ENGINEERING GEOLOGY

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CURRICULUM "EARTH SYSTEM": processes and modelling

1 - Landslide hazard management and risk mitigation

Landslides constitute a major natural hazard in many parts of the world mainly due to inadequate land use, which may either cause the mass movements or expose communities to them.
Therefore, landslide hazard evaluation and the comprehension of its interaction with anthropogenic systems represent key aspects in developing efficient land use plans that minimize landslide risks.
The research is aimed at understanding and quantifying control factors in triggering soil and rock mass movements, through the use of numerical modelling and spatial statistical approaches. The main focus is on the analysis of spatial-temporal components for forecasting instability phenomena through the use of stress-strain analysis at site-specific scale and distributed stability analyses in multi-basin areas.
Specific topics include:

a) quantifying the relationships between critical meteorological events - groundwater flow - deformations and the collapse of slopes;
b) evaluating the effect of climate change on landslide hazard;
c) developing efficient strategies for landslide risk control and prevention;
d) the design of plans for monitoring the control factors.

2 - Micro- to macro-scale modelling of geomaterials for engineering geology applications

Constitutive and numerical modelling is of paramount importance to understand the behaviour of porous and deformable solids subject to a range of environmental and anthropic (mechanical, hydraulic, thermal, chemical, etc.) loadings, featuring in a number of engineering geology applications including foundations, tunnelling and mining activities. Significant challenges arise when one or multiple couplings apply, and approximate solutions must be obtained numerically. In this line of research, both discrete- and continuum-based modelling approaches are employed, and complemented by field and laboratory experimental activity, towards the solution of multi-physical coupled problems in the fields of civil, energy and environmental engineering.
Specific modelling applications include:

a) innovative soil improvement techniques, such as resin injection and bioinduced cementation;
b) post-liquefaction behaviour of sands and their interaction with buried structures;
c) thermo-hydro-mechanical behaviour of geomaterials (soils, rocks and rock joints) subjected to significant temperature variations;
d) geological storage of CO_2 in carbonate reservoirs.

Curriculum B: Georesources

1 - Groundwater management and protection at multiple scales

Regardless of the specific country's economic and political development, three major themes are common worldwide: a) competition for groundwater resources between different uses (agriculture, civil and industry); b) depletion of the resources by all uses; c) quality degradation of the resources by contamination sources related to all uses.
Groundwater sustainability, at different scales, represents the general goal of the specific research studies addressing the various aspects related to water resources quantity and quality, including their evaluation, engineering, management, planning, and restoration.
Specific topics are:

a) deterministic and stochastic modelling of groundwater flow and contaminant transport;
b) natural and human related surface water-groundwater interactions;
c) groundwater contamination and protection to point and non-point civil and agricultural contaminant sources;
d) groundwater resources in mountainous areas including the analyses of springs' regime fluctuations under global change scenarios.

2 - Use of soil and groundwater resources for low enthalpy geothermal systems

The increasing need of energy by our societies has increased the attention towards energy production with a low environmental impact. The general topic of the research is the use of soils and groundwater for the production and storage of low enthalpy geothermal energy, as one of the most efficient alternative sources for space heating/cooling within the principles of environmental sustainability and circular economy.
Specific research topics include:

a) the development of coupled and uncoupled approaches to simulate heat transport in groundwater and the effect on water quality;
b) the effect of heat transport on soil properties;
c) the analysis of the thermal and mechanical performance of so-called energy geo-structures, both at single installation and the urban district scale;
d) evaluating the coupling of geothermal installations with solar energy storage techniques.