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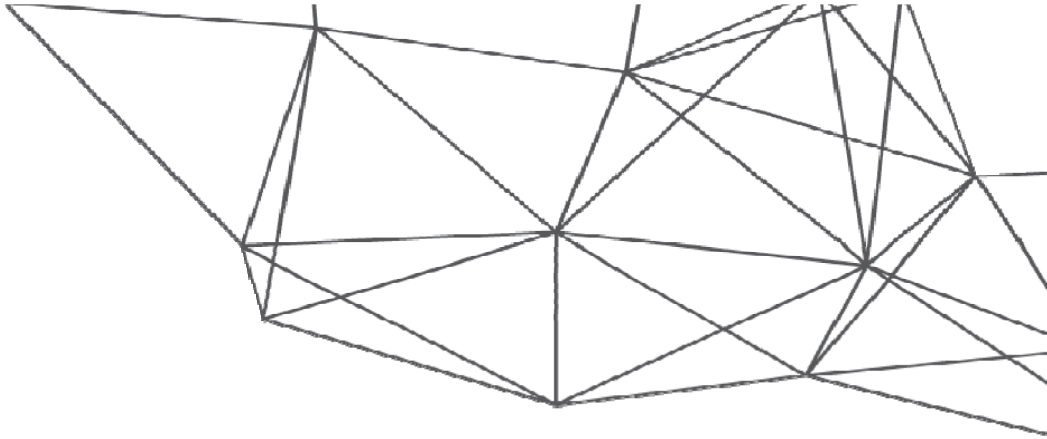

Bridges monitoring-General Approach

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MONITORING SYSTEM ON BRIDGES

WHY WE DO IT?

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WHY DO YOU HAVE TO MONITOR BRIDGES ?

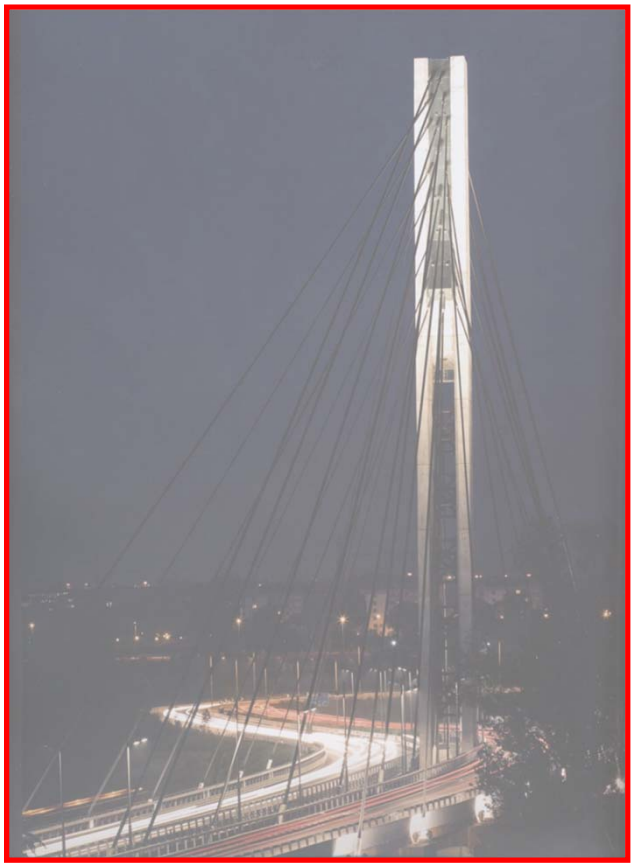
Monitoring is an essential component of successful Bridges Construction and Operation.

It’s very useful also for maintenance prediction.
One of the most important operations is represented by choosing the most appropriate instrument to measure a particular parameter, taking into account its intrinsic characteristics and the environment in which it will be installed.

WHY DO YOU HAVE TO MONITOR BRIDGES ?

Monitoring system is used:

- to verify the project;
- to support testing activities;
- to verify the behaviour over time;
- for management and ordinary and extraordinary maintenance;
- for assistance after exceptional events;
- for re-establishment and structural renovation.



WHY DO YOU HAVE TO MONITOR BRIDGES ?

What we measure:

- Movements on supports, on the span, piles, antennas,etc…..
- Deformations on deck, foundations, in structural elements;
- Loads in cables, on supports, in foundation;
- Environment temperature and structural
- elements;
- Rotations of piles, antennas, deck;
- Settlements of fondations;
- Vibrations of deck, cables, structural elements;
- Accelerations free field, deck, piles, antennas;
- Enviromental conditions : temperature , wind, traffic, accidents, fires;
- Undermining of bridges piles

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WHY DO YOU HAVE TO MONITOR BRIDGES ?

