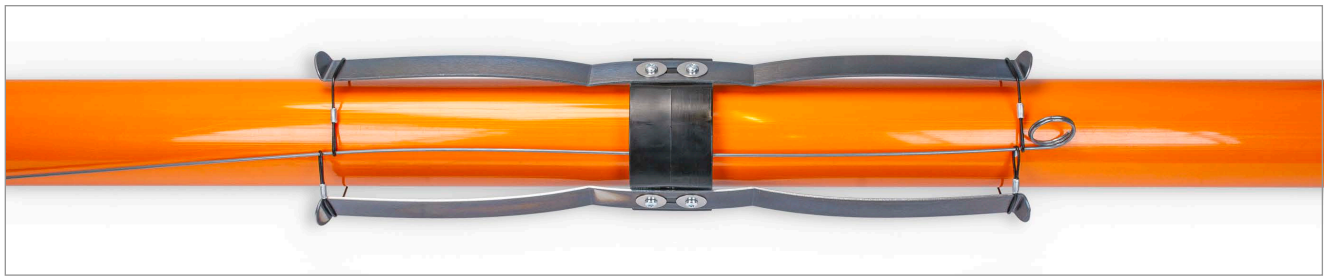

FIGURE 3: *Anchor Assembly / Securing the Leaf Springs*

4. Use the cable lanyards supplied to restrain the ends of the leaf springs. The pull-pin passes through the two looped ends of the cable lanyards holding the leaf springs snug against the access tube. Use 3/4" electricians tape (two turns) around the pull pin above and below the anchor, (see Figure 3). This holds the anchor pull-pin in place and makes it more difficult to pull the pin out, thus reducing the risk of prematurely tripping the anchor during installation. It also holds the spider anchor in place preventing it from sliding up the access tube during installation.
5. Leaving the pull cable coiled, connect the loop on the end of the cable to the anchor pull-pin by clipping the hook through the eye of the pull cable.
6. Wrap a single layer of masking tape around the cable about 30 cm above the hook. This also will make it difficult for the pull-pin to be pulled prematurely.
7. Tape identification tags onto each end of the pull cables, e.g., use "#1" for the top anchor, "#2" for the next anchor, etc. Colored tapes can also be used for identification if identification tags are not available.

2.2.2 INSTALLING THE ACCESS TUBE ANCHOR STRING

1. Begin assembling the access tube string and pushing it into the borehole. If the hole is to be grouted after the string is placed, then the tremie pipe should be taped to the end of the access tube. Tape heavily enough to prevent the tremie pipe from coming loose as it is pushed into the hole but not so heavy that it cannot be pulled loose deliberately at the start of grouting. If the borehole is already filled with grout or water, it will be necessary to fill the access tube with water to overcome the buoyancy forces.
2. When sections with spider anchors are added to the string, the pull-cables should be uncoiled and fed smoothly into the borehole along with the access tubing. **Do not allow any of the pull-cables be snagged, tangled, or pulled on, which could cause premature triggering of the anchors.** It may be advisable to have more than one person in charge of the pull-cables and tremie pipe.

3. Once the access tube has been lowered to the bottom of the borehole, it will be necessary to make sure that all the telescoping couplings are fully extended to accommodate the anticipated settlements. (If heave is being measured, the couplings can be left closed or nearly closed.) This is best done by means of a long push rod (not supplied by GEOKON) made from any easily available water pipe with threaded connectors. The push rod assembly when joined should be sufficient length to reach the bottom of the access tube. To open the telescopic couplings push down on the push rod assembly and pull up on the access tubes.
4. Use the reed switch probe to verify the position of the anchors before they have been tripped. (See Section 3 for information on taking readings.) If the anchors have slipped it is still possible to remove the access tube and reposition them.
5. If the hole is to be grouted, it should be done at this time. Bentonite grout of the type that will remain soft and not impede the settlement of the ground (i.e., grout that will allow the anchor to follow the movement of the ground) should be used. (A typical grout is 43 kgm cement, 2 kgm bentonite and 40 kgm water, or enough water to make the mix thin enough to pump.)
6. If the hole is cased the casing can now be removed. Make sure that the access tubing does not pull upwards during this process.
7. The magnetic spider anchors can now be released beginning at the top anchor. Select pull-cable #1 and give it a quick hard pull.
8. Remove the pull-cable and anchor pull-pin completely from the borehole before tripping anchor #2. Repeat this process for all the anchors.
9. Install the plastic tape guide by sliding the access tube into the slots in the guide.

FIGURE 4: *Tape Guide Mounted to Access Tube*

2.3 INSTALLATION IN FILLS

Plate shaped magnetic anchors (see Figure 5) are used in fills. As the fill is placed the access tube is extended upwards by screwing on more sections along with telescoping couplings (make sure these are fully extended when installed). The plate anchors are laid on top of the fill surface as soon as it reaches the desired anchor elevation. They are then buried as more fill is placed.

Each new section of access tube that is added will alter the reed switch probe readings; however, the data reduction process will remain the same.

FIGURE 5: *Plate Magnetic Anchor*

3. TAKING READINGS

Before taking readings, check the battery voltage by depressing the "TEST" button on the side of the tape storage reel; if no beep is heard the nine-volt alkaline battery needs to be replaced, preform the following:

a. Remove the three screws on the buzzer side flange of the reel.

b. Remove the flange, being careful not to not allow the tape to fall off the reel while doing so.

c. Replace the nine-volt battery (located on the backside of the flange) with a new one. Make sure the + and - sides of the battery are in the correct positions.

d. Reinstall the flange and the screws.

