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MONITORING OF THE CONSTRUCTION SUBLOT MAIN WORKS UNDERCROSSING ISARCO

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CONTRACT INFORMATION

Location: Brennero Base Tunnel lot Isarco
Customer: BBT se
Project start date: 2016

RECOGNISE

The required monitoring system involves the application of sensors capable of providing information such as: convergence measurements of the tunnel during the excavation phase, tensional state of the tunnel in the first phase and final, longitudinal deformations of the tunnel, pressures and loads of the first phase and definitive, contour deformations, excavation front deformations and final coating deformations. Outdoor measures of deformation and displacement of railway platforms, highways, state road, pylons, viaducts, decks, structures, subsoil.

PROJECT DESCRIPTION

Underground geotechnical monitoring aims at the following measures:

- Measurement of sprizbeton coating deformations by three-dimensional geodesic measurements of displacement with reflective target (convergence measurement points).
- Measurements of the movements of the cavity or of the deformations of the cluster by means of an incremental fiber optic strain gauge.
- Measurement of the stress of the spritzbeton coating by radial and tangential pressure cells.
- Measurements of the deformations of the final coating of concrete cast on site by means of geodetic measurements of three-dimensional displacements (convergence measurement points).
- Measurement of the stress of the final concrete coating cast on site by means of tangential pressure transducers, and strain meters with Optical Fiber with temperature compensation, drowned in concrete on the entire perimeter of the intrados and extrados cable.

For the undercrossing section of the Isarco River, it is planned to install longitudinal Fiber Optic strain gauge chains at the height of the Plan of the Centers, so as to be able to detect any tensions and displacements of the tunnel caused by the dragging of the river subalveum

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PROJECT DETAILS

The Isarco tunnel project envisaged:

1. Monitoring for tunnel sections under the River Isarco
2. Surface monitoring
3. Monitoring of attack sections, escarpments, third-party works, infrastructures
4. Monitoring of excavations of artificial tunnels
5. Monitoring of well excavations

1. MONITORING FOR TUNNEL SECTIONS UNDER THE RIVER ISARCO

For the interconnections of the tunnel, passing under the river Isarco have been provided:

- 4 convergence sections of the pre-coating
- 1 section of measurement of deformations/ tensions within the final coating by means of pressure cells and pairs of Fiber Optic strain meters chained along the entire ring of the final coating, with temperature compensation
- 19 thermometric probes, parallel to the axis of the tunnel, with a wheelbase of 2m, of length equal to the section subjected to freezing, with the aim of verifying the freezing of the soil, and its correct maintenance until the end of the excavation operations.

2. SURFACE MONITORING

Geotechnical monitoring on the surface has as its objective the following measures:

- Three-dimensional geodesic measurements on the surface and in the areas of the road and existing works.
- Measurement of the movements of the cluster by means of a fiber optic strain gauge-assestimeter from the surface.
- Spatial measurements of displacements.
- Measurements of elongations.
- Pressure measurements.

The infrastructures concerned are, above all, the 4 traffic infrastructures:

- Motorway A22
- SS12
- Existing RFI historical line
- RFI historical line moved

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3. MONITORING OF ATTACK SECTIONS, ESCARPMENTS, THIRD-PARTY WORKS, INFRASTRUCTURES

the project includes the following measurements and measurement methods:

- three-dimensional geodesic measurements of deformations of attachment sections, natural land escarpments and other artificial escarpments (studded walls, anchor walls, etc.);
- three-dimensional geodesic measurements of deformations on third-party works (e.g. buildings, walled canals, radio antenna pylons or pylons for overhead lines, or similar);
- three-dimensional geodesic measurements of deformations on infrastructures, together with the related works (e.g. A22 motorway, SS12 state road, RFI historical line, canals, any lines, etc.);
- three-dimensional geodesic measurements of deformations/subsidences of the countryside plane;
- measurements of the subsidence of the ground floor by means of strain gauges (assestimeters) placed along cross-sections to the axis of the natural tunnels.

The monitoring subsystem of the **area north of the River Isarco** consists of:

- 134 reflective points installed on the ground or on elements of road infrastructures (barriers, handrails, etc.), arranged in transversal and longitudinal alignments to the road infrastructures, extended to the North Entrance area with longitudinal and transversal alignments to the natural tunnels;
- 42 reflective points installed on structures (pylons, walls, etc.);
- 3 workstations equipped with Robotic Total Stations, equipped with data acquisition units and fiduciary reference points;
- 14 deep strain gauges equipped with 6 bases, of variable depth in correlation with the project, with the lower base placed at the height of the iron plane of the natural tunnel, and the subsequent 5 at step 1 meter towards the surface. Each workstation is implemented with a single Data Acquisition and Transmission Unit. The strain gauges will be aligned on n.03 cross-sections to the natural tunnels, and placed at a distance between 10 and 15 meters from the axis of the natural tunnels themselves.