Which kind of instrumentations do we use?

Movements:	**Displacement trasducer: joinmeter, crackmeter;**
Deformations:	**Vibrating wire strain gauges**
Loads:	**Anchor load cells;**
Temperature :	**Resistance thermometer**
Rotations:	**Clinometers**
Settlements:	**Fixed extensometer, borehole rod extensometer;**
Accelerations:	**Accelerometers;**
Undermining of bridges piles:	**Sonar**
Environmental conditions :	**wind, anemometer (metereological station)**

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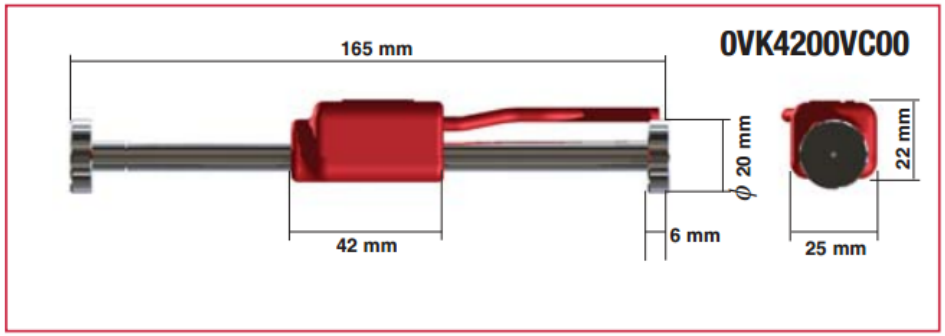
INSTRUMENTATIONS

VIBRATING WIRE STRAIN GAUGES

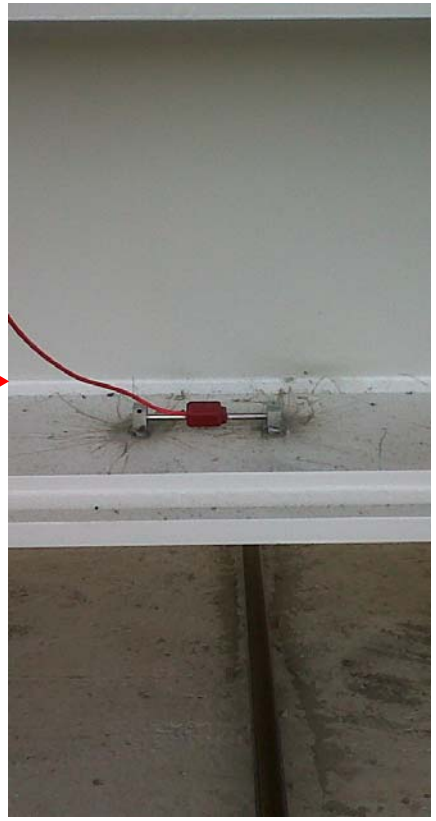
Vibrating wire strain-gauges are used to monitor strain in steel or in reinforced concrete and massive concrete structures.
It consists of a length of high tensile steel wire, tensioned between two end blocks welded or affixed to the surface.



Deformation of the structure will cause the two end blocks to move relative to each other, thus altering the tension of the steel wire.
The tension of the wire is determined remotely, using an electromagnet to excite the wire and then by measuring its' resonant frequency of oscillation.

INSTRUMENTATIONS

VIBRATING WIRE STRAIN GAUGES



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INSTRUMENTATIONS

JOINMETER

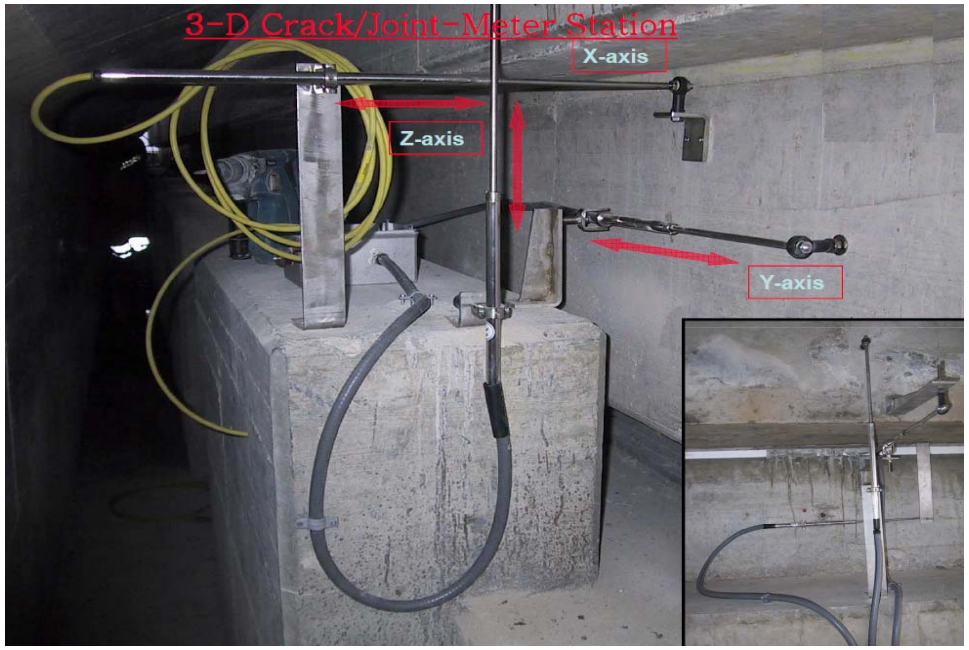
The jointmeters are used to monitor movement across joints in concrete structures.