Readings are taken by lowering the reed switch probe down the access tube until an audible beep is heard from the buzzer in the tape reel. A reading of the graduated measurement tape is taken opposite the top of the access tube when the buzzer just starts to sound.

For greater accuracy, a second reading can be obtained at the same anchor by lowering the probe until the buzzer continues to beep. Take a measurement on the tape, as before, and average the two readings to get the position of the anchor.

Repeat this process for all the anchors and the datum anchor at the bottom of the hole.

4. DATA REDUCTION

4.1 TRUE SETTLEMENT OF INTERMEDIATE ANCHORS

If the datum magnet is located in solid ground (i.e., no settlement) then the true settlement (TS) of any intermediate anchor is given by the equation:

$$TS = (D_t - D_n) \text{ at } T_0 - (D_t - D_n) \text{ at } T_1$$

EQUATION 1: *True Settlement of an Intermediate Anchor*

Where:
D_t = The distance from the datum magnet to the top of the access tube.

D_n = The distance from the top of the access tube to any one of the intermediate anchors; designated as D_1, D_2, D_3, etc.

T_0 = The distance recorded at initial readings.

T_1 = The distance recorded at current or subsequent readings.

EXAMPLE:

If the distance recorded at the initial reading (T_0) are:

D_t = 29.214 m

D_1 = 3.632 m

And the distance recorded at the current reading (T_1) are:

D_t = 28.943 m

D_1 = 3.595 m

Then;

$$TS = (29.214 - 3.632) - (28.943 - 3.595)$$

$$TS = 0.234 \text{ m}$$

Hence anchor D_1 has settled 0.234 m.

4.2 SETTLEMENT OF THE TOP OF THE ACCESS TUBE

Assuming the datum is located in a non-displacing formation, the settlement of the top of the access tube (S) can be determined by the equation:

$$S = D_t \text{ at } T_0 - D_t \text{ at } T_1$$

EQUATION 2: *Settlement of the Top of the Access Tube*

Where:
D_t = The distance from the datum magnet to the top of the access tube.

T_0 = The distance recorded at initial readings.
T_1 = The distance recorded at current or subsequent readings.

EXAMPLE:

If the distance recorded at the initial reading (T_0) is:

D_t = 29.214 m

And the distance recorded at the current reading (T_1) is:

D_t = 28.943 m

Then;

$$S = 29.214 - 28.943$$

$$S = 0.271 \text{ m}$$

Hence anchor D_1 has settled 0.271 m.

4.3 COMPRESSION OF THE GROUND

The compression of the ground between the top of the access tube and anchor any intermediate anchor (C) is given by the equation:

$$C = S - TS$$

EQUATION 3: *Compression of the Ground*

Where:
S = The settlement of the top of the access tube.

TS = The true settlement of any intermediate anchor.

EXAMPLE:

If using the values calculated in the previous examples:

S = 0.271 m

TS = 0.234 m

Then;

$$C = 0.271 - 0.234$$

$$C = 0.037 \text{ m}$$

If it is required that all measurements be referred to the top of the access tube, then the actual elevation of the borehole anchors can be computed by subtracting the measured distances D_1, D_2, D_3, etc. from the surveyed elevation of the top of the access tube. The settlement of each anchor is then the observed difference of elevation from one survey to the next.

APPENDIX A. SPECIFICATIONS

A.1 MODEL 1900 SPECIFICATIONS

Tape Lengths	30, 50, 100, 150, 200 m 100, 125, 200, 300'
Resolution	1 mm (0.04")
Repeatability	±3 mm (±0.12")
Temperature Range[1]	-30 to +80 °C
Material	Probe: Stainless Steel Access Tube Top Cap: PVC 1" Sch. 80 Plate Magnet: PVC Spider Magnet: Body, ABS Plastic. Legs, Hardened 17-7 SS Datum Magnet: ABS Plastic
Dimensions	Probe: 178 x 19 mm (7 x 0.75") Access Tube Top Cap: 33 mm O.D. Plate Magnet: 300 x 300 x 9.5 mm (11.8 x 11.8 x 0.37") Model 1900-7A Spider Magnet: Closed, 430 x 70 x 34 mm (16.9 x 2.75 x 1.34") Released, 410 x 190 x 34 mm (16.1 x 7.5 x 1.34") Model 1900-7B Spider Magnet: Closed, 430 x 120 x 73 mm (16.9 x 4.7 x 2.87"). Released, 410 x 228 x 73 mm (16.1 x 9 x 2.87") Model 1900-5A Datum Magnet: 51 x 70 x 34 mm (2 x 2.76 x 1.34") Model 1900-5B Datum Magnet: 51 x 110 x 73 mm (2 x 4.33 x 2.87")
Leaf Spring (Spider Leg) Stiffness	>20N
Borehole Size[2]	102 - 216 mm (4 - 8.5")
Power	9V Alkaline Battery

TABLE 1: *Model 1900 Magnetic Extensometer Specifications*

Note:

[1] Other ranges available on request.

[2] Other sizes available.

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