Gage Technique International Ltd.
GEOTECHNICAL & STRUCTURAL INSTRUMENTATION

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Gage Technique International

Standard Inclinometer Casing

Installation Guide

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Introduction

The guide tube and coupler system is known to be the simplest and most robust approach for inclinometer tube assembly, it allows assembly without compromising strength and elevation changes or in-situ repairs are relatively quick and easy.
As is the nature of geotechnical installations each and every installation will be different and require a considered approach to achieve a successful outcome. With this in mind this guide has been written as a generic document and should the content should be adapted to suit field conditions. Installations should be undertaken by experienced, competent personnel with an understanding of the field conditions, parameters to be measured and materials used.

Delivery Checks

Whilst Gage Technique prides itself that we provide the best service to our customer's mistakes do happen and incidents in transit are unfortunately all too frequent.
It is strongly advised that when equipment is received it is thoroughly checked over to ensure there is no damage and that the articles requested have been sent.

How to Store Casing

Casing should be supported evenly over its entire length, so that it does not warp or bend during storage. In the field keep casing in the shade since prolonged exposure to direct sunlight may cause deformations.

Borehole Dimensions

Prior to drilling, **borehole diameter** should be considered. The outside diameter of the inclinometer coupler is 80mm, however depending on the site conditions there may be a requirement for grout pipes, grout valves, external anchors and enough room has to be left to accommodate the grout being placed around the instrument. The minimum diameter recommended is 100mm (4 inches) however the costs saved in reducing the diameter can quickly be expended by having a more complicated and lengthy installation.
Borehole length should also be considered, not only does the hole have to extend to the depth to be monitored but, if grouting from the bottom, a grout pipe needs to be accommodated. If there is likely to be buoyancy in the pipe an anchor or weight will need to be attached at the bottom to counteract this and dependant on the material being drilled through and the method of drilling there could be debris in the bottom of the borehole.

Assembly and Installation

Gage Technique can provide the tubing in a part assembled configuration, however for clarity we are assuming in this text that this hasn't been provided.
Where reference is made to contact adhesive silicon sealant can be used instead.
Solvent based fluids are used so the assembly area should be well ventilated. The necessary guide tubing should be laid out in an area free from dirt and debris and checked for damage or irregularities.

1. The borehole should be dipped to ensure the correct depth has been reached, there are no obstructions and determine where the water is within the borehole.
2. For comfort it is advisable to use a trestle table or similar to raise the tubing to a workable level.
3. The tubing and couplers should be clean, dry and free of dirt or grease. If necessary a solvent can be used to remove grease.
4. The bottom cap has contact adhesive painted along the edge of the inside circumference. The bottom cap is pushed on to one of the guide tubes. Excess adhesive is removed using a rag.
5. One 3.1mm drill hole is drilled into guide tube and bottom cap.
6. A 3mm aluminium rivets is then expanded within this hole.

7. Denso tape is them rapped around the joint between the guide tube and end cap including the top of the rivet.
8. The ends of the remaining guide tubing should then be marked with indelible pen at ½ the distance of a coupler i.e. for a 200mm coupler the tubing should be marked at 100mm at both ends.
9. Contact adhesive should be painted on to the outside circumference edge of one end of the guide tubing and a coupler moved over the tubing until the pen marked is reached. The residue of contact adhesive is then wiped away with a rag.
10. Two opposite 3.1mm drill holes will be drilled through coupler and guide tube in a position that avoids the internal grooves in the guide tube. A dotted line is printed on one side of the coupler as a guide.
11. Two 3mm aluminium rivets are then expanded within these holes.
12. Denso tape is them rapped around the joint between the guide tube and coupler including the tops of the rivets.
13. Repeat points 8 – 11 until all guide tubes have one coupler attached except for the top guide tube that will not require a coupler.
14. The tubing is now ready for installation and final assembly.
15. The borehole should again be dipped to determine the exact depth of the borehole and whether the ground water in the borehole has significantly changed elevation as this could indicate artesian head which could require additional grouting procedures.
16. Once the borehole depth is known mark on the top guide tube the expect position of ground level this will give an immediate visual check on installation that the tubing has been installed to the bottom of the borehole.
17. The tubing is now ready for installation and final assembly.
18. For pre grouted boreholes go to 19 for post grouted boreholes go to 35

Pre Grouted Borehole

(Often used in small diameter boreholes)

19. Lower the grout pipe to the bottom of the borehole.
20. Pump in the grout taking note of the volume used.
21. At the same time gradually raise the grout pipe ensuring that the bottom of the pipe remains within the grout.
22. Continue this process until a constant grout return is seen at the top of the borehole matching the same consistency as the grout being placed.
23. Determine the grout volume used and compare this to the predicted volume required.
24. Watch the final grout level within the borehole.
25. If the initial grout required was significantly greater than the predicted volume, say 25% and the borehole grout level is dropping noticeably this would suggest that the surrounding geology is taking up the grout. Various actions can be taken at this point to ensure a successful installation and this will require further knowledge of ground conditions and engineering judgement to determine the correct course. This user guide does not cover these actions, Gage Technique would be happy however to provide guidance on an individual basis.

If grout take was not significantly different to predicted and final borehole grout level only changes marginally the installation can continue as below.

26. Determine the direction of expected maximum movement.
27. Lower the bottom section of tubing into the grout ensuring that the orientation of the tube primary axis corresponds to the expected maximum movement.

NOTE: To prevent the possibility of twist being induced into the tubing it is important that the top of the tube is not subjected to any torque i.e. DO NOT TWIST whilst in the grout.