The instrument assembly includes sensor housing and target, both parts are equipped with screw anchors. Typically the anchors are bolted on the opposite sides of the joint.

The instrument applied in bridges is used for the control of the movements of joints between decks or to control the movements between support and bridge deck.

INSTRUMENTATIONS

JOINMETER



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INSTRUMENTATIONS

JOINMETER

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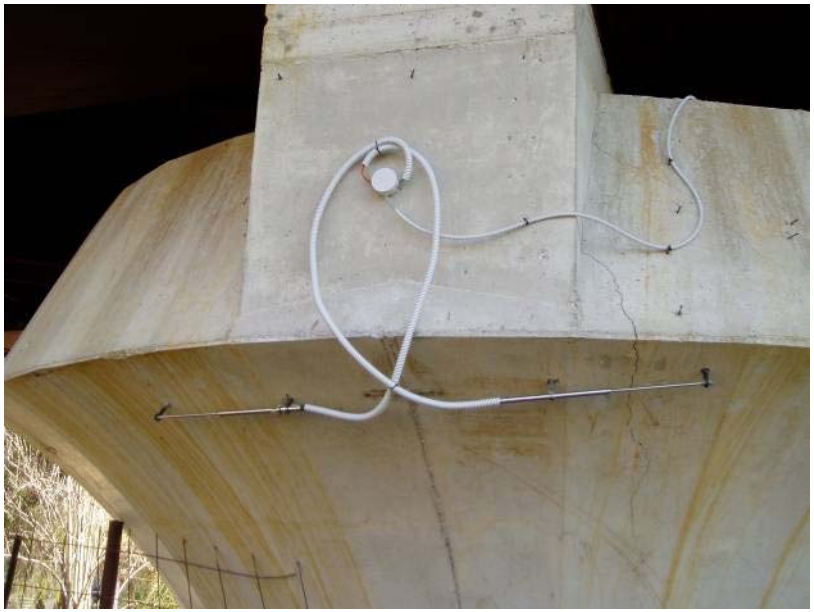
INSTRUMENTATIONS

CRACKMETER

Crackmeters are used on fissures on piles or decks of bridges.

These instruments are generally used for monitoring the behavior of a structure, where is useful to measure a crack.



The mechanical crackmeter is used when the displacement is along a prevailing direction. The instrument has to be installed with rod in the same direction. Possible transverse movements are compensed from two spherical joints.

INSTRUMENTATIONS

ANCHOR LOAD CELLS

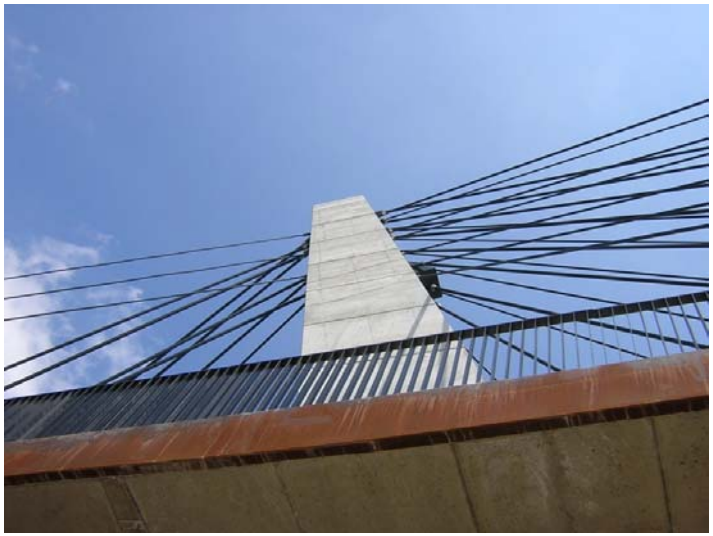
Load cells are used in cable anchor tendon, to measure load distribution during testing and operation and under the supports of bridges and viaduct. There are two different types of load cells: electric (see figure nearby)or hydraulic.

