Rotation Errors

What is Rotation Error?

Rotation is a small alignment change in the measurement axis of the inclinometer probe. The change is usually less than one degree.

Ideally, the mechanicals of the probe are aligned so that the A-axis accelerometer measures tilt only in the A-plane.

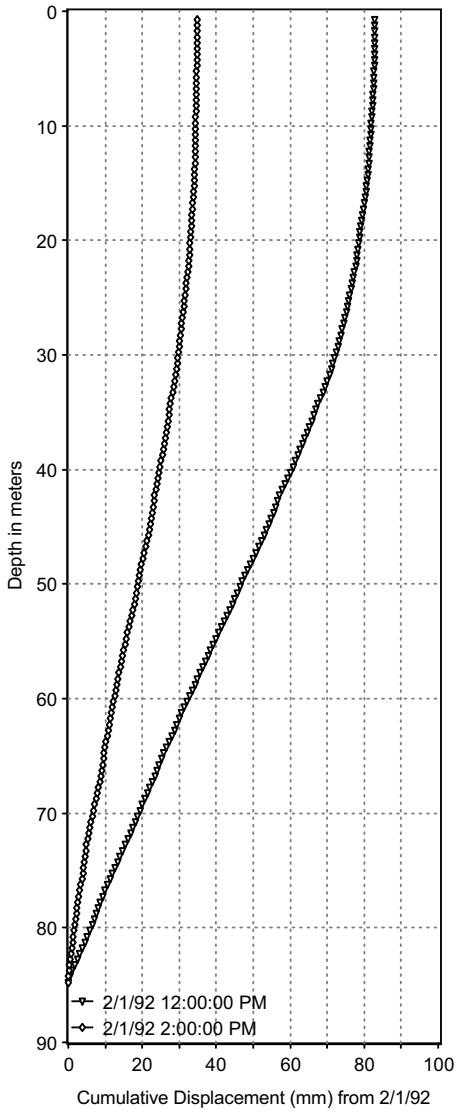
If the mechanicals of the probe are rotated slightly towards the B-plane, the A-axis accelerometer becomes slightly sensitive to tilts in the B-plane, too.

The B-component in the A-axis reading is rotation error. Rotation error is the cross-axis component in a reading.

Rotation error is responsible for the apparent displacements in the graph at right.

Rotation errors become important when two conditions combine:

1. There is significant inclination in the cross axis.
2. The alignment change occurs after the initial set was taken (otherwise, error would not be visible.)



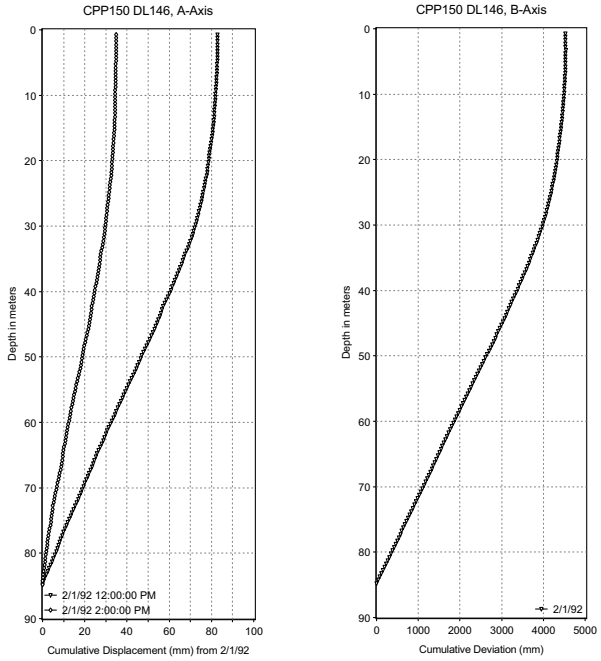
What Causes Alignment Changes?

The change in the alignment of the measurement axis is caused by:

- Wear and tear on wheel yokes and bearings. This affects A and B axis readings equally.
- Changes in the accelerometer's meter movement, usually caused by bumps to the probe. This affects A and B axis readings separately.
- Changes in the alignment of the accelerometer package within the probe. For example, a change typically occurs during a repair, when the accelerometer package is removed and replaced. The same effect can be produced by using different probes to survey the same inclinometer.

