Bias-Shift Errors

What is Bias?

If you hold your inclinometer probe absolutely vertical and check the reading, you will typically see a non-zero value. This is the probe's bias.

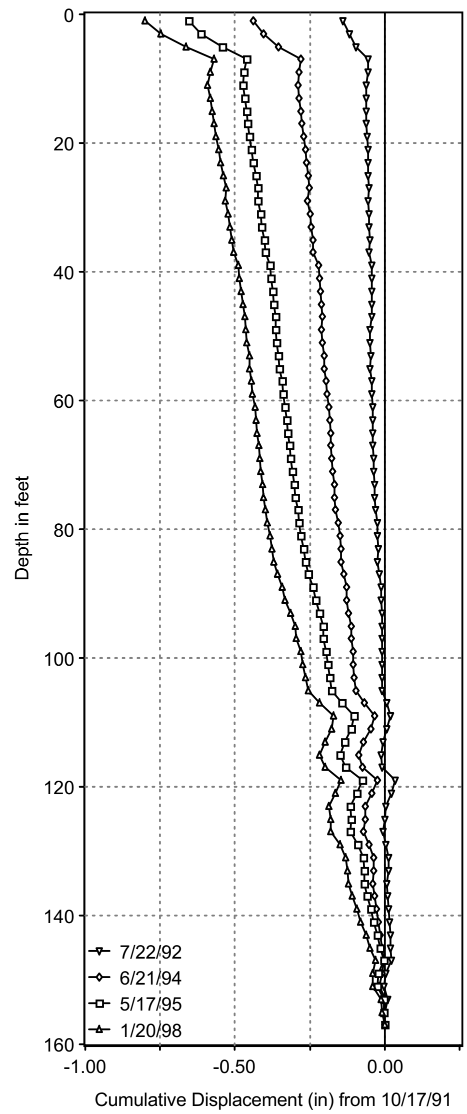
When the probe leaves the factory, it has a very small bias, but the bias shifts by the time the probe reaches the user. In fact, the bias shifts through the life of the probe.

Bias shifts are not normally a matter for concern because the value of the bias is effectively eliminated by the standard two-pass survey and data reduction procedure.

What is a Bias-Shift Error?

A bias-shift error occurs when the data reduction procedure is unable to eliminate the entire value of the bias. This happens when:

- A survey does not contain data for the second pass through the casing.
- The bias changes *during* a survey.



If the error is systematic, a constant value added to each reading. This adds a linear component to the plot. In the graph at right, each of the datasets includes a bias-shift error.

What Causes Bias-Shift?

