In-Place Extenso-Inclinometer

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Numero 004
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STRUMENTI E MISURE GEOTECNICHE
E STRUTTURALI

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WARNINGS

This instrument must be utilized only for the application it has been designed for, OTR declines all responsability for any improper use.

Do not let the instrument fall into the hole quickly.

Do not put the instrument in flammable liquids or potentially explosive gases. Do not put the instrument in flammable liquids or potentially explosive gases.

Do not use the instrument in water where an electric dissipation is in progress.

Use protective gloves.

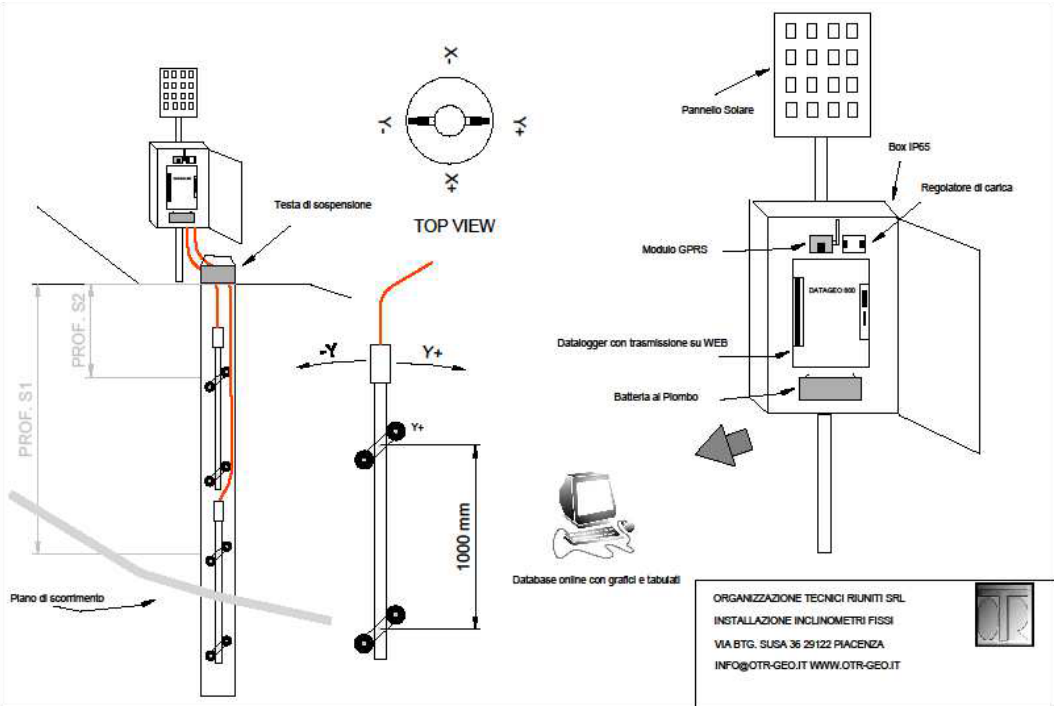
Furthermore

- Do not open the instrument, contact the manufacturer for checks and repairs;
- Keep out of reach of children;
- Do not connect the instrument to the readout unit with wet hands;
- Clean the instrument and its cable with alcohol or water, do not use acetone or aggressive liquids for plastics or labels;
- During the installation phase, disconnect the instrument from measuring devices or from any device connected to the AC power supply;
- Use surge arresters for installations with unprotected cables longer than 30 meters.

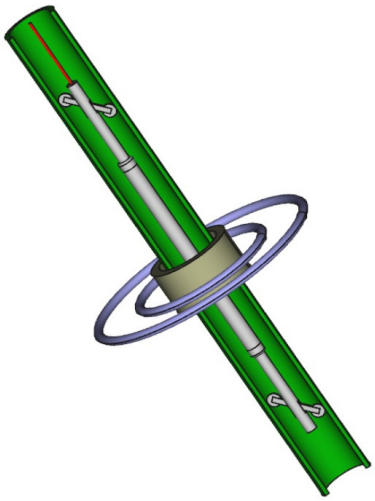
Application

The In-Place Extensometer and In-Place Extenso-Inclinometer are used for the continuous automatic monitoring of the inclination and settlement of an Extenso-inclinometer casing.
In particular it ca be applied in:

- walls and rock masses
- landslides and unstable slopes
- tunnels excavations
- bulkheads and levees
- earth and concrete dams
- foundations



Description



The In-Place extensometers and In Place Extenso-Inclinometers are designed to measure settlement (just extensor-sensor) and settlement + biaxial inclination (3D combined sensor). A robust stainless steel body ensure an instrument rugged and reliable.

Identification

Every bore hole extenso inclinometer or bore hole extensometer is identified by:

- Serial Number associated with a calibration chart;
- Model;
- Output details;
- Power supply

Technical Specifications

Voltage Supply	24 Vdc±10%
Current Consumption	Max 95 mA
Output	Incli ±4 Vdc, 280 mV/°, Est. 0-10 Vdc
Resolution	0.001° / 0.01 mm
Range	Incli ±10° Vdc, Est 0-100 / 0-200 mm
Material	Stainless Steel
Wheels step	1000 mm

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Installation

Before installing a vertical in-place extenso-inclinometer or a in-place extensonmeter, it is advised to take some measurements using a removable probe, so as to find the right depth and location at which the inclinometer probes will be positioned.
The 1000 wheelbase makes it easier to position the probe at the established depth. A steel wire connected to the top cap of the probe makes it possible to lower the inclinometer into the borehole and to suspend it at the proper depth.

The inclinometer sensors detect 2 axes. The Y-axis runs along the plane of the castor wheels, and the X-axis runs perpendicularly to the plane of the castor wheels.

