Borehole Measurements

Solexperts provides services to measure the depth and position of boreholes and buried pipes. The wide range of available instrumentation allows selection of the correct measurement system to meet the specific site characteristics and conditions (borehole length, diameter, direction, type of casing).

The EZ-Trac is often used to measure boreholes and pipes without steel casing. The Maxibor and Gyrosmart are used to measure boreholes with steel casing. Vertical boreholes are measured with a special borehole inclinometer which uses installation rods to maintain the reference direction.

Applications of Borehole Position Measurements

- Survey measurements may be used to determine the positioning of exploratory boreholes relative to depth thus providing the locations of collected soil specimens relative to a future structure.
- Bearing capacity and effectiveness of earth and rock anchors can be influenced by the anchor’s relative positions. When new anchors are being added to a site it is important that they are correctly positioned to avoid impairing the performance of existing anchors.
- The position of boreholes used in the construction of pipe curtains, grouting and ground freezing must be within specified limits if a load-bearing arch or a continuous barrier against groundwater is to be successfully constructed. The same is true for monitoring boreholes which contain temperature measuring chains to overview ground freezing projects.
- The position of blasting drill holes must be accurately known for the planning of blast loads and the determination of blasting effects (dangers due to blasting operations, excavated mass of rock).
- By making directional measurements as the borehole is drilled the current position of the borehole can be checked in a timely manner. This allows corrective measures to be taken to adjust the drilling direction assuring that the desired borehole location is achieved.
Borehole Position Measuring Systems:

• **EZ-Trac**

The EZ-Trac probe is fitted with an electronic magnetic compass that determines the direction of the probe with reference to the Earth's magnetic pole. The strength of the Earth's in-situ magnetic field is recorded and is taken into account in the interpretation of the results. The EZ-Trac is used at sites where the disturbance to the Earth's magnetic pole is small. It cannot be used (or used only in a limited way) if the borehole has a steel casing or is in the proximity of earth anchors, pipe curtains, earth reinforcement, steel components or magnetically active rock. It is often possible to use the EZ-Trac if only the start of the borehole is cased because the disturbance to the Earth’s magnetic field decreases at depth. In this situation the position of the cased borehole section is determined by means of geodetic measurement and by extrapolation of the borehole direction from the undisturbed borehole section.

**Important characteristics:**

- Open uncased boreholes to great depths
- Probe size: Length: 1.03 m; diameter: 35 mm; the probe should be centred in the borehole when measured
- Accuracy: slope: +/- 0.25°, azimuth: +/- 0.35°

• **Gyrosmart**

The Gyrosmart probe determines the direction of the borehole using a gyroscopic compass. Within the probe a freely spinning gyroscope maintains the direction of its axis of rotation. The direction of the probe with reference to this axis of rotation is used to measure the direction of the borehole. Gyrosmart works independently of the Earth’s magnetic field and therefore exhibits no magnetic deviation. However, a deviation from the actual borehole direction can result from a rapid self-initiated movement of the measuring probe. Gyrosmart is used mainly in boreholes having a steel casing.

**Important characteristics:**

- Probe size: Length: 1.8 m; diameter: 40 mm; the probe should be centred in the borehole when measured
- Vertical boreholes can only be measured with the aid of a calibration device
- Accuracy: slope: +/- 0.2° azimuth +/- 0.5°
• Maxibor

Maxibor is an optical measuring deflectometer with an integrated angle gauge. The probe is moved in a stepwise manner along the borehole, one half probe lengths at a time. At each position the change in direction of the borehole with respect to the previous measuring section is determined. Maxibor works independently of the Earth’s magnetic field and therefore exhibits no magnetic deviation. Although the Maxibor can have a deviation from the actual borehole direction due to an accumulation of error along the borehole, its accuracy is quite high.

Important characteristics:
• The Maxibor is often used to measure cased, magnetically disturbed boreholes. Typical applications are sub-horizontal boreholes for anchors, pipe curtains and ground freezing
• Size of measuring probe: Length: 8.5 m or 6.5 m; diameter: 44 mm; the probe should be centred in the borehole when measured
• Limitation: Not suitable for boreholes that are vertical or inclined up to +/- 10° from the vertical
• Accuracy: 1/1000 of the borehole length, i.e. over a 100 m length of borehole it is +/- 0.1 m from the position of the borehole

Unique construction and measuring principle: An image of concentric rings is projected onto a sensor within the probe. The position of the projected rings on the sensor changes when the probe experiences a deflection while passing along the borehole. The position change allows the deflection to be measured.

• Borehole Inclinometer

The borehole inclinometer consists of a biaxial, high precision slope sensor. The probe is kept aligned using stiff torsion installation rods. The probe is fitted with a centring device and moved in a stepwise manner along the borehole. The influence of errors is largely minimised because each measurement of the borehole inclination is carried out at two positions.

Important characteristics:
• Suitable for the vertical direction and up to approx. +/- 10° from the plumb line. Both cased or uncased boreholes can be measured. This probe is used mainly for vertical boreholes up to a depth of about 50 m
• Probe Size: Length: 1.5 m; diameter: 70 mm; the probe should be centred in the borehole when measured
• Accuracy: slope: +/- 0.5 mm/m, azimuth +/- 2°, typical value for 30 m is +/- 20 mm
**Principle of Borehole Measurement**

The relative borehole position is given by section-wise measurements of the slope and direction (azimuth) over the length of the borehole. The position calculation assumes that the borehole is uniform between the measuring points. For determination of the absolute borehole position the coordinates, direction and slope at the start of the borehole must be taken into account. The starting slope is measured using a slope sensor and the direction is measured with an electronic magnetic compass, a gyroscopic compass, an angle gauge or a measuring rod.

**Data Acquisition, Evaluation and Presentation of Results**

The data from all the systems are electronically measured and stored. Measurements can be evaluated immediately after the survey is complete and the results can be displayed graphically and numerically. The borehole position with depth is given relative to a coordinate system or as a deviation from a given initial borehole direction and slope.