The monitoring subsystem of the **area south of the Eisack River** consists of:

- 124 geodetic control points, materialized by means of special frames installed at the railway platform, for the monitoring of the existing Historical Line;
- 100 geodetic control points, materialized by means of special frames installed at the railway platform, for the monitoring of the moved Historical Line (100 of which prepared by reusing those previously installed for the existing line);
- 136 geodetic control points installed on the electrical voltage poles of the existing Historical Line;
- 128 geodetic control points installed on the electrical voltage poles of the moved Historical Line (128 of which prepared by reusing those previously installed for the existing line);
- 77 reflective points installed on the ground, in longitudinal and transverse alignments to the tunnels;
- 30 geodetic control points installed on structures (pylons, walls, etc.);
- 05 workstations equipped with Robotic Total Stations, equipped with data acquisition units and fiduciary reference points;
- 01 monitoring system with fiber optic technology of the distributed type, consisting of 2327 meters of optical fiber implemented with strain and temperature sensors, n.01 Data Acquisition and Transmission Unit, for the control of the railway platform of the existing Historical Line;
- 01 monitoring system with fiber optic technology of the distributed type, consisting of 2220 meters of optical fiber implemented with strain and temperature sensors, n.01 Data Acquisition and Transmission Unit (providing for the reuse of the Data Acquisition Unit referred to in the previous point), for the control of the railway platform of the existing Historical Line;
- 06 deep strain gauges equipped with 4 bases, of variable depth in correlation with the project, with the lower base placed at the height of the iron plane of the natural tunnel, and the subsequent 3 at step 1 meter towards the surface. Each workstation is implemented with a single Data Acquisition and Transmission Unit. The strain gauges will be placed at a distance between 10 and 15 meters from the axis of the natural tunnels.

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4. MONITORING OF EXCAVATIONS OF ARTIFICIAL TUNNELS

The following measurements and measurement methods are envisaged:

- measurements of deformations in the support structure of the excavations with geodetic measurement procedures (three-dimensional trigonometric measurement) and measurements with inclinometers;
- measurements of stresses in struts;
- measurements of deformations (measurements of lifts and failures) with geodetic measurement procedures (trigonometric measurement) inside and outside the excavation.

The monitoring subsystem consists of 11 instrumented sections, each consisting of:

- 2 automated biaxial vertical inclinometers, each implemented with n.03 probes with a 3-meter pitch, installed in the support works of the tunnel;
- 1 load cell installed on the summit strut;
- 4 geodetic control points for the control of support works;
- 1 Data Acquisition and Transmission Unit.

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5. MONITORING OF WELL EXCAVATIONS

The following measurements have been carried out

- measurements of deformations in the support structure of the excavations with geodetic measurement procedures (three-dimensional trigonometric measurement) and measurements with inclinometers;
- measurement of tensions in metal profiles placed inside the sub-masonry;
- measurements of interstitial pressures and groundwater level by piezometers.

The monitoring subsystem for the even Nord Binary Well consists of:

- 6 inclinometer columns with a depth of 35.0 meters, for manual measurements, installed on the back of the perimeter of the well;
- 12 topographic aims placed on the top curb, placed at a wheelbase of about 10.0 meters;
- 8 load cells installed at a junction plate between the reinforcing profiles of the curbs; the position will be approximately above the key cap of each fornix;
- 1 Data Acquisition and Transmission Unit

The monitoring subsystem for the even Sud Binary Well consists of

- 6 inclinometer columns with a depth of 35.0 meters, for manual measurements, installed on the back of the perimeter of the well;
- 14 topographic aims placed on the top curb, placed at a wheelbase of about 10.0 meters;
- 8 load cells installed at a junction plate between the reinforcing profiles of the curbs; the position will be approximately above the key cap of each fornix;
- 1 Data Acquisition and Transmission Unit.

