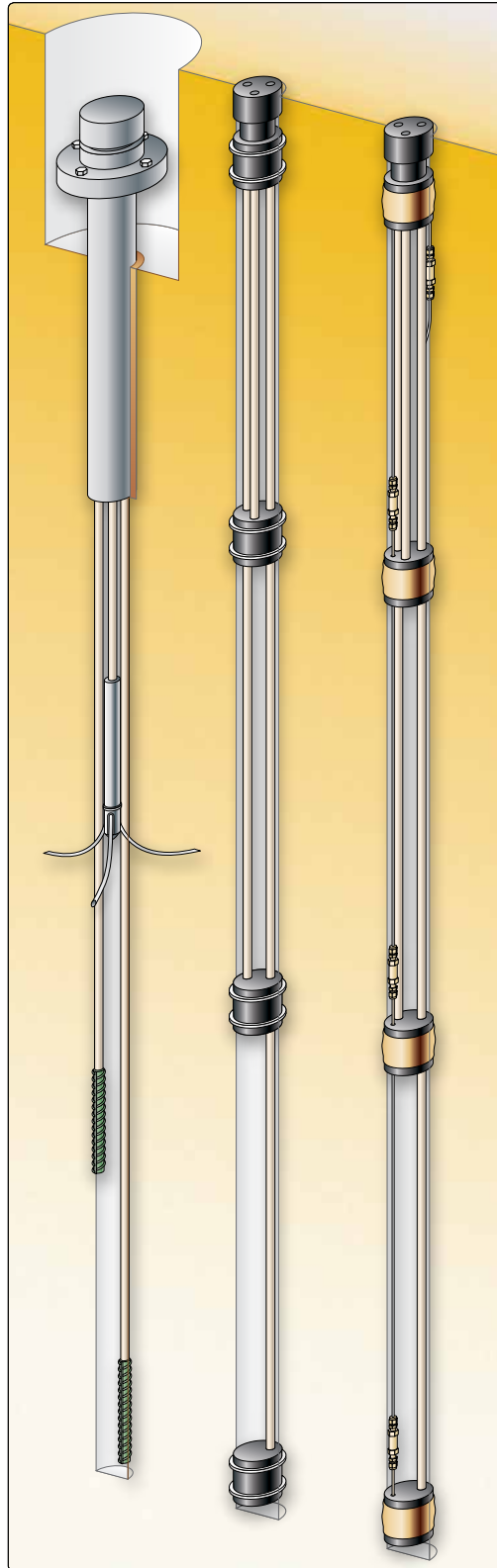


Rod-Type Borehole Extensometers

Applications

Rod Type Extensometers measure displacement or deformation in soil, rock and concrete structures. Typical applications include the measurement of...

- Ground movements around tunnels
- Deformation of dam abutments and foundations
- Ground movement behind retaining walls, sheet piling, slurry walls, etc.
- Ground movements in the walls of open pit mines
- Deformation of concrete piles (tell-tales)
- Fracturing in the roofs and walls of underground caverns
- Subsidence above tunnels and mine openings
- Settlement and heave of foundations in soft soil



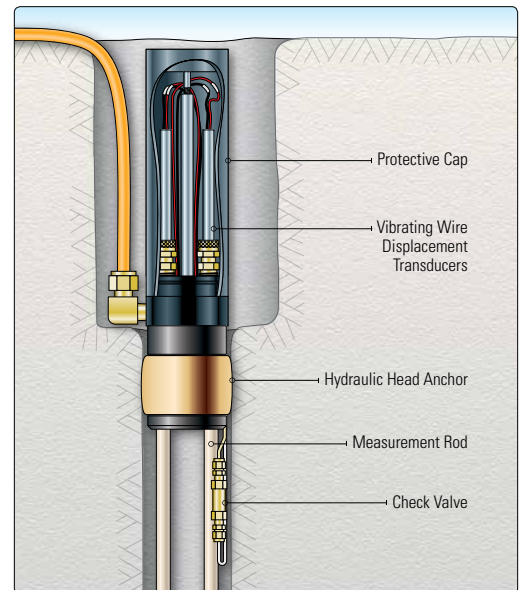
• Model A-3, A-4 and A-5 Multiple Point Extensometers (left to right).

Operating Principle

Rod Extensometers are usually installed in boreholes with from one to eight borehole anchors. Movement of rods attached to the anchors is measured relative to the head of the extensometer anchored at the mouth of the borehole and can be analyzed to reveal the magnitude of the deformation between the anchors.