The electric one, generally used on ties of bridges, is made by a ring shaped stainless steel body instrumented by straing gauges in a Wheatstone bridge configuration with 4 – 16 gauges to minimize the sensitive to excentric loads; a distribution steel plate to obtain a more homogenous load distribution; an electric cable of proper characteristic to transmit the signal.

INSTRUMENTATIONS

ANCHOR LOAD CELLS

The cell subject to a load is strained and the gauges will change their resistence value; as a conseguence the output electrical signal results directly proportional to the applied load. Reading is performed by means of a read out unit that provides power supply to the cell and shows reading on a digital display.



INSTRUMENTATIONS

RESISTANCE THERMOMETER

Temperature is a very important parameter during monitoring for evaluating the influence of thermal effects on measurements and on structures which are monitored. The thermometers are generally installed in the vicinity of the instruments used and that are affected by effects of temperature, such as welding strain gauges, clinomter, jointmeter.

INSTRUMENTATIONS

CLINOMETER

The measure of tilt of structure is made by clinometers.
Surface clinometers are tilt sensors used to measure changes in the inclination of a structure. They are permanently installed to provide automatic long-term monitoring.

They provide a direct measure of the effect on the structure of complex process as for example the soil consolidation with related differential settlement, sand liquefaction, water table variation, etc.
The instrument are generally installed on piles and decks of bridges to control of rotations with respect to the vertical.
Reading the inclination values we obtain information on:

- construction stability;
- soil foundation behavior.

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INSTRUMENTATIONS

CLINOMETER

All the instruments of this family are based on electrical sensor of different types that have different performance and are available both monoaxial and biaxial to monitor rotation in the two orthogonal planes.

According to the scope, the instrument can be measured manually or in connection with automatic data acquisition system. In this confiuration the measuments can be taken even at high frequency and system can activate alarm when a thereshol value is reached.

Two main type of instruments are available:

- removable, called tiltmeter
- in place

INSTRUMENTATIONS

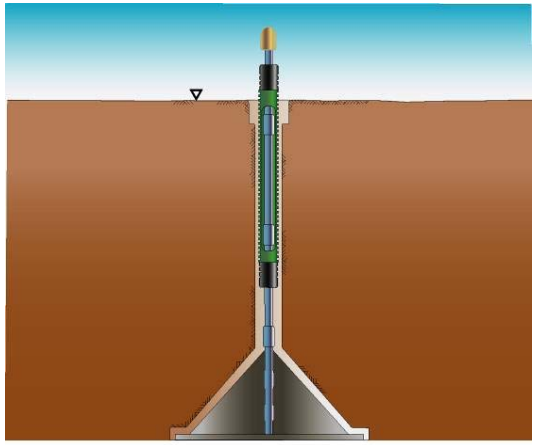
FIXED EXTENSOMETER AND BOREHOLD ROD EXTENSOMETER

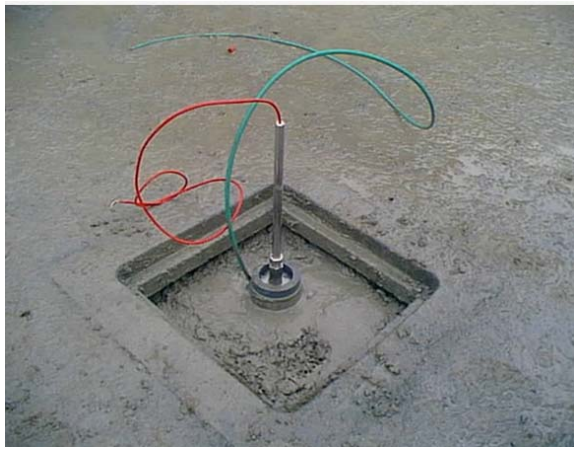
The soil – structure interaction is a continuos process developing in the time, beeing controlled both by the action of the structure on the soil during the construction and operation phases as by the soil behaviour on the foundation structures as resul for example, of seismic event or of water table level variations.

As result of the lateral and vertical soil variability commonly found, monitoring the ral behaviuor of the works is a very effective method to incresae the knoweldge and to verify the quality during the construction along the life.

One of the most meaningfull measured for this purpose is the vertical displacement or better the settlement.