28. Use pipe clamps just below the coupler to hold the casing at the borehole collar.
29. Fill the guide tube with clean water, this will assist in counteracting buoyancy of the tubing and provide a degree of positive pressure within the tube to reduce the effects of the external grout pressures.
30. Contact adhesive should be painted on to the outside circumference edge of the next guide tube end and pushed on to the tubing in the borehole until the pen marked is reached. The residue of contact adhesive is then wiped away with a rag.
31. Two opposing 3.1mm drill holes will be drilled through coupler and guide tube in a position that avoids the internal grooves in the guide tube.

32. Two 3mm aluminium rivets are then expanded within these holes.
33. Denso tape is them rapped around the joint between the guide tube and coupler including the tops of the rivets.
34. Repeat steps 27 to 32 until the final guide tube has been assembled and the tube has been lowered to the bottom of the borehole, check that the mark coincides with ground level.
35. Secure the assembly at the collar of the borehole either by using wooden wedges or tying of the top of the pipe.

Post Grouted Borehole

(Often used when borehole is either self supporting or supported with drill rig casing)

36. To ensure that grout fills the bottom of the borehole and therefore covers the bottom of the inclinometer assembly, the grout pipe needs to extend further than the bottom cap by at least 200mm in a fashion that will prevent the grout pipe being blocked by borehole debris during installation. The grout pipe now needs to be attached to the inclinometer casing. Dependant on whether the grout pipe is sacrificial or recoverable will determine how this pipe is to be attached. In addition, in deep installations a second grout pipes may be used at a higher elevation to provide some insurance against blockages.
37. Steps 26 to 35 should then be repeated ensuring that the grout pipe is fed down gently with the inclinometer assembly.
38. Pump in the grout taking note of the volume used.
39. If using a recoverable grout pipe slowly raise the pipe ensuring that the bottom of the pipe remains within the grout.
40. Continue this process until a constant grout return is seen at the top of the borehole matching the same consistency as the grout being placed.
41. Determine the grout volume used and compare this to the predicted volume required.
42. Watch the final grout level within the borehole.
43. If the initial grout required was significantly greater than the predicted volume, say 25% and the borehole grout level is dropping noticeably this would suggest that the surrounding geology is taking up the grout. Various actions can be taken at this point to ensure a successful installation and this will require further knowledge of ground conditions and engineering judgement to determine the correct course. This user guide does not cover these actions, Gage Technique would be happy however to provide guidance on an individual basis.

Grout Design

In normal operation you will need a grout mixer a group pump, grout pipe (or hose) for grout delivery along with the necessary compression fittings.
Properly mixed grout requires high workability, thin enough to be pumped but thick enough that it will not excessively shrink and will set in a reasonable length of time.
Avoid super-plasticizers that accelerate curing by significantly increasing the temperature as this may damage the casing.
Ideally the grout should reflect the characteristic strength of the surrounding geology. In reality there is nearly always a compromise. It is possible to provide staged grouting that can reflect the geological strata changes however a continuous, homogeneous column of grout is generally sufficient to achieve a successful installation. Staged grouting should also be considered if the depth of the installation is likely to introduce grout pressures that would exceed the collapse strength of the assembly.
The most commonly used grout mix is a cement bentonite mix. Bentonite's main constituent is clay it can be bought in either pellet or granular form and comes dried. When hydrated it is capable of swelling to 16 times its own volume. For this reason it is advisable to mix the cement with the water first. Then mix in the bentonite granules slowly, adjusting the amount of bentonite to produce a grout with the consistency of toothpaste. If the grout is too thin the solids will separate, if it is too thick there will be problems pumping.

<u>For guidance only</u>
For soft soils with 28 day strength of 30kPa: By weight, a cement bentonite mix of 1:0.4 with a water cement ratio 6:1 would be appropriate.
For hard to medium soils with 28 day strength of 350kPa: By weight, a cement bentonite mix of 1:0.2 with a water cement ratio 3:1 would be appropriate.

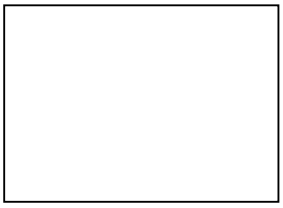
The appropriate quantity of bentonite powder will vary depending on the grade of bentonite, the water used, the input mixing energy and the temperature.

Above Ground Detail

Project specifications usually specify the final detail required for the top of the inclinometer assembly. For ease of taking readings, it is advantageous to have an up-stand, this also prevents dirt and debris from rain water run off accumulating in the access tube, extensions to be added and allows a pulley reading system to be attached if appropriate. However it can present a trip hazard and make it prone to vandalism.
On secure sites a simple top cap can be fitted, this merely provides a cover to the assembly.

Left: GT/INC/1.4 Clear top cap

In areas where there is slight risk of vandalism a simple lockable top cap may be incorporated that will prevent opportunist vandals



Left: GT/INC/1.5 Lockable top cap

In areas where there is a high chance of damage a steel outer sleeve with a lockable top cap can be used.

Left: GT/INC/1.6 Steel security top assembly

Base Readings

Prior to the grout strengthening, the weight of a probe and reel passing down the tube can induce voids to form between the tube surface and the grout, base readings should not be taken until the grout has had sufficient time to strengthen. If this is not done subsequent probe passes could then induce movements in the tube that are not representative of the surrounding structure being measured. As a guide a minimum of 5 full days between grouting and base readings should be observed.