Marmota Engineering AG

marmota
geotechnical experts
fiber-optic monitoring

GeoScan

Soil-embedded distributed fiber-optic sensors
for monitoring pipelines, dams, embankments, railways and roads
endangered by soil movements

Technical Documentation & Application Examples

Content

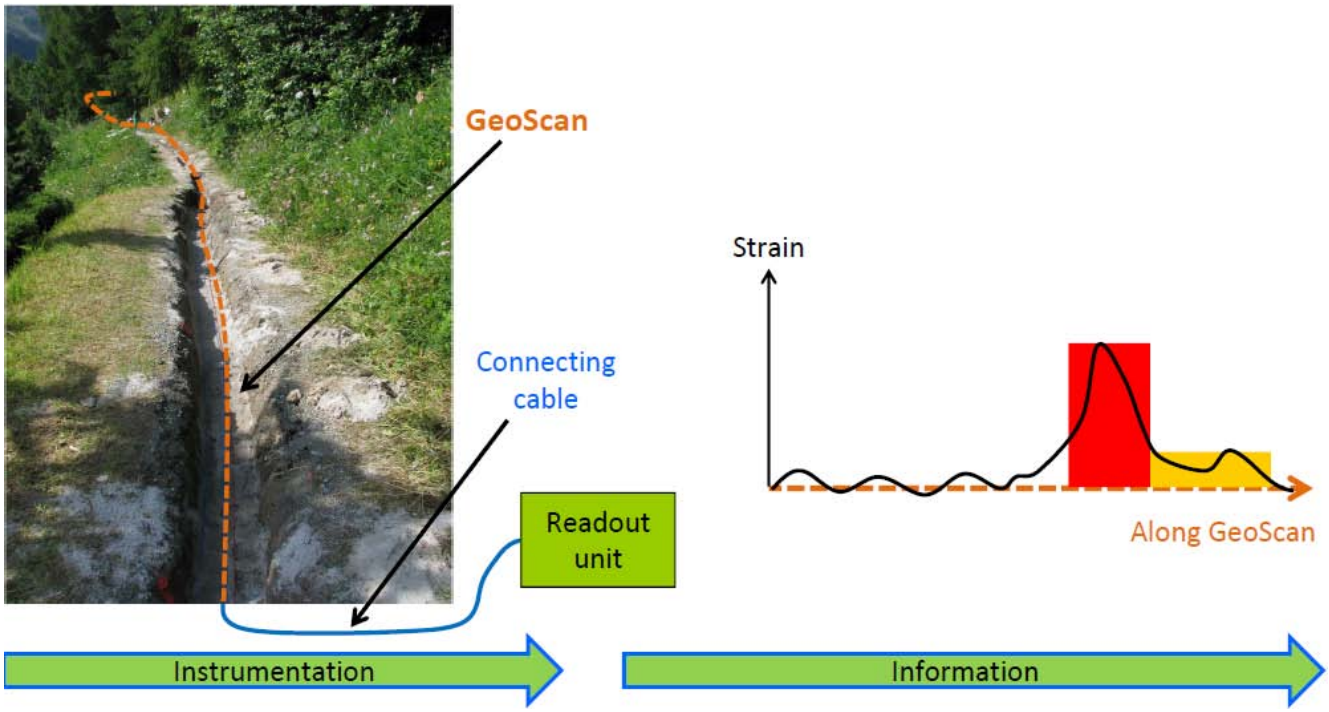
Marmota Product Overview

GeoScan
BoreScan
PileScan
StructureScan
TempScan

The system

Soil-embedded fiber-optic sensor connected to a readout unit

- Detection and quantification of ground movements (landslides, instabilities and settlements).
- Automatic measurement of strain in every meter along a sensor of up to 30 km length.
- Continuous monitoring (every few minutes) of sensitive infrastructure.
- Sporadic measurements (every few weeks or months).



The solutions

Large-scale site and infrastructure monitoring

- Site monitoring during construction and mining (urban tunneling, excavation and open-pit mine).
- Infrastructure lifetime monitoring (oil/gas/hydropower pipelines, high speed railway, embankment, tunnel and road).

The benefits

Cost-efficient and flexible high-tech solution for quicker problem detection

- Large amount of spatially resolved data (more than what you are used to get with your monitoring budget) leads to quicker problem detection.
- High flexibility to project specific requirements (sensor length, routing, extra sensitivity in delicate areas and possible connections to other Marmota products, e.g. TempScan or BoreScan). On-site adjustment possible.
- Automatic measurements by simply connecting to the cable, no manual labor required.
- The only practicable solution in some cases (e.g. for long, one-dimensional structures).