Both fixed estensometer and dex in – place extensometer are used to evaluate settlements at basement foundation of piles and bridge abutments on soft ground.





INSTRUMENTATIONS

ACCELEROMETER

An accelerometer is a device that measures proper acceleration, also called the four-acceleration.
It's flat frequency and phase response together with the very low short- and long-term drift provides true engineering data that require no post-processing.

INSTRUMENTATIONS

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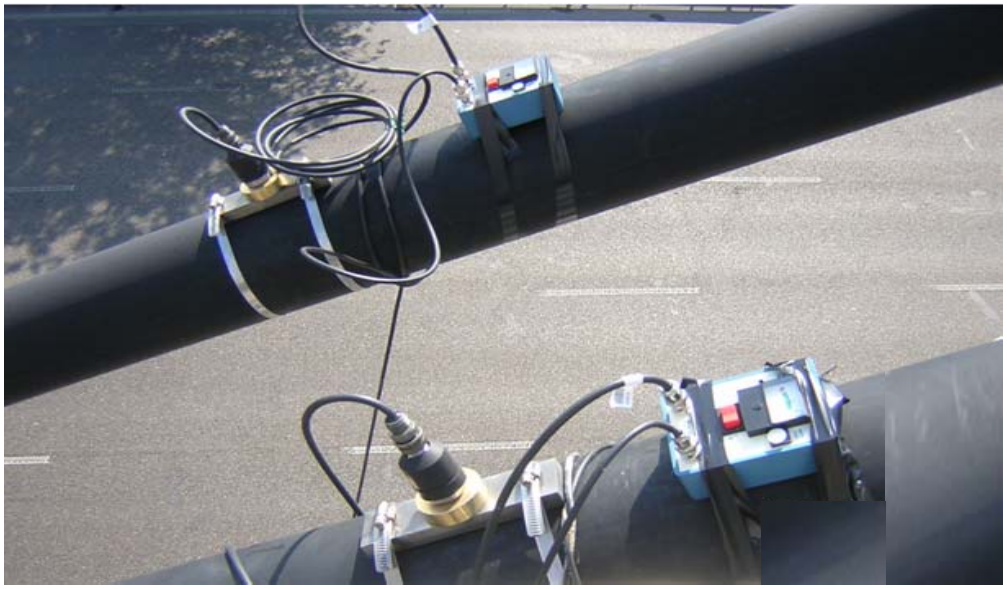