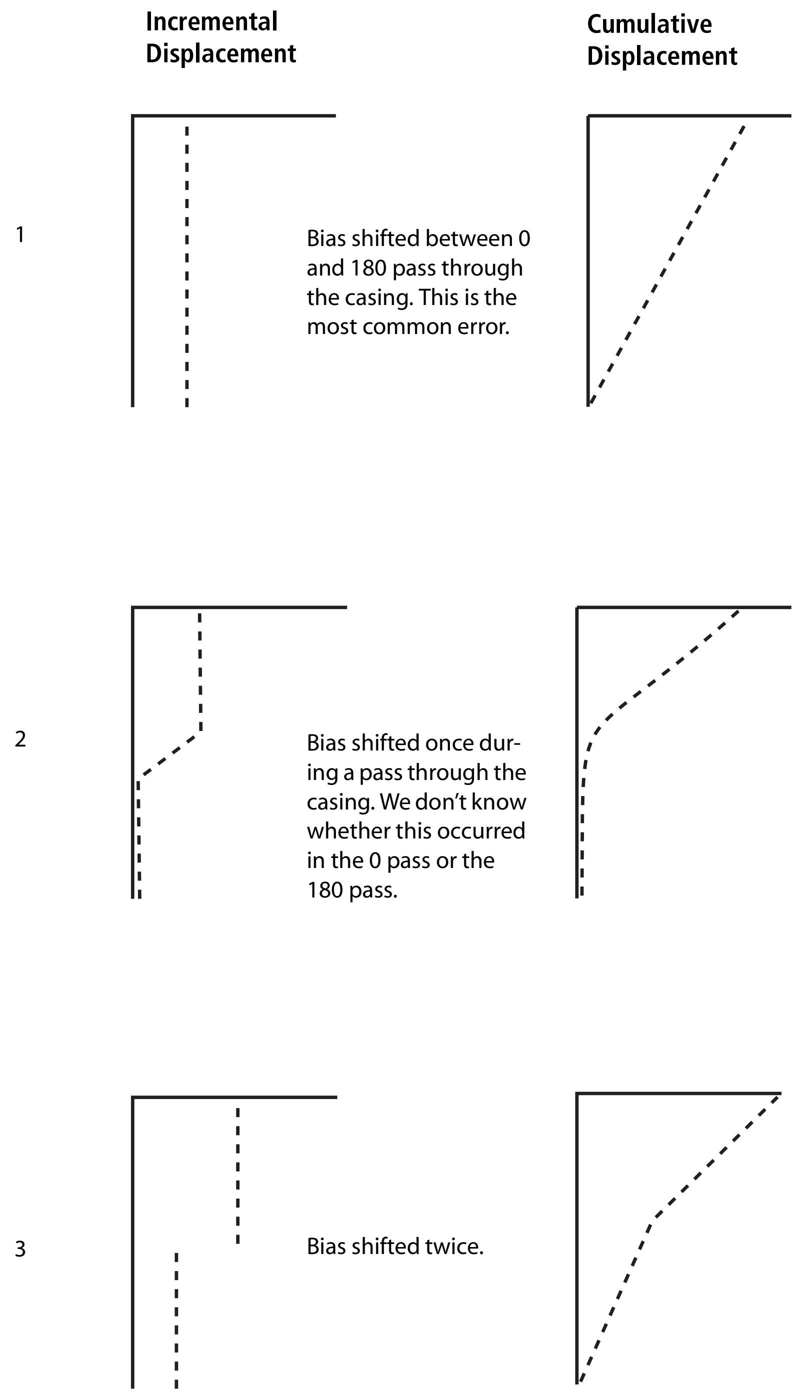
Rough Handling: Dropping the probe is certain to change the bias, and simply bumping the probe might change the bias. For example, the operator may bump the probe against the pulley assembly when he pulls it out of the casing to rotate it for the second pass.

Warm-Up Drift: Slope Indicator manuals ask users to power up the probe, lower it to the bottom of the casing, and then wait 5 to 10 minutes before starting the survey so that the probe can adjust to the temperature of the water and stabilize. If the warm-up period is omitted, readings taken during the first 5 or 10 minutes of the survey will include a drifting bias value. When plotted, the readings with the drifting bias will show apparent movement at the lower part of the borehole.

Identifying Bias-Shift Error

The drawings below show the typical patterns produced by bias-shift error when plotted as incremental displacement and cumulative displacement.

Checksums follow the pattern of incremental displacements. For type 1, the mean checksum remains relatively constant. This is the most common pattern and is easy to correct. For type 2, The checksum will shift once and then remain constant. For type 3, the checksum will change twice.



Correcting Bias-Shift Errors

Systematic bias-shift are easy to correct. You can use a graphing program such as DigiPro or GTilt to correct the error visually or to generate a displacement value for calculating a correction.

Correction values will be different for A and B data since they are generated by separate accelerometers. Correction values will be different for different datasets as well, unless they overlay each other.

Visual Correction

1. Using DigiPro or GTilt, display a cumulative displacement graph using datasets that contain suspected bias-shift errors.
2. Identify displacements that are produced by bias-shift error. For example, if the bottom 20 feet of the casing is installed in rock, any apparent displacement there is actually bias-shift error. The error typically appears as a straight line that is tilted away from vertical.
3. In DigiPro, enable offset (bias-shift) corrections and enter a value (typically less than 20). Enter a positive value if the tilt is positive (the right side of the plot) or enter a negative number if the tilt is negative.
4. Apply the correction and inspect the redrawn plot. The tilted line should be vertical when the bias-shift error has been corrected.