For the probe installation, it is advised to acquire the following materials (which can be provided by OTR as accessories): top cap, steel wire (1.5 mm in diameter), and fastening clamps.
In order to install the instrument, proceed as follows:

- Cut a length of steel wire equal to the installation depth (+ 20 cm) of the first in-place probe (the one that is installed deeper down). Tie the cable in a loop around the suspension ring which is welded to the sensor cylinder. Tie the steel wire with a fastening clamp;
- Starting from the instrument, unwind the electrical cable and tape it to the steel wire every 1 to 2 meters;
- Prior to installing the instrument, take a control reading with the readout unit, positioning the instrument at a known angle and checking that the measurement taken by the readout unit is correct;
- Insert the in-place probe in the tube aligning the wheels with the groove, then lower the instrument to the selected depth using the steel wire;
- Route the steel wire at the center of the tube welded on the top cap. Create a loop in the cable, and clamp it with a fastening clamp after the in-place probe has reached the selected depth;
- Route the electrical cable over the top cap for the following wiring;
- Repeat all the steps above for all the in-place probes to be installed in the tube;
- After the installation has been completed, take some control measurements and write down the obtained values.

In case the instruments are removed, either for maintenance or to take measurements with a removable probe, remember taking measurements before and after repositioning the probes, so as to process data correctly.

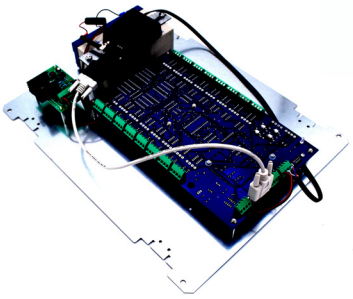
IMPORTANT ADVISE

To install an in-place extensometer it is very important to place the instrument where the magnetic ring is positioned:

- Position the instrument in the hole slowly one by one to intercept the ring to be monitored;
- Switch on the insturment with 24 Vdc and sign the position in whiche th extensometer output (yellow cable) is approxiamtely 5 Vdc ;
- Sign the rope where this output is 5 Vdc, repeat the operation for every sensor;
- at the end position all the instruments in the hole recording the zero value after installation.

Readout

Instrumental's mesurements should be done using a manual readout unit or a datalogger (best solution to the continuous parameter's monitoring) and espressed in electric uits (mV) or directly converted in angles (°).



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Taking Measurements

In order to take measurements, it is necessary to connect the instrument cable to the readout unit, following the instruction manual of the instrument in use:

- Whether the instrument is equipped with a uniaxial or biaxial sensor with output signal in mV, the wiring has to be carried out connecting the cable connectors according to their functions, which are shown below.

Extenso-Inclinometer model

Red Cable	= + 24 volt
Black Cable	= GND
Light blue Cable	= Y signal
Green Cable	= X signal
Yellow Cable	= Z signal (extensometer)
Shield	= Protective earth to connect to earth of datalogger

Only Extensometer model

Red Cable	= + 24 volt
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Data processing Inclinometers

The measurement of the local displacement of the in-place inclinometer is obtained by measuring the tension (mV) with the electrical inclination transducer for the X- and Y-axes, and then processing the data as a variation in the trim of the in-place inclinometer inside the tube where it is installed.

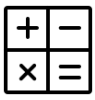
Depending on the instrument and the reading unit in use, the electrical measurement is expressed in mV to be converted in [°] degrees using the instrument's sensitivity factor shown on the instrument's calibration sheet (supplied by OTR):

Here follows an example of a conversion of electrical data (in mV) with a vertical in-place inclinometer equipped with a MEMS sensor.

Calculations and Formulas

According to the following definitions and given a generic reading

Yo= Y-axis inclination expressed in mV (reading "Zero" Yo) – along the plane of the castor wheels
Xo = X-axis inclination expressed in mV (reading "Zero" Xo) – perpendicular to the plane of the castor wheels



Y' = Inclination on the Y-axis expressed in in mV (reading "Performance" Y')
X' = Inclination on the X-axis expressed in in mV (reading "Performance" X')
1000 = 1000 mm wheelbase of the in-place probe

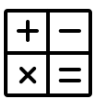
KY= Y axis sensor sensitivity factor
KX= X axis sensor sensitivity factor

Y axis local displacement:

$$\Delta IY = 1000[\sin(Y'/KY)-\sin(Yo/KY)] \quad \text{WITH } KY = mV/°$$

X axis local displacement:

$$\Delta IX = 1000[\sin(X'/KX)-\sin(Xo/KX)] \quad \text{WITH } KX = mV/°$$



Result of the local displacement of the in-place inclinometer probe on the Y-X plane, expressed in mm:

$$\Delta I = \sqrt{(\Delta IY^2 + \Delta IX^2)}$$

Direction of the local displacement of the in-place inclinometer probe on the Y-X plane, or azimuthal angle:

$$\theta = \text{arctg}(\Delta IY / \Delta IX)$$

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Data Processing Extensometer

The local settlement of the in place estensometer probe is obtained by measuring the voltage output (mV) of the electrical transducer and the data processing of the variation of the position of the probe inside the inclinometer casing.

Calculations and Formulas

Considering these definition of a measure:

E0 =of the settlement sensor in mV ("Zero Reading" E0)
E1 =Measure of the settlement sensor in mV ("Reading" E1)

ΔE = E1 - E0 = Differential measure in mV
Sensitivity (100 mm range) = 100 mV/mm (for 200 mm range this value is 50 mV/mm)

$$\text{Settlements} = \frac{E_1 - E_0}{\text{Sensitivity}}$$

A positive value represents a greater distance between head and reference ring (if the instrument is suspended from the top), a negative value represents a lower distance between head and reference ring (if the instrument is suspended from the top).