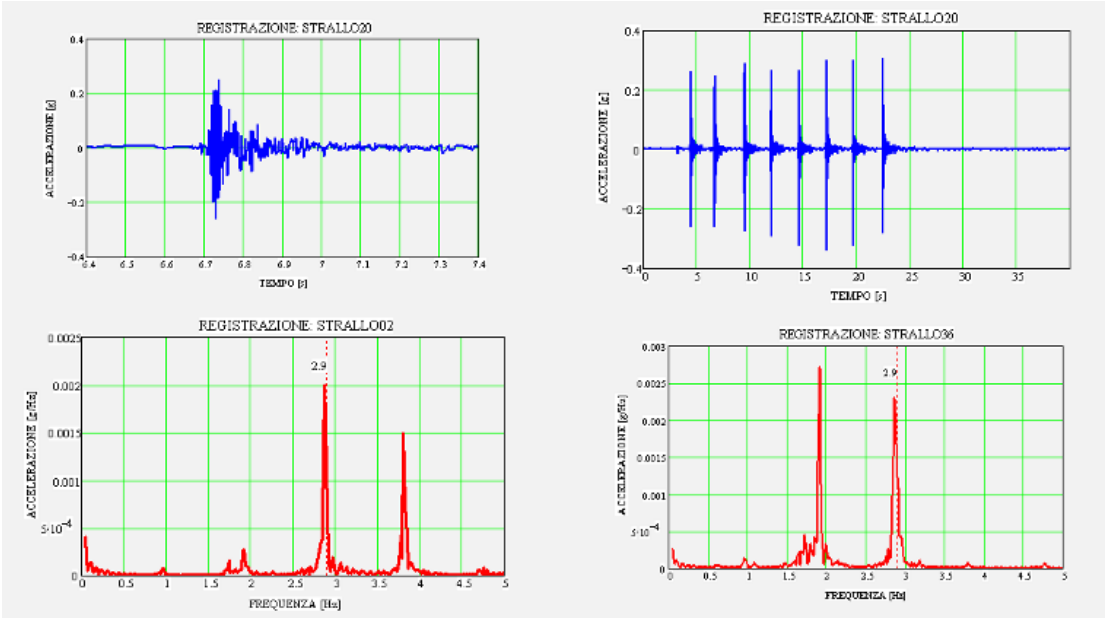

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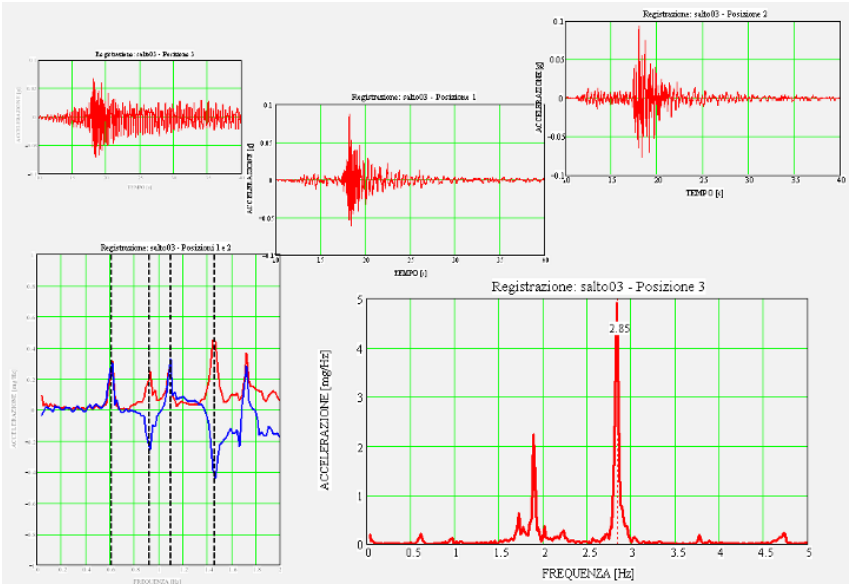
INSTRUMENTATIONS

ACCELEROMETER

Single- and multi-axis models of accelerometer are available to detect magnitude and direction of the proper acceleration (or g-force), as a vector quantity, and can be used to sense orientation (because direction of weight changes), coordinate acceleration (so long as it produces g-force or a change in g-force), vibration, shock, and falling (a case where the proper acceleration changes, since it tends toward zero).



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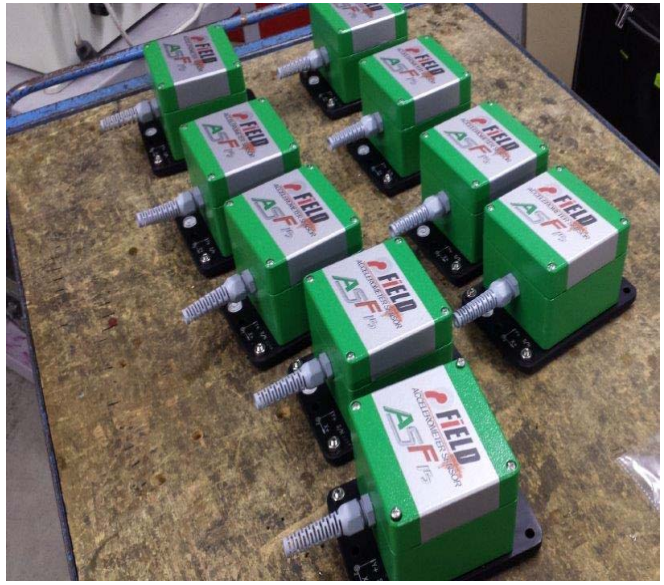
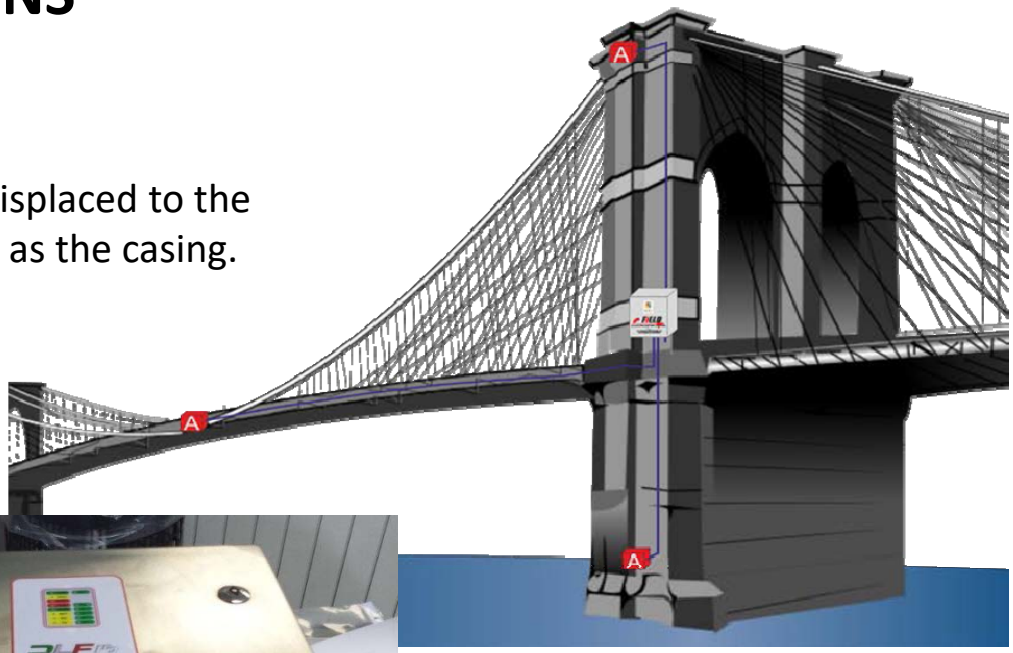
INSTRUMENTATIONS