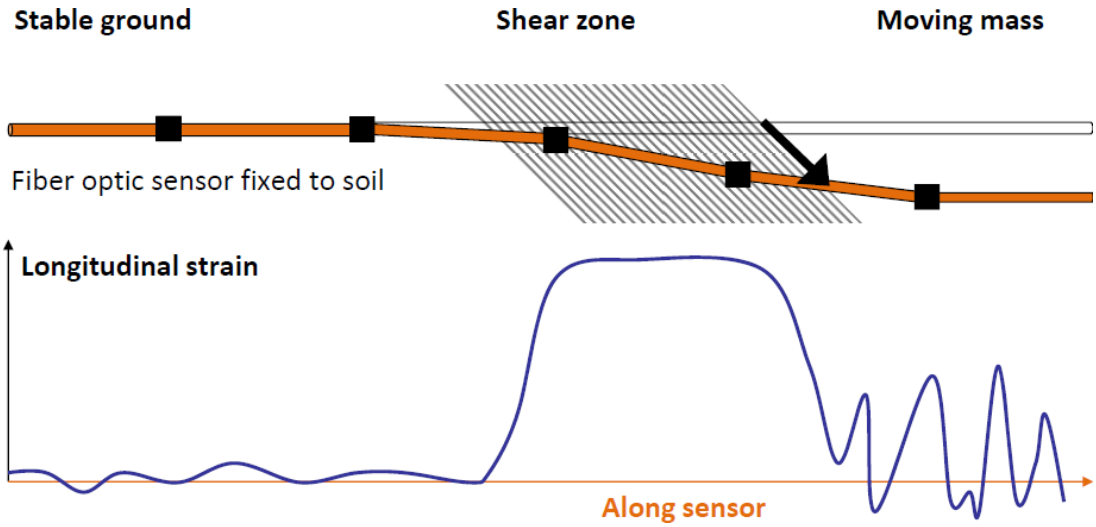
The GeoScan details

Principle

The principle of the GeoScan is that any differential soil displacement along the embedded sensor will eventually translate into longitudinal strain in the sensor. The strain is measured in every meter along the fiber-optic sensor. For example shown below is a distributed sensor passing from stable ground (basically no longitudinal strain) through a shear zone (large longitudinal strain) to a moving mass (irregular longitudinal strain).

Distributed fiber-optic technology

The GeoScan measurement technology is based on Brillouin scattering within the glass fiber (BOTDA/R). This technology allows for strain measurements with a readout resolution of 2 με (microstrains) (0.0002%) in every 1 m section of an up to 30 km long cable. The Brillouin scattering effect is also temperature sensitive. Thus, temperature compensation is necessary. The GeoScan includes a temperature sensing cable.



Three steps to the optimal GeoScan

Our background of several years on soil-sensor interaction studies and projects enables us to select the most efficient method of sensor fixation to soil for our client. The output is an optimum between sensor protection, ease of installation, and last, but not least, costs. The optimal GeoScan is achieved in three steps. Step 1 is the study of the project (may include a site visit) and the design of the system. Step 2 is the selection of the system components (choosing the best strain cables available, the fixations, protection and instruments) and possible preassembly thereof. Step 3 consists of the on-site instrumentation.

Fixation of sensor to soil

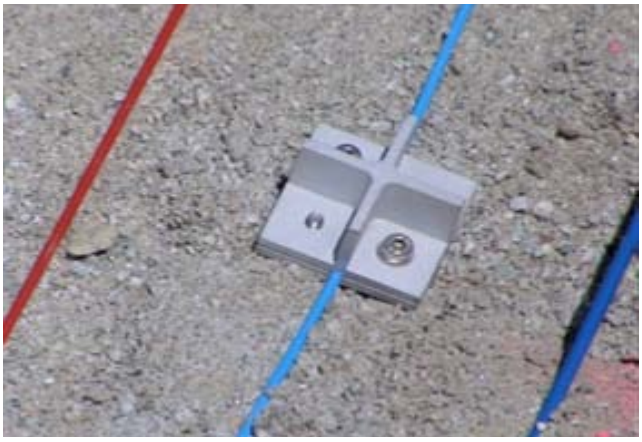
In order to make this principle work, the sensor must be fixed to the soil. Soil fixation is provided on a project specific modular basis. The sensor system parts are chosen according to the requirements: sensitivity, durability and costs. For example, fixation to soil can be achieved by: a very flexible sensor through friction, a “micro anchor”-cable system or a geotextile.

Installation

GeoScan installation steps:

1) Preparing ground
2) Sensor and fixations placing
3) Sensor pre-straining
4) Sensor-embedding
5) Cabling
6) Zero-measurement and monitoring

The installation may be carried out by the client, supervised by Marmota.



The GeoScan data

Technical specifications of the monitoring system

The sensitivity of the monitoring system depends on several factors: the fixation, the sensor itself and the expected direction of the ground movement. The GeoScan is designed based on the sensitivity and accuracy that is required for a specific project. The sensitivity is given in terms of movement detection (in mm) over the sensor gauge length (m).

Data and engineering interpretation

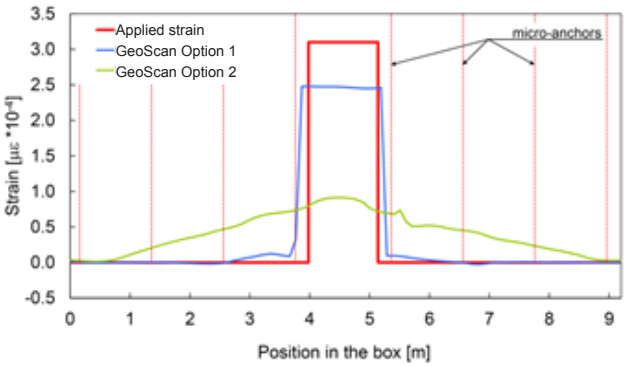
The data obtained is expressed as strain along the fiber-optic sensor. The data may be processed further considering the actual movement direction (e.g. downhill). Our goal is to provide easily interpretable strain and/or deformation data for the client.