Calculated Correction

1. Display a cumulative displacement graph as above.
2. For each affected dataset, identify displacements that are really bias-shift error. Find the depth with the greatest cumulated bias-shift error.
3. In DigiPro, right click in the DataSets dialog to display a popup menu. Choose "Print Plotted Data".
4. On the printout, find the exact displacement value for the depth noted above. Also, count the number of intervals up to and including this depth.
5. Calculate an bias correction as shown below and enter the correction into your graphing program.

$$\text{English-Unit Correction Value} = \frac{\text{Bias-Shift Error}}{0.0006}$$

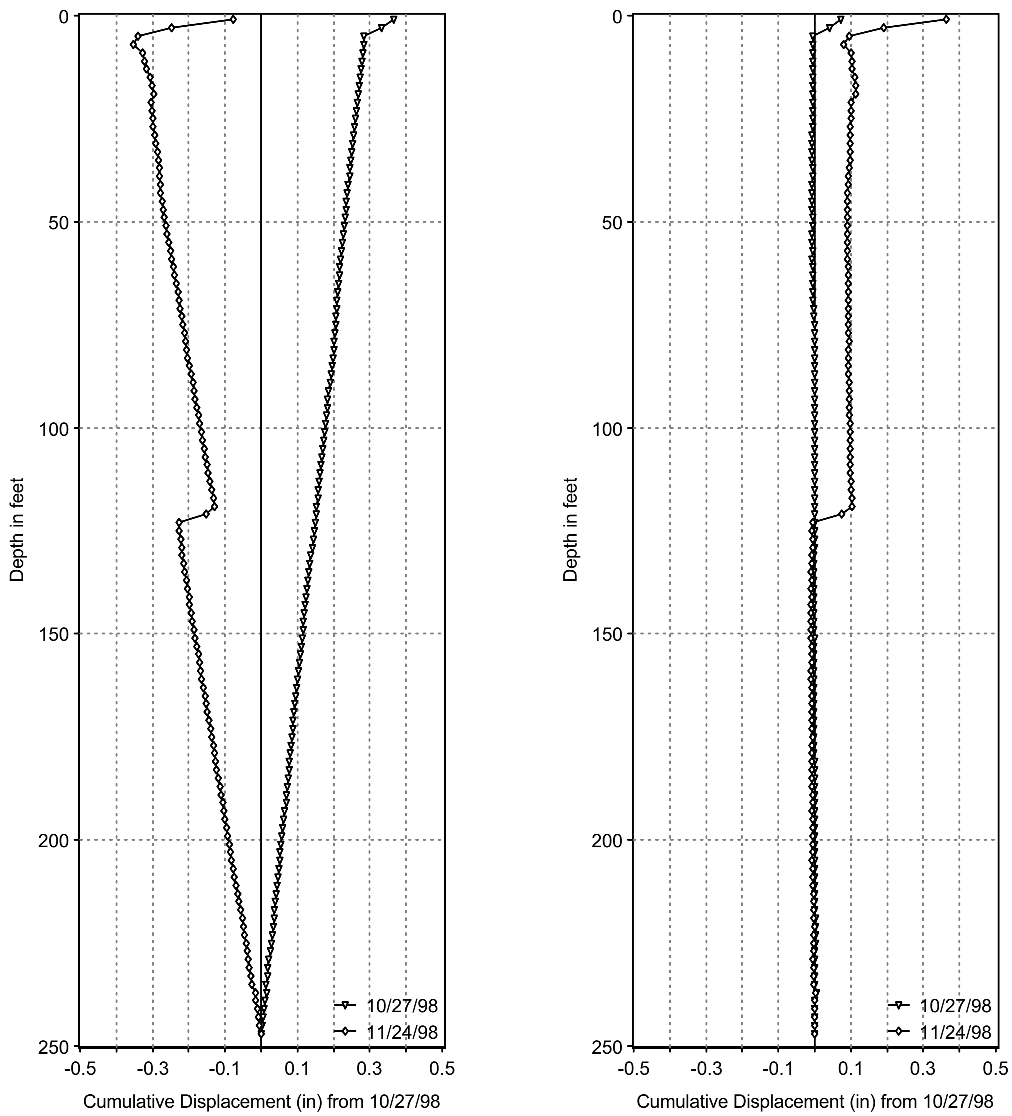
OR

$$\text{Metric Unit Correction Value} = \frac{\text{Bias-Shift Error}}{0.01}$$

$$\text{Bias-Shift Error} = \frac{\text{Cumulative displacement due to bias-shift}}{\text{Number of intervals}}$$

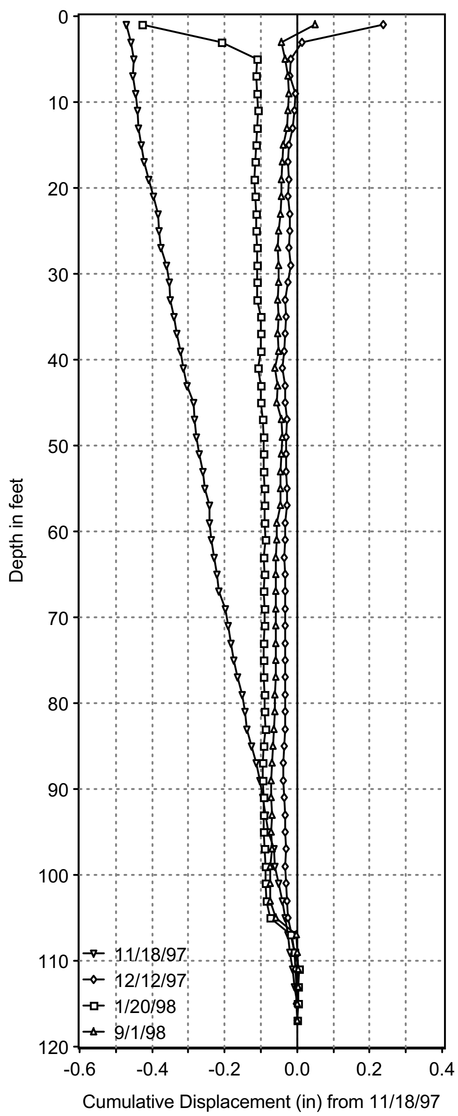
Bias-Shift Error Example 1

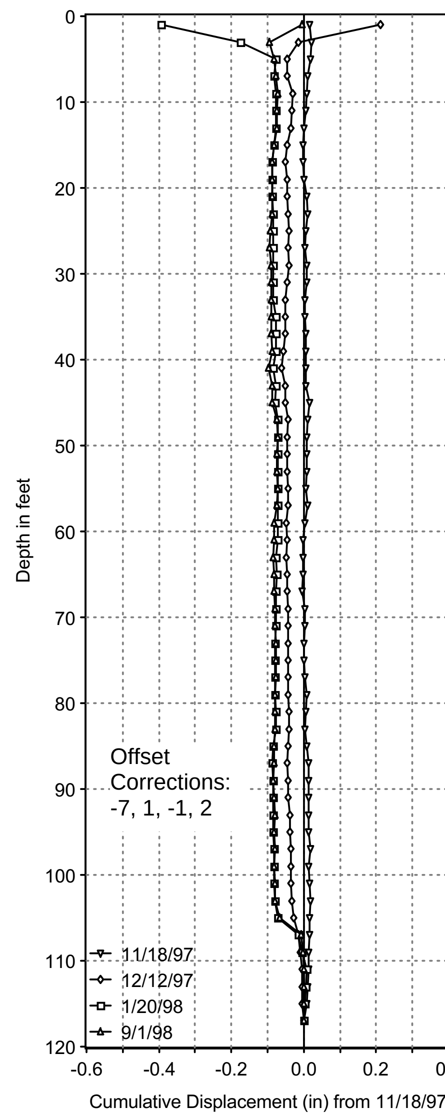
In this example, both datasets show bias-shift error.We see the typical linear pattern of bias-shift error. The second dataset was obtained the same day as the initial set, so movement is false. The third dataset shows movement in the opposite direction. The corrected plot is shown at right.