ACCELEROMETER

An accelerometer behaves as a damped mass on a spring.
When the accelerometer experiences an acceleration, the mass is displaced to the point that the spring is able to accelerate the mass at the same rate as the casing.
The displacement is then measured to give the acceleration.
Under the influence of external accelerations the proof mass deflects from its neutral position.
This deflection is measured in an analog or digital





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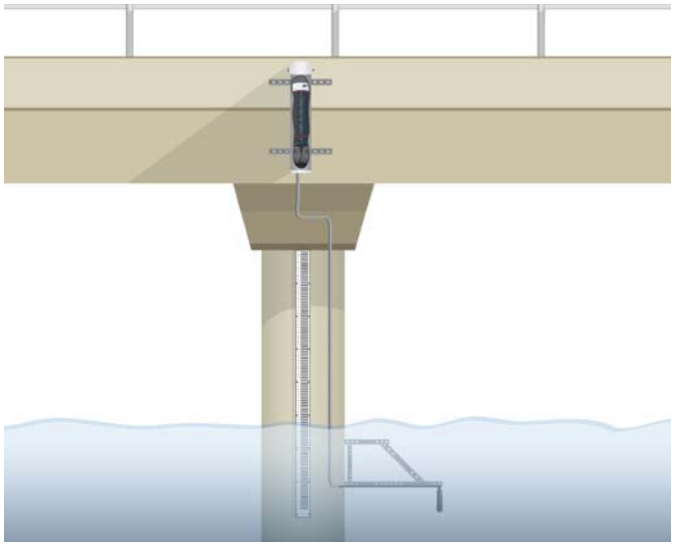
INSTRUMENTATIONS

SONAR

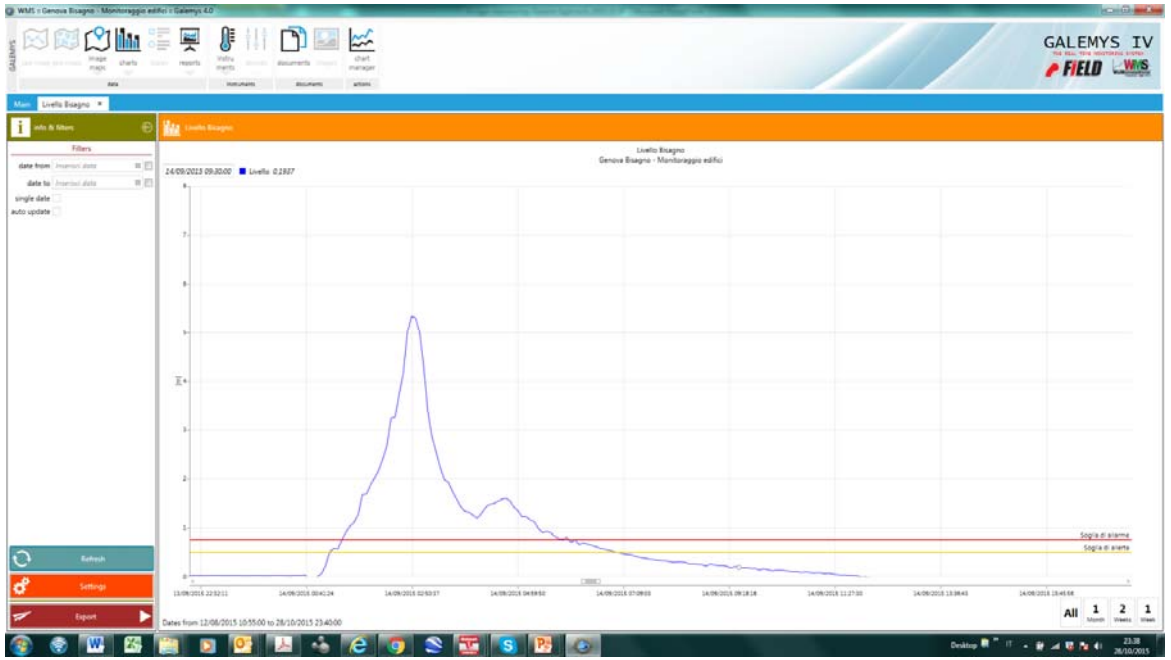
Altimeters Sonar are used for measuring bottom bed of rivers and/or embankment realized at the basements of piles, in order to measure a possible erosive phenomenon. They are placed in number of three or six around the pile.



