



When designing underground structures there is a large amount of uncertainty due to a large number of factors:

- Uncertainties in the geomechanical parameters
- Large simplifications made to model the ground and the natural stresses
- Limitation of geological-geotechnical explorations due to financial reasons

This is why there is the need of a system of control that enables us:

- To check during the construction the hypothesis that were taken during the design, verifying that the computational predictions of the behavior of the ground correspond to reality. If deviations arise and these are too large, then a back analysis of the input parameters is made.
- To detect in advance imminent damages or collapses, allowing to take measures on time

In order to establish a control system, monitoring of different parameters is made by means of different techniques and tools:

Parameter recorded	Tool
Settlement at the surface	Levelling
Displacements and convergences in the opening skin	Tachymeter, tunnel scanner, extensive tape, etc
Displacements within the rock mass	Extensometers , sliding micrometers, inclinometers, deflectometers

Stresses on support

Strains on support

Primary or natural stresses in the ground

Pressure cells

Strain gauges

Hydraulic fracturing, unloading drills,

More info:

- [Tunnels and shafts in rock by US Corp of Engineers](#) (Adobe Pdf 6mb)