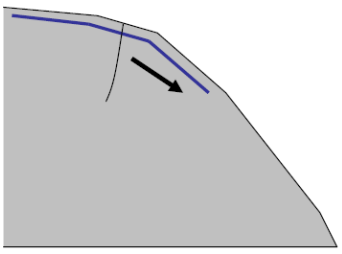
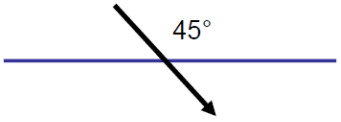
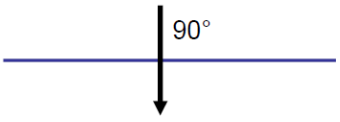
Sensor system calibration

Different configurations of the GeoScan were tested in a large laboratory shear box. The purpose was to demonstrate the functionality of the GeoScan, as well as to calibrate the various configurations. This allows Marmota to choose the best GeoScan setup for your project.

Threshold values

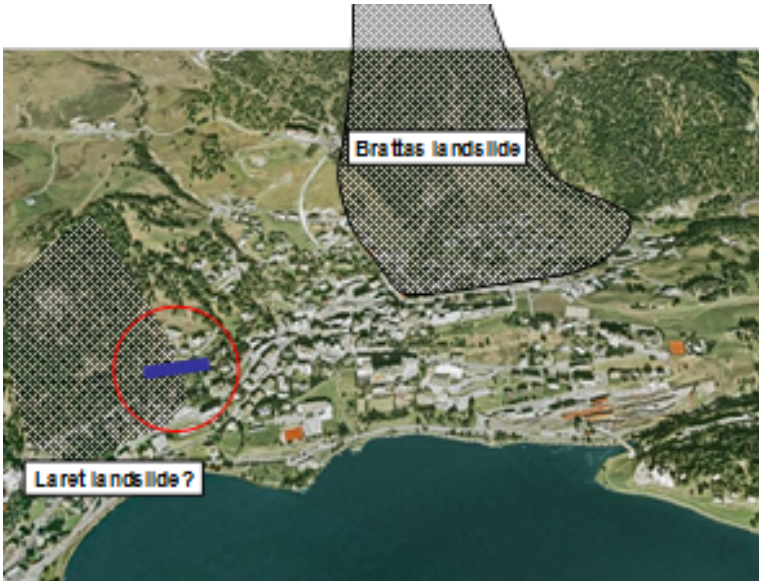
There is also the possibility of defining threshold values and setting up an alarming system.



Example	Sensor crossing a crack opening due to a creeping landslide. 	Sensor crossing a creeping landslide boundary at 45°. 	Sensor crossing a creeping landslide boundary at approx. 90°. 
Gauge length	1 m	1 m	1 m
System sensitivity	+/- 0.02 mm of soil movement	+/- 0.04 mm of soil movement	+/- 0.2 mm of soil movement
System accuracy	+/- 0.1 mm of soil movement	+/- 0.2 mm of soil movement	+/- 2 mm of soil movement +/- 0.2 mm with enhanced configuration
Sensor range*	+/- 20 mm of soil movement	+/- 40 mm of soil movement	+/- 200 mm of soil movement

Selected application examples

Creeping landslide monitoring, St. Moritz, Switzerland



Hydropower pipeline monitoring, Switzerland

Details of these projects and further examples, you can find on the Marmota Project reference sheets:
www.marmota.com/projects.php

The comparison

Distributed fiber-optic sensors deliver more data for your monitoring budget

Compared to traditional monitoring methods, such as inclinometer and geodetic measurements, the GeoScan provides lower costs per measurement point, faster data acquisition and the possibility of remote sensing. This is a clear advantage for large projects.

The sensitivity of a single measurement gauge is in the order of magnitude of the other methods. But with the large number of gauges aligned along the cable, the overall system sensitivity is significantly better. Furthermore, a continuous aligned sensor means that there are no gaps. This makes your project less vulnerable to unexpected happenings and the detection of hazard zones and ground movements can be carried out much faster and with a higher degree of localization.

The company

Geotechnical experts for fiber-optic monitoring

We are geotechnical engineers and therefore, able to understand the problems and challenges in your project. In combination with our state of the art technology, we can provide you well-functioning solutions of fiber-optic sensing for the harsh geotechnical environment.

Marmota is a Swiss company. We have strong links to one of the world's leading Technical Institutes (ETH Zurich) and the European fiber-optic sensing community (COST Action TD1001). Thus, for challenging projects, we can profit from the knowledge and expertise of these Institutions.

Have a look at our other technical documentations and consider choosing us as your fiber-optic sensing consultant. You will be pleased with our competent, friendly and prompt services.

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