Bias-Shift Error Example 2

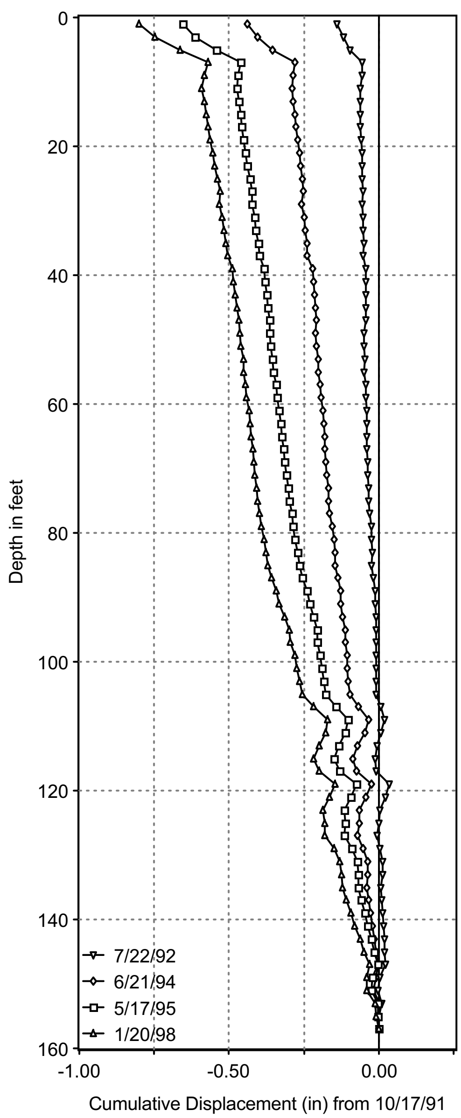
These datasets were obtained with an older probe, which generally performs well but has a history of producing bias-shift errors. The dataset with the most error was obtained on the same day as the initial and shows the linear pattern of bias-shift error. Bias-shift corrections for the other datasets are justified because they show an inconsistent movement.

