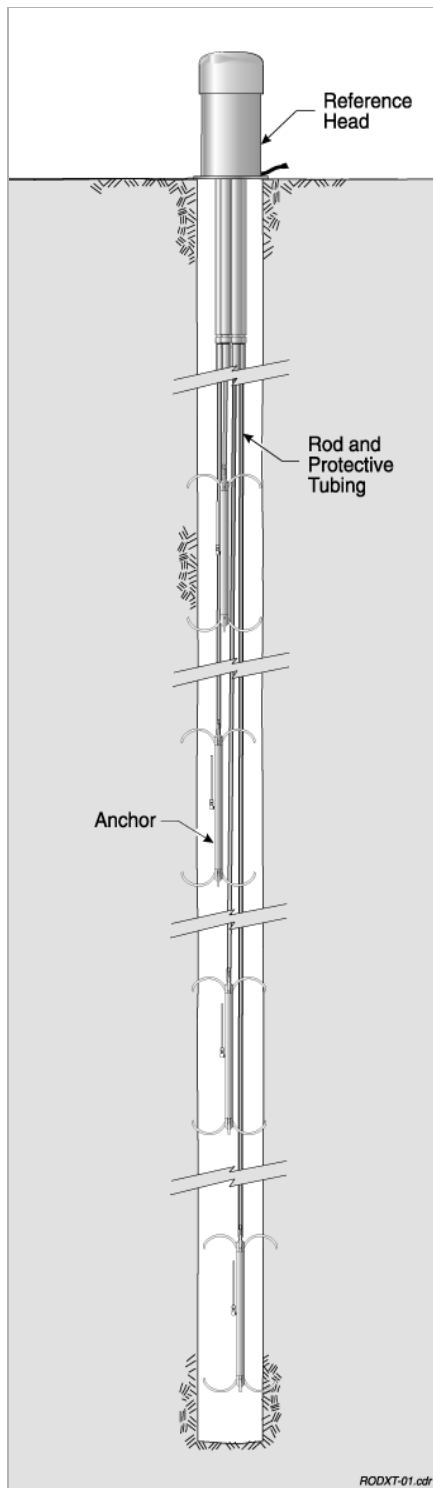


Rod Extensometer



Applications

The rod extensometer is installed in boreholes to monitor settlements in foundations, subsidence above tunnels, displacements of retaining structures, and deformations in underground openings.

Operation

The main components of a rod extensometer are anchors, rods inside protective pipe, and a reference head.

The anchors are installed downhole with rods attached. The rods span the distance from the downhole anchors to the reference head at the surface. The protective plastic pipe prevents bonding between rods and grout backfill.

Readings are obtained at the reference head by measuring the distance between the top (near end) of the rod and a reference surface. A change in this distance indicates that movement has occurred.

Movements are referenced to a stable elevation, typically a downhole anchor. The resulting data can be used to determine the zone, rate, and acceleration of movements, and to calculate strain.

Anchors

Anchors are selected to match field conditions. The groutable anchor is suitable for rock; the hydraulic anchor is suitable for soil; and the packer anchor can be used in either rock or soil. The packer anchor is especially convenient in jointed rock or non-cohesive soils, or where there is flowing water.

Rods

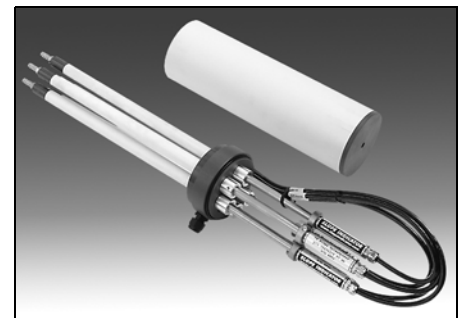
Rods are made of fiberglass or stainless steel. Fiberglass rod extensometers are assembled at the factory and shipped to the site, ready to install. The flexibility of these extensometers also makes them easier to install in confined areas, such as tunnels.

Stainless steel rod extensometers must be assembled on site. However, their stiffer rods can be used for deeper anchor depths. A table on the next page presents maximum recommended lengths for fiberglass and steel rods.

Reference Heads

Mechanical reference heads can be used when there is easy access to the extensometer. Measurements are obtained with a depth micrometer.

Electric reference heads are used when access to the reference head is difficult or where continuous monitoring is required. Measurements are obtained with displacement sensors and a readout or data logger.



PERFORMANCE NOTES

System Accuracy: The main variables in system accuracy are site conditions and the quality of the installation. In general, the best performance is achieved when the borehole is straight and rods are held in tension to keep them straight while the grout backfill cures.

Maximum Recommended Rod Length: In general, rods in tension can be longer than rods in compression, and steel rods can be longer than fiberglass rods. In non-vertical installations, friction between rods and the protective pipe becomes a limiting factor. The table below suggests maximum lengths for rods in tension and compression.