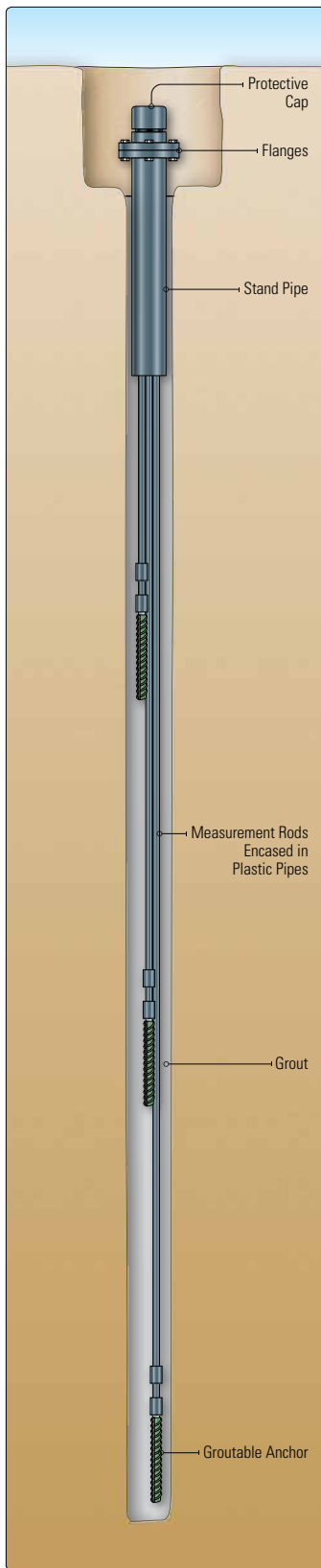
Installation is accomplished by assembling the anchors, rods and pipes outside the borehole, placing the assembly in the borehole then fixing the anchors in place. The head of the extensometer can be configured for manual readout using a dial indicator and/or for electronic readout using vibrating wire sensors, linear potentiometers or DC-DC LVDT's.

Two main types of extensometer heads can be identified. The Flange type is designed to sit on the surface of the rock, soil or concrete structure at the mouth of the borehole. The Flangeless type is designed to be recessed into the borehole or into an enlarged section of the borehole; usually to provide protection of the head from traffic, vandalism or from blasting, construction activity, etc.



• Flangeless type head assembly.

Model A-3 Multiple Point Groutable Anchor



● Model A-3 with groutable anchors.



● Groutable anchors.

The Model A-3 is the preferred design for installation in downward directed boreholes that are easily filled with cement grout.

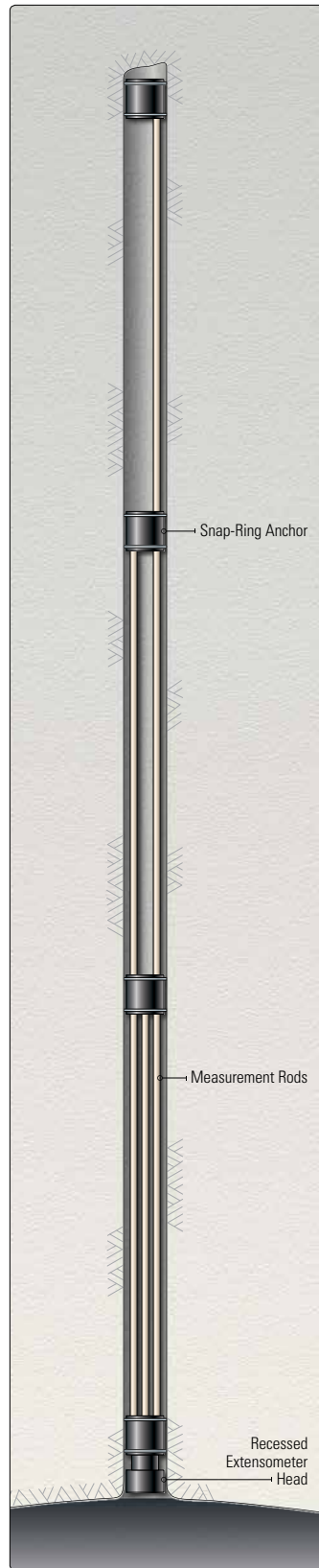
The borehole anchors of the Model A-3 are made from lengths of steel reinforcing bars, which are connected to the measurement rods. The rods are protected from the grout by plastic pipes to ensure their free travel.