INSTRUMENTATIONS

SONAR

The altimeter sends a signal in frequency by taking their time of reflection, that is directly proportional to the distance between the sensor and the bottom of the river, which reflects the signal; by reading out over time changes of the bottom of the river and thus the embedding in correspondence of monitoring point.



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INSTRUMENTATIONS

METEO STATION

An anemometer is a device for measuring wind speed, and is a common weather station instrument. The term meaning wind, and is used to describe any airspeed measurement instrument used in meteorology or aerodynamics.

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INSTRUMENTATIONS

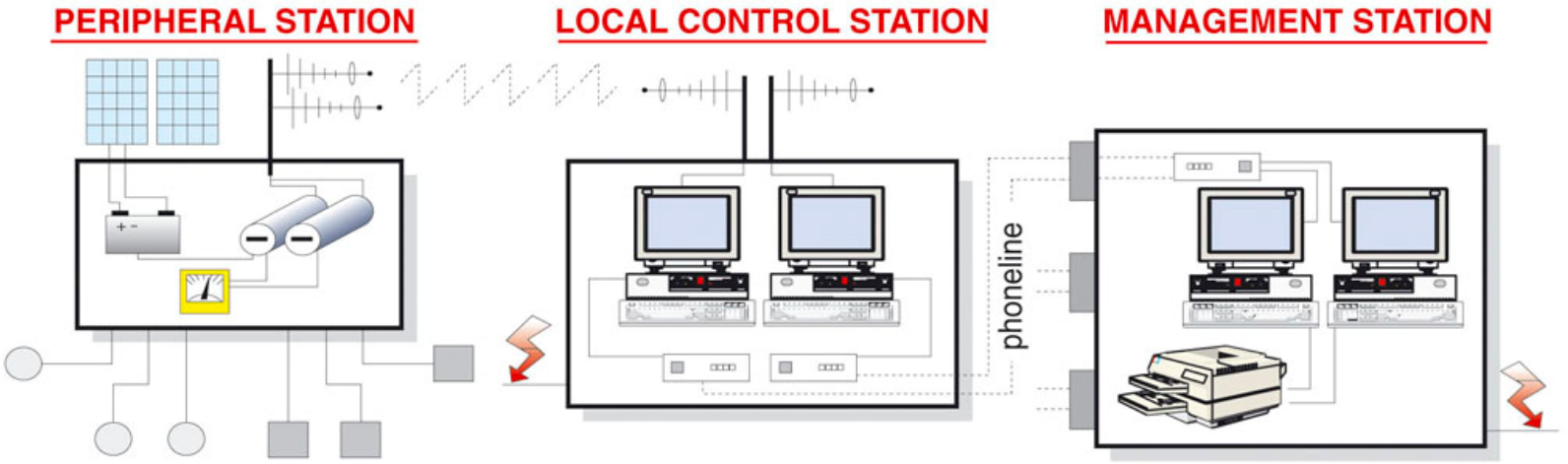
METEO STATION

The installation of a weather station, allows you to know a number of elements that Associated with the data from monitoring system, they become essential for the study and analysis of the behavioUr of bridges and for their maintenance and protection.

The main parameters measured are: rainfall, air temperature, barometric pressure, wind speed and air humidity.

INSTRUMENTATIONS

MONITORING STATION - DATA ACQUISITION SYSTEM



Main activities

- Dayly readings of all geotechnical instruments
- Automatic acquisition of AE/MS conditioned by trigger

Main activities

- Remote management of peripheral stations
- Syncronisation using absolute time
- Dayly data acquisition from peripheral stations
- Management of alarm levels

Main activities

- Remote management of local control stations
- Periodical data acquisition from local control station
- Analisys and graphical elaboration of measure results
- Data storage in data base

Key of symbols

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