Max Rod Lengths: Tension / Compression		
Orientation	Fiberglass	Steel
Vertical Down	20 / 15 m	40 / 30 m
Vertical Up	45 / 30m	60 / 45 m
45° Down	25 / 20 m	40 / 30 m
45° Up	35 / 25 m	55 / 40 m
Horizontal	35 / 20 m	45 / 30 m

Number of Monitored Points: The rod extensometer can monitor up to six points. In practice, the number of monitored points is limited by the size of the borehole, the type of anchor used, the diameter of the protective pipe, and the amount of tubing required for activating anchors and grouting. The table below shows typical borehole requirements:

Monitored Points	Borehole Diameter	
	1 to 6 groutable or hydraulic anchors; 1 to 3 packer anchors	76 mm
4 packer anchors	101 mm	4"
6 packer anchors	126 mm	5"

ANCHORS

Groutable Anchor51815852
Made from rebar, 19 x 365 mm (.75 x 14.5").

Hydraulic Anchor51703952
Double-acting hydraulic anchor drives 150 (6") mm prongs into soil. 32 x 620 mm (1.25 x 24.5"). Requires hydraulic tubing & pump.

Packer Anchor, 1 to 3 points51804361
Packer Anchor, 1 to 4 points51804362
Packer Anchor, 1 to 5 points51804363
Packer Anchor, 1 to 6 points51804364

The packer anchor employs a geotextile bladder that is inflated with grout. Grout tubing is required for each anchor.

FIBERGLASS RODS

Fiberglass Rod51815855
Protective Tubing51815860
Rod Completion Kit51836240

Fiberglass rod has a diameter of 5 mm (3/16") and is supplied in continuous lengths. Protective polyethylene tubing is supplied in continuous lengths. Rod completion kit includes components for top and bottom of rod. Order 1 kit per anchor.

STAINLESS STEEL RODS

Stainless Steel Rod51704310
Protective Pipe51704321
Rod Completion Kit51836210

Stainless steel rod has a diameter of 6.4 mm (0.25") and is supplied in 10' lengths, each threaded and tapped for assembly. Protective pipe is supplied in 10' lengths and includes couplings. Requires PVC solvent cement, which can be obtained locally. Rod completion kit includes components for top and bottom of rod. Order 1 kit per anchor.

MECHANICAL REFERENCE HEAD

Single-Point Head51836110
Multi-Point Head51836120
Digital Depth Micrometer51809620

Single-point head works with 1 rod and anchor. Multi-point head works with up to 6 rods and anchors. Readings are obtained with depth micrometer. Digital depth micrometer displays readings in inches and millimeters. 150 mm (6") range, 0.01 mm (0.001") resolution.

ELECTRIC REFERENCE HEAD

Single-Point Head51836130
Multi-Point Head51836140
VW Sensor, 60 mm range52636305
VW Sensor, 100 mm range52636325
Potentiometer, 60 mm range51836152
Potentiometer, 100 mm range . . .51836154

Single-point head works with 1 rod and anchor. Multi-point head works with up to 6 rods and anchors. Displacement sensors are supplied with 0.6 m (2') of signal cable.

VW sensor provides resolution of 0.01% FS. Potentiometer provides resolution of 0.1% FS. Repeatability is better than ±0.5% FS.

Special ranges and waterproof ratings can be quoted on request.

VW sensors are read with a VW readout or a data logger: VW minilogger for single points or Campbell Scientific logger for multiple points.

Potentiometers are read with the Extensometer Indicator or a Campbell Scientific data logger.

SIGNAL CABLE

Signal Cable, 12-Wire50612512

Used between the reference head and the readout station. Accommodates up to 6 VW sensors or potentiometers. Shielded cable has twelve 20-gauge tinned-copper conductors and a polyethylene jacket.

Signal Cable, 4-Wire50613524

For one VW sensor. Not required if 12 wire cable above is used.

Signal Cable, 6-Wire53102900

For one potentiometer. Not required if 12 wire cable above is used.

Universal Terminal Box57711600

For use with portable readout. Not required with data logger. Splashproof fiberglass box is 290 wide x 345 high x 135 mm deep (11.5 x 13.5 x 5.25").

INSTALLATION ACCESSORIES

Pipe Adapter51835170

Optional adapter for anchoring reference head to 3" diameter steel pipe installed at collar of borehole.

Flange51836175

Optional adapter for anchoring reference head to concrete pad at borehole collar. 190 mm (7.5") plastic flange with 152 mm (6") bolt circle.

Grout Tubing50721008

Used to deliver grout from grout pump to borehole or packer anchor. 1/2" polyethylene tubing rated for 425 psi at 23 °C.

Grout Pump51815880

Manually operated pump used to inflate packer anchors. 15 bar (225 psi) maximum pressure, 19 liters per minute (5 gpm), 23 kg, 51 lb.

Hydraulic Tubing51702701

Used to activate hydraulic anchors. 0.25" nylon tubing filled with oil.

Hydraulic Anchor Tools51704600

Hydraulic pump with gauge, T-connection, oil volume indicator, 1 gallon of oil, and adapter for filling hydraulic tubing.

Spare Nut & Ferrule51703950

Replacement hardware for connecting hydraulic tubing to anchor.