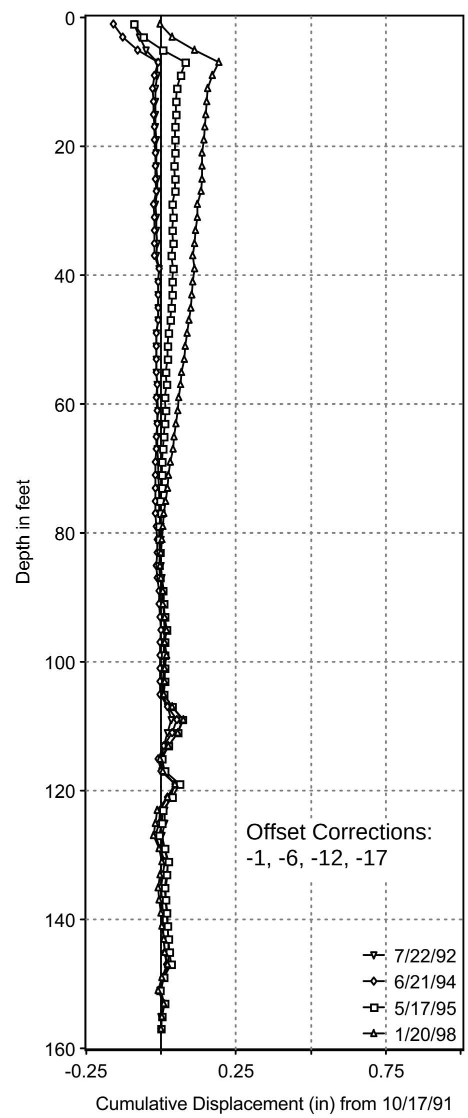




Bias-Shift Error Example 3

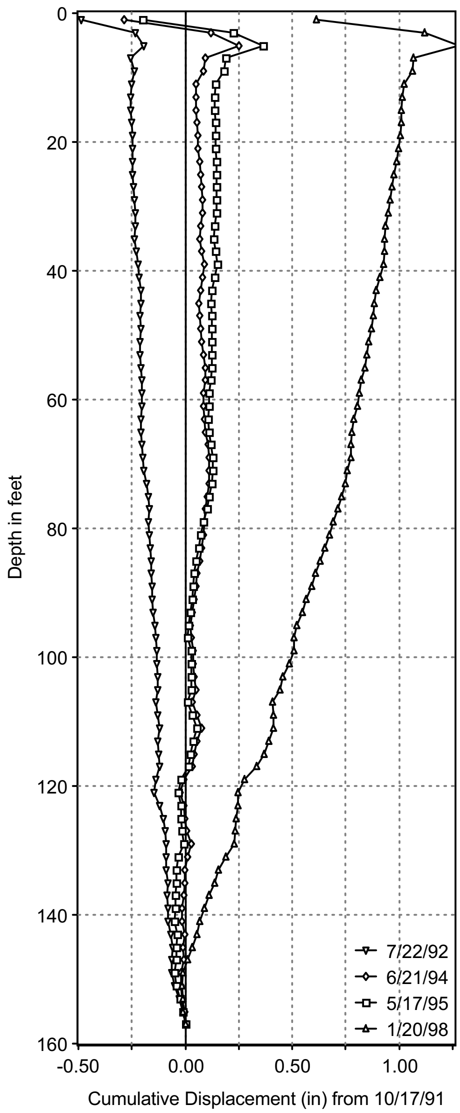
In this example, we see the linear pattern of bias-shift error. We also know that the bottom 80 feet of casing are stable. Thus we can safely enter correction values to make the plots vertical in that zone. The corrected plots are shown on the right. The “noise” in the stable zone probably originates in the initial dataset, but it is within the band of error.

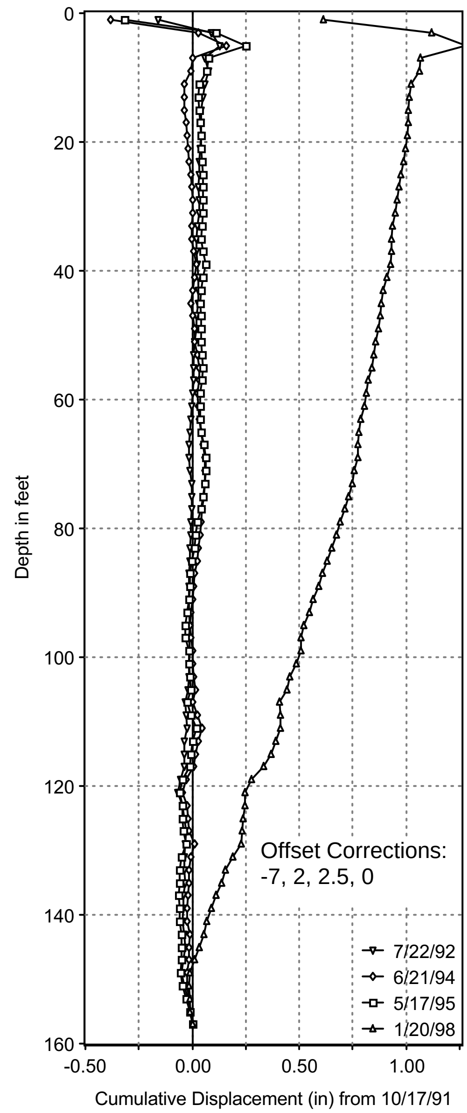




Bias-Shift Error Example 4

This is the B-axis of the same inclinometer shown in Example 3. Bias-shift corrections were applied to three of the datasets. The fourth set, from 1998, shows a rotation error.





Magnitude of Bias-Shift Error