Anchor movements are sensed mechanically using a dial indicator or depth micrometer, or electronically to measure the position of the top of the attached rod relative to a stainless steel reference plate in the head of the instrument. Up to six of these rod / pipe / anchor combinations of differing lengths can be installed in one borehole. This not only enables the measurement of the magnitude of any movements but also the location of any failure planes and zones of movements.

A special bayonet modification to the anchor will allow the measurement rod to be disengaged from the anchor and moved a known distance. With such a feature it is possible to check the correct functioning of the instrument during its working life, which adds to its reliability.

By means of flanges, the head of the extensometer is designed to fit a 3" standpipe that is firmly anchored in the mouth of the borehole at the surface.

Model A-4 Multiple Point Snap-Ring Anchor



● Model A-4 with snap-ring anchors.



● Snap-ring type anchor.

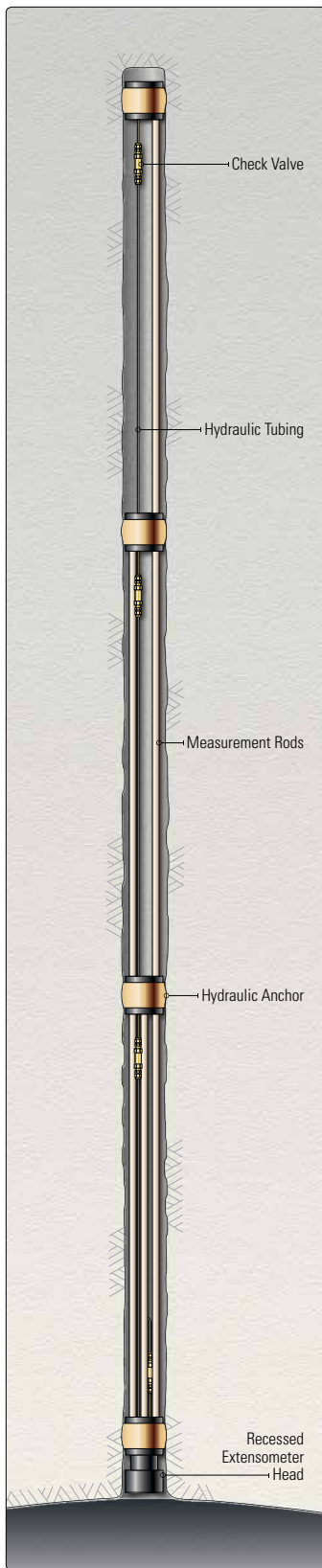
The Model A-4 is designed for upward directed boreholes, in hard or competent rock, that are smooth, uniform in diameter and will stay open.

Anchors are easily installed by pushing them to the required depth on the end of the setting rods and then pulling on a cord to remove the locking pin. This allows two retaining rings on each anchor to snap outward and grip the borehole. Up to eight anchors may be installed at various depths in the borehole.

Stainless steel rods from each anchor terminate in machined tips which rest inside the collar anchor. This collar anchor is set inside the mouth of the borehole, again using a snap-ring type anchor. If the mouth of the borehole is enlarged, a collar stabilization tube may be required; it is cemented inside the borehole to provide a good gripping surface for the collar anchor.

The collar anchor has a stainless steel reference plate containing holes through which the stem of a depth micrometer or dial indicator can be inserted to measure the position of the rod tips. Alternatively, or additionally, the collar anchor can be configured for electronic readout. Intermediate borehole anchors tend to support and space the longer rods, however additional spacers may be installed as required.

Model A-5 Multiple Point Hydraulic Anchor



● Model A-5 with bladder anchors.



● Bladder type hydraulic anchor.

The Model A-5 uses hydraulic borehole anchors and can be easily installed in boreholes oriented in any direction. They are particularly useful in boreholes which are fractured or oriented upwards and which are difficult to grout.

The hydraulic bladder type anchors consist of a spool of high strength plastic around which a sealed, pressure tight, soft copper tube is wrapped. Attached to the copper bladder is a high pressure nylon inflation line and check valve. The inflation of the anchors is accomplished with a hydraulic pump which causes the copper bladder to expand and “unwind,” filling the space between the spool and the borehole wall. The copper permanently deforms so that the shape does not change and the grip is not lost even if the check valve fails.

The hydraulic bladder type anchors are designed for nominal borehole diameters but can accommodate up to 30 mm of oversize without loss of grip.

Readout is achieved using dial indicators, depth micrometers or electronically.

Borros Type Anchors



● Single-action borros anchor before and after prong extension.

Borros type anchors are recommended for soft soils where deep penetration of the prongs is required for good anchorage.