Identifying Rotation Errors

1. The cumulative displacement plot shows a curved line, when the line should be straight.
2. The cumulative deviation plot (profile plot) shows significant tilt in the cross axis.
3. The two plots have a similar shape.



Cumulative Displacement, A-Axis

Cumulative Deviation B-Axis

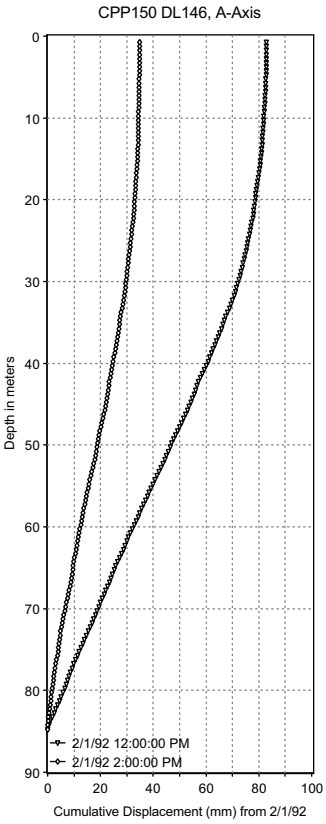
Correcting Rotation Error

Rotation errors are relatively easy to correct, using your inclinometer graphing program. Correction values will be different for different datasets.

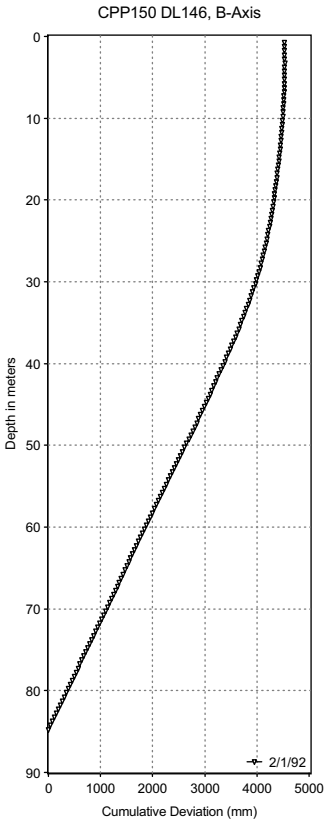
1. Display a cumulative displacement graph. Use datasets that contain the error.
2. Identify displacements that are produced by rotation error. Find the depth of the maximum error.
3. Display a cumulative deviation plot of the cross axis. Find the deviation value at the same depth noted above.
4. Divide the displacement value by the deviation value. The result is a starting value for correcting rotation.
5. In DigiPro, enable rotation corrections and enter the rotation value.
6. Apply the correction and inspect the redrawn plot. The curve in the line should straighten.

Rotation Error Example 1

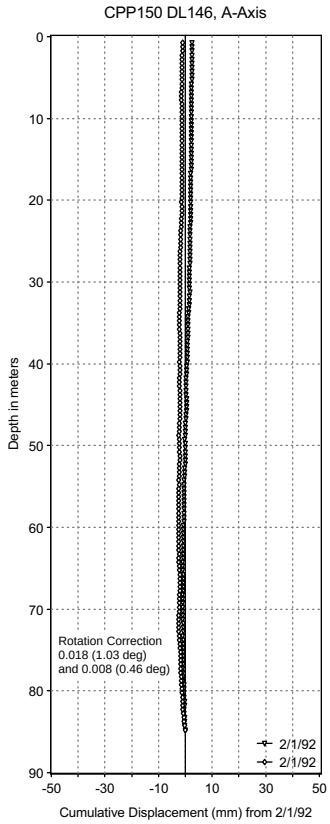
This example was a test of three inclinometer probes. Readings from two probes are plotted against the third probe. All readings were taken on the same day, so any displacement is error. The casing was tilted about 4 degrees in the B-axis, as shown in the B-Axis cumulative deviation plot. The similarity between the A displacements and the B profile signals rotation error. The corrected displacements are shown on the right. Correction values were 0.018 and 0.008 (1.03 and 0.46 degrees).



