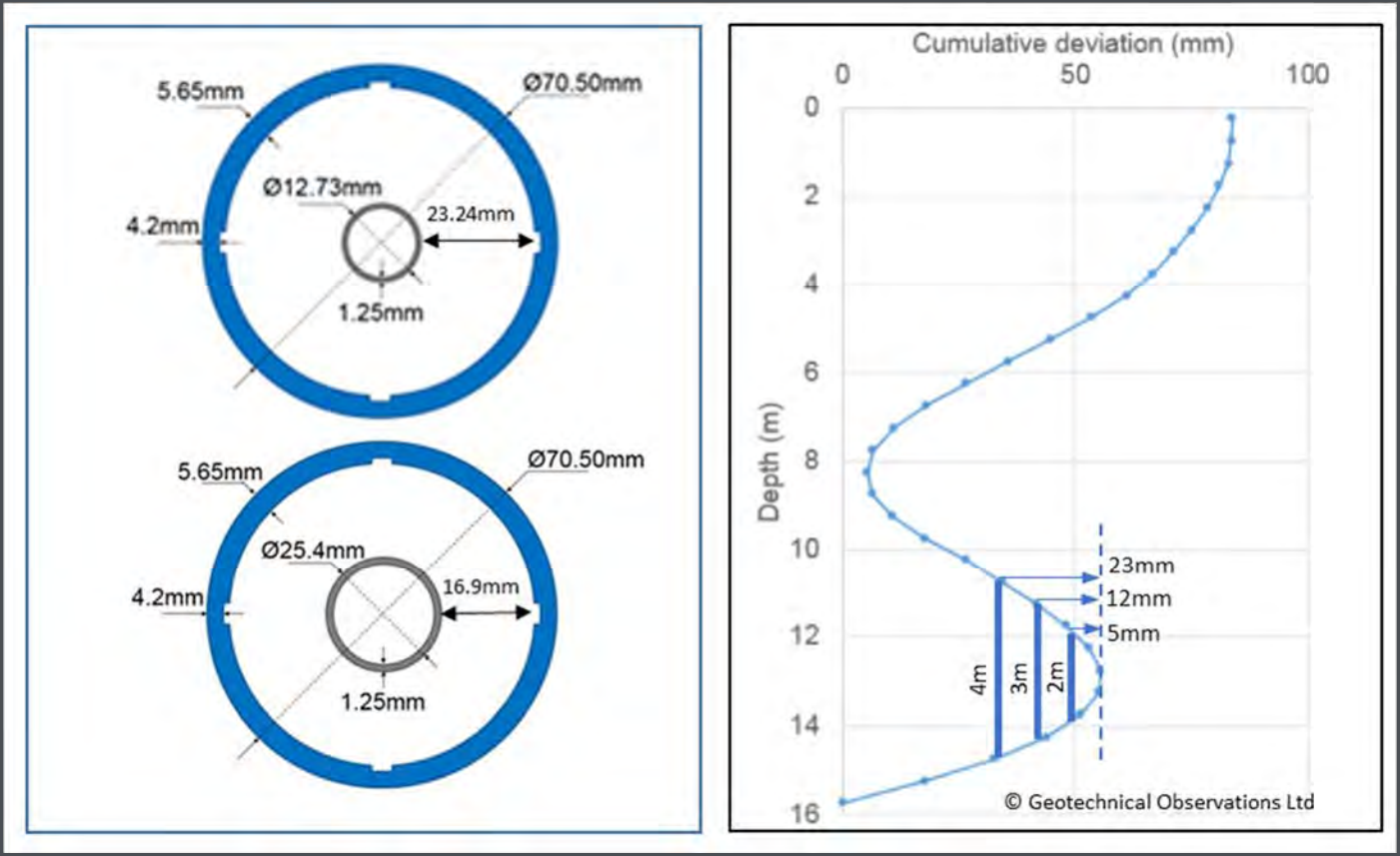
A note on the importance of gauge length for making accurate measurements with in-place inclinometers

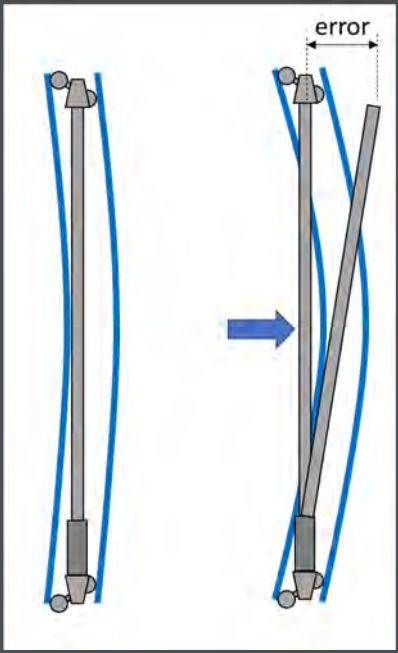
An in-place inclinometer consists of an array of displacement sensors connected by gauge rods. A question that is often raised is what length of gauge rod should be used for an in-place inclinometer? BS EN ISO 18674-3:2017 (Measurements of displacement across a line: inclinometers) recommends that gauge rods should not exceed 2m and that shorter gauge rods produce better results. Why is this?



The figure on the left shows gauge rods with diameters of 0.5" and 1" inside a inclinometer casing with an external diameter of 70mm. If the gauge rod is concentric with the inclinometer casing the distance from the outside of the rod to the inside of the inclinometer casing is about 23mm for the 0.5" gauge rod and 17mm for the 1" gauge rod.

The figure on the right shows the shape of an inclinometer casing measured using an inclinometer probe. Note it is not perfectly straight, although if it were looked at with proportionate scales it might seem so. Also shown are three gauge lengths and the associated distances from the appropriate chord to the point of inflection. For this casing an in-place inclinometer with 4m long, 0.5" diameter gauge rods will interfere with the inside edge of the inclinometer casing as it is inserted around the curved section. The interference would occur with shorter gauge rods if they are 1"

diameter. In the worst case this might cause the gauge rod to bend and at the very least the assumption of linearity between the nodes is unlikely to be true.



If, after installation a gauge rod is touching the inside edge of an inclinometer casing it will feel displacements of the casing at the point of contact and these displacements will cause the connected sensor to rotate. Displacements are calculated by assuming that adjacent sensors are connected by a straight line and this will not be so if the gauge rod is forced around a bend with a point of contact part way along the gauge rod. The measured displacement will therefore be false, as shown in the figure. Short gauge rods can tolerate more deviation before this problem shows itself. The deviation of the inclinometer casing can be measured using an inclinometer probe.

BS EN ISO 18674-3:2017 says that before selecting the length of the gauge rod, the initial profile of the inclinometer casing should be measured using an inclinometer probe and used to select a gauge rod with an appropriate length and diameter for the range of measurement that is expected. The Institution of Civil Engineers' Specification for Piling and Embedded Retaining Walls goes further than this and says that "Non-torpedo type…shall be incorporated such that their effective gauge length is 0.5m and each gauge length jointed to the next gauge length to provide an accurate continuous deformation profile in orthogonal planes…"

References

BS EN 18674-3:2017 Geotechnical investigation and testing – Geotechnical monitoring by field instrumentation. Part 3: Measurement of displacements across a line: Inclinometers.

ICE Specification for Piling and Embedded Retaining Walls, Third edition. 2016.

For more information about inclinometer measurements visit our website at www.geo-observations.com

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