The monitoring subsystem for the Odd Track Well North consists of:

- 6 inclinometer columns with a depth of 35.0 meters, for manual measurements, installed on the back of the perimeter of the well;
- 10 topographic aims placed on the top curb, placed at a wheelbase of about 10.0 meters
- 8 load cells installed at a junction plate between the reinforcing profiles of the curbs; the position will be approximately above the key cap of each fornix;
- 1 Data Acquisition and Transmission Unit.

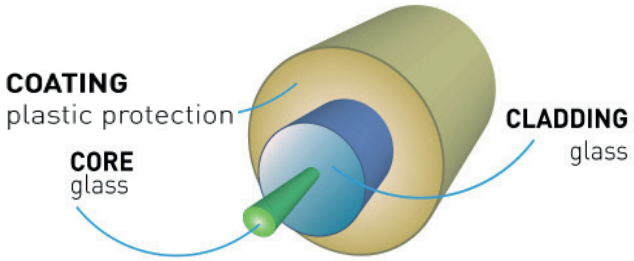
The monitoring subsystem for the South Odd Binary Well consists of:

- 5 inclinometric columns with a depth of 35.0 meters, for manual measurements, installed on the back of the perimeter of the well;
- 13 topographic aims placed on the top curb, placed at a wheelbase of about 10.0 meters;
- 8 load cells installed at a junction plate between the reinforcing profiles of the curbs; the position will be approximately above the key cap of each fornix;
- 1 Data Acquisition and Transmission Unit

The subsystems are complemented by:

- 2 piezometers in the South Entrance area, manually readable and equipped with Casagrande cell located at 30.0 meters and Open Tube up to a depth of 15.0 mt.
- 1 piezometer in the North Entrance area, manually readable and equipped with Casagrande cell located at 30.0 meters and Open Tube up to a depth of 15.0 mt;
- 20 topographic aims installed on the ground in the South Entrance area.

THE FIBRES STRUCTURE



DIAMETER
Core: 5-9 µm
Cladding: 125 µm
Coating: 170-250 µm

COMPARISON
Human hair:
About 90 µm

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WHY CHOOSE "OF" SYSTEM

Optical fiber sensing is a passive measuring instrument, immune to the environment, long-lived, eco-sustainable and with reduced maintenance costs. Buildings, roads, bridges, tunnels, railways, trains.

Vehicles in constant motion, people on the street, operators at work. In a world in constant activity and movement, monitoring infrastructure means checking the health of structures and guaranteeing the safety of the users. The "OF" solutions create a nervous system of sensors that monitor the structures and their critical elements, activating a timely and constant remote control.

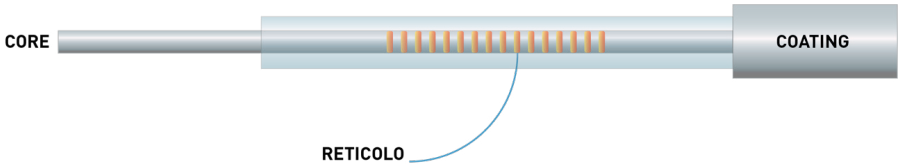
The proprietary data processing software EG-NTSG and the IoT-NTSG software platform, process the data, analyse the information and estimate the state of the structure, with the ultimate aim of optimizing the planning of maintenance activities.

Our systems prevent failures, damage, for the safety and health of all..

ADVANTAGES OF THE SYSTEM

- Chance to place the data acquisition tool at **large distance** (km) from the monitoring area, without reducing the accuracy of the measurement;
- **Multiplexing**, up to 160 sensors, even of different types, applied in series on the same fibre;
- Reduce the required wiring to monitor a structure.
- **High sensitivity**;
- **Small size** and insertion possibilities inside composite materials;
- **Sensors are passive**, do not generate and are not affected by electric and magnetic fields.
- **Reduction of maintenance costs** and energy consumption up to 17 times less than traditional systems with copper cables: a valid tool on the way to aecological transition

THE FIBRES, THE SENSOR, THE MATERIALS



FBG - fibre Bragg Grating
The grating is "written" in the fibre core with an ultraviolet laser.
The grating is the sensor itself.

Grating dimension: 0.5-2 cm.
A peculiar characteristic of the FBG technology is that on a single optical cable can be wired in series, for the measurement of various parameters, using different sensors such as strain gauges, accelerometers and temperature sensors. The acquisition is performed with just one interrogation system.

MOBILE INTEGRATION & DATA FEED

Deformation can be read remotely using Tablet, PC and Smartphones

MULTIPLEXING

Multiple sensor readable at the same time, installed on the same fiber.