Cumulative Displacement Plot, A-Axis, Before Correction



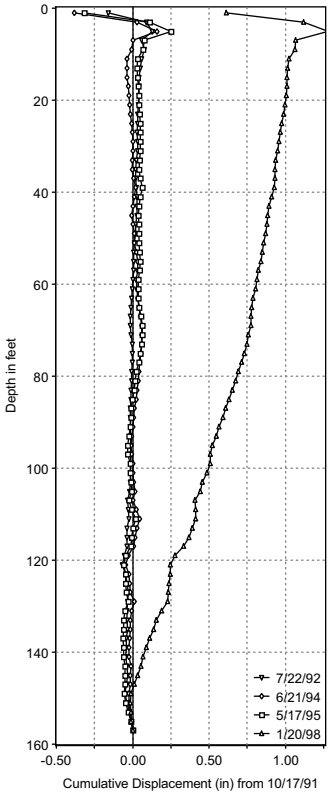
Cumulative Deviation Plot B-Axis



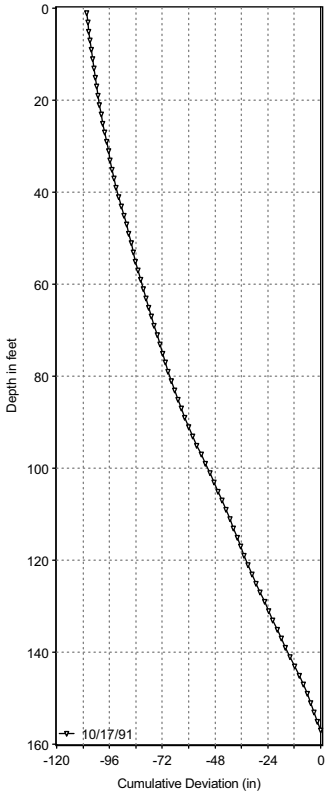
Cumulative Displacement Plot, A-Axis, After Correction

Rotation Error Example 2

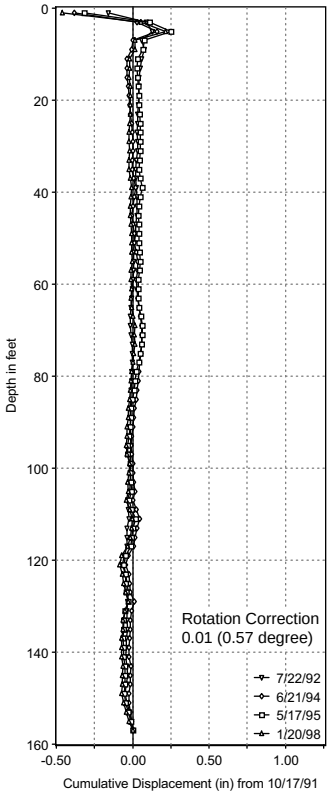
This example shows an uncorrected cumulative displacement plot of the B axis, the cumulative deviation plot of the A-axis, and finally the corrected displacement plot of the B axis.



