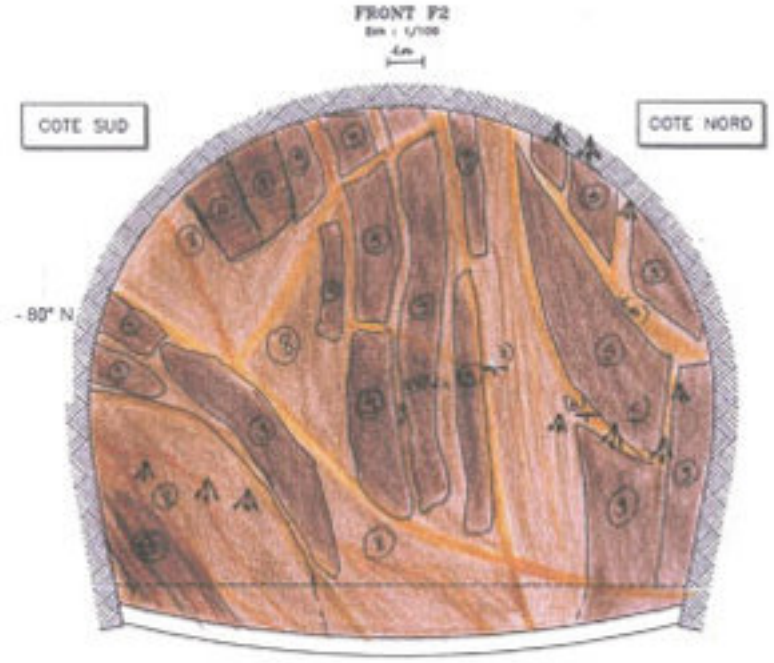

Geotechnical studies and investigations are a complement to geology and hydrogeology.

Their objectives are to know the basic characteristics of the ground which will have an impact on the mechanical behavior of the rock or soil, the initial state of equilibrium of the natural stresses and the changes of loads and actions that will be exerted over the structure during the construction and operation.

In order to do so, geotechnical investigations aim at quantifying the geomechanical characteristics of the ground by means of different parameters that are dependent on both the micro and the macro structure.

For instance, the mechanical behavior of a rock mass will depend not only on the composition and mineralogical structure of the rock matrix itself, but also on the presence and characteristics of the different faults, cracks and joints that will appear on the rock mass, weakening its general strength and changing the way it behaves at the underground structure scale.

This is why the geotechnical investigation will look for obtaining the value of different parameters related to the intact rock or rock matrix, and a way of quantifying the general state of the rock mass at a macroscopic scale.

On the other hand, geotechnical investigations also target to know the conditions where the underground structure is to be built from a mechanical point of view: in situ natural stresses in the ground, pressure of the water if existent, consolidation of the ground, etc

Parameters related to the intact rock or rock matrix

The following chart sums up the different geotechnical parameters that are related to the intact rock or rock matrix, the information they provide and the procedures that are normally followed to obtain these parameters. In the case of soils, these will also be applicable. This list is not exhaustive, but represents the main and most used parameters.

Parameter	Information	Procedure to obtain
Elastic modulus E	Elastic deformation	Compression tests
Poisson coefficient ?	Elastic deformation	Compression tests
Cohesion C	Strenght	Triaxial compression tests
Friction angle ?	Strenght	Triaxial compression tests
Uniaxial compression strength UCS	Strenght	Triaxial compression tests, related to C and ?
Dilantancy ?	Plastic deformation	Compression tests
Permeability K	Permeability of the rock or soil	Lugeon tests, wells, laboratory tests, etc

Parameters related to the rock mass at the scale of the project

In the case of underground structures to be built in soils, the parameters related to small samples of soil are normally usable at the scale of the structure and can be assumed to represent well the behavior of the whole soil mass.

Soils can be assumed to be quite homogeneous in their behaviour and scale-independent. However, in the case of rocks, the presence of discontinuities, cracks, fractures and joints make them very dependent on the scale. So, the mechanical behaviour of a little sample of rock tested in the laboratory will differ very much from the one displayed by the whole mass of fracture rock.

This is why geomechanical classification systems like the RQD, RMR and Q system have been developed to quantify how to translate the properties of the rock from the matrix to the whole rock mass where the underground structure is to be built.

All these geomechanical classifications give quantitative marks to the rock mass depending on the number and kind of fractures, the state of their surfaces, the presence or not of water, the orientation of discontinuities and in some cases the stress state of the ground.

Here below the three main geomechanical classifications are summed up, with the main parameters or concepts that are taken into account by each of them:

Rock Mass Classification

RQD - The Rock Quality Designation parameter was developed by D.U. Deere and nowadays serves as input of the main geomechanical classifications. It is based on measuring core recovery percentage which incorporates only pieces that are greater than 100 mm in length.

RMR (Bienawski) - The Rock Mass Rating (RMR) system is a geomechanical developed by Z.

T. Bieniawski. A number of parameters are evaluated by means of a chart given by Bieniawski, that assigns a number of points depending on their value. The sum of all the points give the total RMR value.

Parameters evaluated
Uniaxial compressive strength of intact rock
Rock Quality Designation (RQD)
Spacing of discontinuities
Condition of discontinuities
Groundwater conditions
Adjustment for unfavorable orientation of joints

Q (Barton) - After evaluating a large number of case histories of underground excavations, Barton proposed the Tunneling Quality index Q, which is expressed as: Q = (RQD/Jn) x (Jr/Ja) x (Jw/SRF)

These parameters are related to the following concepts of the rock mass:

Q System Parameter	Rock Mass Condition
RQD	RQD
Jn	Number of joint sets
Jr	Joint roughness
Ja	Joint alteration
Jw	Joint water
SRF	Stress reduction factor

According to a chart, a value for each of the parameters is given and then the Q quantitative rating is obtained by means of the mathematical expression.

Parameters related to the state of the rock mass or boundary conditions

It is also very important to know the state of natural stresses in the ground where the underground structure is to be built.

For this, approximations can be obtained by means of maps of natural stresses, projects already made in the area or testing at the site.

Other aspects also important are the piezometric pressures of water within the ground, risk of seismic activity in the area, etc.

Links:

- Geomechanical classifications (Adobe Pdf)
- Tunnels and Shafts in Rock by US Army CE : Geotechnical investigations (Adobe Pdf)
- AFTES (free registration required) Characterization of rock masses useful for the design

and the construction of underground structures
- AFTES (free registration required) The choice of geotechnical parameters and tests useful to the design, dimensioning and construction of underground structures