With the borros type anchor, hydraulic pressure is applied to extend 3 (single action) or 6 (double action) prongs from the anchor body into the borehole

wall. Fully extended, the prongs protrude approximately 150 mm from the anchor body at 3 places, spaced 120° from one another. This helps to ensure positive, end bearing anchorage as opposed to friction bearing anchorage in the case of the bladder anchor.

Rod Types

Extensometer rods are 6 mm in diameter and are available in three different materials. The standard material is 303 stainless steel connected together using flush couplings in 3 meter or shorter lengths. Fiberglass rods may be substituted using continuous lengths as in the Model A-6 Extensometer. Carbon composite rods are recommended

where temperature effects need to be reduced to a minimum.

Long rods (i.e. 50 m to 100 m long) can be tensioned by means of springs inside the extensometer head. This has the effect of taking out any slack in the rods and improves the precision of the measurement (contact **GEOKON** for details).

Rod Properties

| Material | Diameter | Weight/ Meter | Young's Modulus | Temperature Coefficient |
|---------------------|----------|------------------|--------------------|----------------------------|
| 303 Stainless Steel | 6 mm | 0.25 Kg/m | 200 GPa | 17.5 ppm/°C |
| Fiberglass | 6 mm | 0.06 Kg/m | 20 GPa | 3.0 ppm/°C |
| Carbon Composite | 6 mm | 0.05 Kg/m | 130 GPa | < 1.0 ppm/°C |

Readout Instruments

Manual/Electronic

Manual readout is performed using the Model 1400-1 Dial Indicator (50 mm range) or 1400-4 Depth Micrometer (50-150 mm range).

Electronic readout is achieved using Model GK-404 or GK-405 Vibrating Wire Readouts (Model 4450) or the Model RB-100 Linear Potentiometer Readout (Model 1500). (See below).



• Model 1400-1 Dial Indicator (top) and Model 1400-4 Depth Micrometer.

Automatic Monitoring

Automatic monitoring is best accomplished using the Model 8021 or Model 8025 Dataloggers which can be configured to read at predetermined intervals, and to initiate alarms in the event threshold levels are exceeded. Alternatively, for extensometers installed in active roadways the Model 8026 Wireless Datalogger provides a convenient option.



• Model 8026 Datalogger and Model 1150 (A-3) Extensometer in manhole.

Sensors

Model 1450 DC-DC LVDT

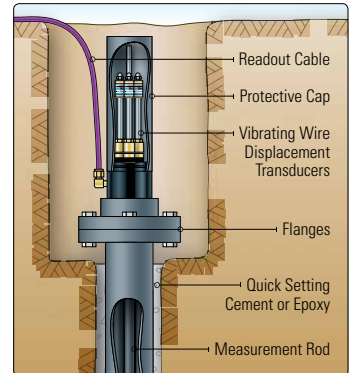
DC-DC LVDT's for dynamic and/or high temperature applications are also available. Standard ranges are 50 mm, 100 mm and 150 mm. Other ranges available on request.



• Model 1450 DC-DC LVDT

Model 4450 Vibrating Wire Displacement Transducer

The Model 4450 Vibrating Wire Displacement Transducer provides remote readout for **GEOKON®** extensometers. They are particularly useful where other types of Vibrating Wire sensors are used and for installations where long cable runs are required.



• Model 4450 Extensometer Head Assembly.

Model 1500

Linear Potentiometer

The Model 1500 utilizes a sturdy 6.5 mm diameter rod which protrudes from both ends as the actuating shaft. This facilitates connection of the linear potentiometer to extensometer rods and also permits a mechanical check on the readings using either a dial indicator or a depth micrometer.



• Model 1500 Linear Potentiometer pictured with Model RB-100 Readout.

Technical Specifications

| | |
|-----------------------|---------------------------|
| Standard Ranges | 50, 100, 150, 250, 610 mm |
| Least Reading | 0.025 mm |
| Accuracy ¹ | ±0.25% F.S. |
| Nonlinearity | < 0.5% F.S. |

¹Accuracy established under laboratory conditions. Accuracy of ±0.1% available on request.

Technical Specifications

| | |
|--------------------------------|--------------------------------|
| Standard Ranges ¹ | 12.5, 25, 50, 100, 150, 200 mm |
| Resolution | 0.02% F.S. |
| Accuracy ² | ±0.1% F.S. |
| Nonlinearity | < 0.5% F.S. |
| Temperature Range ¹ | -20°C to +80°C |

¹Other ranges available on request.

²Accuracy established under laboratory conditions.