Cumulative Displacement
B-Axis, Before Correction

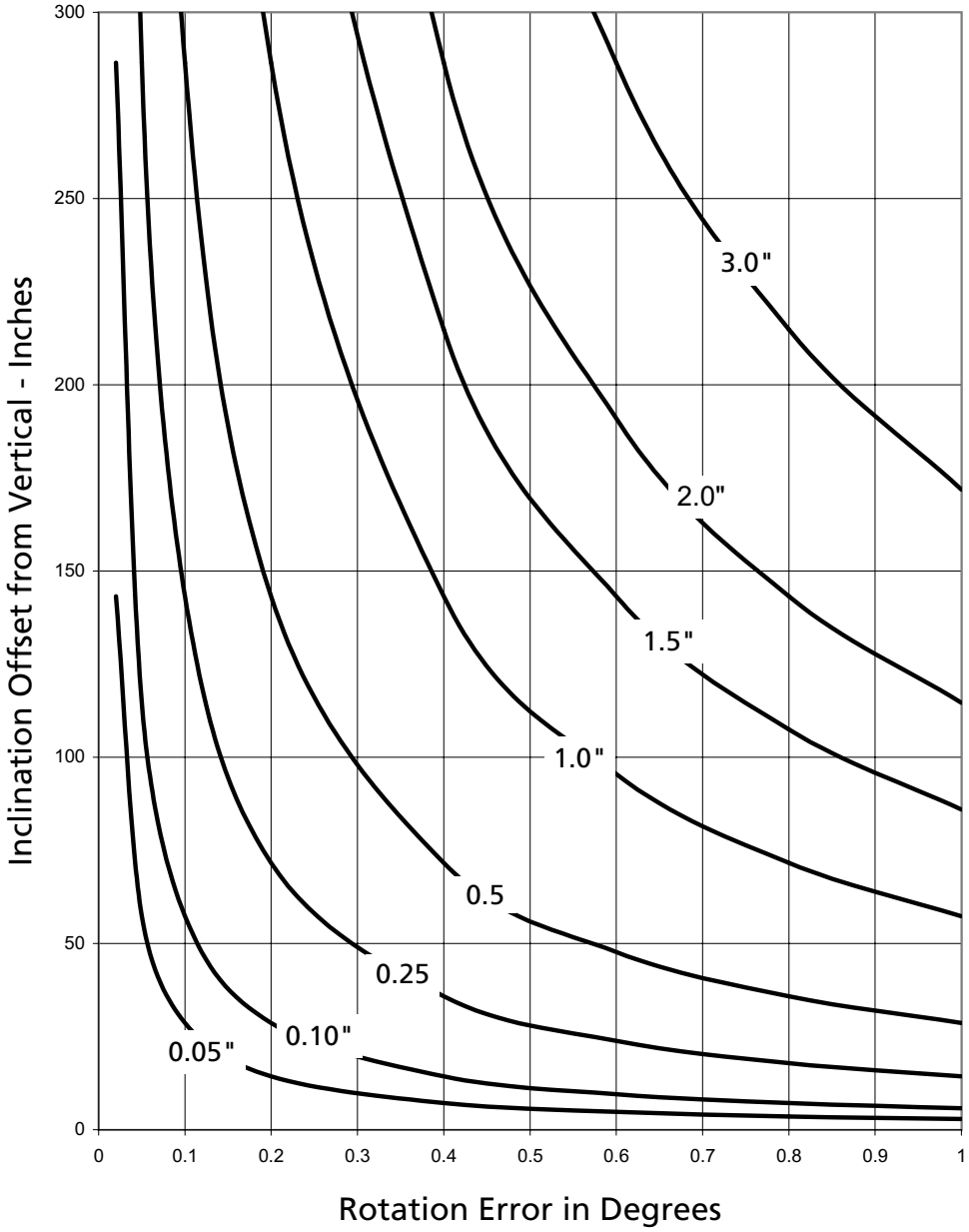


Cumulative Deviation
A-Axis



Cumulative Displacement
B-Axis, After Correction

Magnitude of Rotation Error



Rotation vs Spiral and Orientation Corrections

The term "rotation," as used by Slope Indicator, refers to a change in the measurement axes of the probe. There are two other phenomena that also involve a kind of rotation but have nothing to do with rotation error. These are spiral in casing grooves and orientation of casing grooves.

Spiralled Grooves: Inclinometer casing controls the orientation of the inclinometer probe. If the casing is spiralled, the resulting data will indicate incorrect magnitudes of tilt in the A and B measurement axes. (Note that there is no error in the resultant magnitude of tilt.) Correction for spiralled casing is not normally required. However, it is a good practice to measure spiral in inclinometers deeper than 200 feet long or in access pipe that is not controlled for spiral by the manufacturer.

Applying spiral data to the displacement results is normally not necessary, especially if there is no displacement and what is indicated is all due to systematic error. For small displacements in particular, just around the "ordinary" accuracy of the instrument, spiral correction mixes A-axis and B-axis data that may contain more significant systematic errors. Error detection and correction must be done prior to spiral correction.

Casing Orientation: Groove orientation correction can be useful for final presentation in a resultant displacement plot, but must not be applied before systematic error corrections are made. Again, A and B readings are mixed in the reorientation of the axes.