Final dissertation: Master of Science in Engineering Geology A.Y. 2021/2022

17th February 2023

Dr. Ilaria Barbaraci

Thermo-mechanical characterisation for non-conventional underground geo-engineering applications

Internship at NESOL (Lausanne - CH)

During my two-month internship at Nesol – Numerical Engineering Solutions, an engineering company based in Lausanne, Switzerland, I had the opportunity to deal with some non-conventional and advanced issues related to the underground geo-engineering applications: radioactive waste disposal, for which I conducted a detailed mechanical characterisation of argillaceous sedimentary rocks (especially Opalinus Clay, of which the Swiss territory is rich), and energy geostructures, which led me to execute a thermal characterisation of clays of variable consistency.

The first part of the activity was dedicated to the study of the so-called shales, sedimentary rocks with clay content more than about 40% (Shaw and Weaver, 1965), and to the evaluation of the mechanical behaviour by varying physical properties, mineralogical composition and confining pressure in triaxial compression tests. In particular, I focused my attention on the post-peak phase, or rather on the transition from brittle to ductile behaviour for high stress values. This study was necessary to investigate Opalinus Clay behaviour in more detail. In fact, as it is particularly suitable for containing radioactive material for long periods of time, it was chosen by Switzerland for the construction of a deep repository for the storage of nuclear waste. Near the town of St. Ursanne, in the canton of Jura, there is the international underground laboratory of Mont Terri, aimed at analyzing the geological, hydrogeological, geochemical and geomechanical characteristics of Opalinus Clay. Starting from the data of about 150 triaxial compression tests performed in undrained conditions by Nagra (The Swiss National Society for the disposal of Radioactive Waste), with which Nesol currently collaborates, I carried out an advanced analysis of the shear band evolution during the tests, and of the impact that this evolution has on the final value of the residual strength.

Instead, the second part of the internship focused on the construction of some energy geostructures (GSE) in the canton of Vaud. It is now known that this tecnique is able to exploit the heat capacity of the ground as an energy storage system, representing a low environmental impact solution. For the preliminary phase of the design, it was necessary to study the mechanism of heat transfer in soils, clay in this case, and to conduct specific laboratory tests to obtain the main soil thermal properties (conductivity, diffusivity and heat capacity). Moreover, I evaluated their variability as a function of the water content of the available samples.

Via Vetri Vecchi, 34 - 52027 - San Giovanni Valdarno (AR)- Italy
Tel. +39 055 911.94.1
Fax +39 055 911.94.39
geotecnologie@unisi.it
C.F.: 80002070524 - P.iva: IT00273530527
www.geotecnologie.unisi.it

Dr. Riccardo Ortolan

Geological report for the enlargement and modernization of the S.P. 34, road section between Montecchio Maggiore and Altavilla Vicentina (VI - Italy)

Internship at IGS SRL (Trieste - IT)

This work analyzes the geological, geotechnical, hydrogeological e geophysics conditions necessary for the realization, modernization and enlargement of S.P. 34 located between Montecchio Maggiore and Altavilla Vicentina towns, the realization of a overpass and two lamination tubs.

For realize this project were used several literature analysis, done near the study area, and were execute several specific geotechnical and geophysical analysis. The geological proves performed specifically for this project were: 2 continuous core surveys, 6 standard penetration test (SPT), 4 Lefranc permeability proves in variable load, 1 undisturbed sapling for determinate natural weight of the sediment, water content and one oedometric test, 2 Multichannel Analysis of Surface Waves (MASW) and 3 Super Heavy Dynamic Probing.

The results of this analysis permit to identify two geotechnical and stratigraphic units:

- Lithotype A: clay and silt with sporadic layers of sand and silty-sand, this soil shows a cohesive behaviour. This stratigraphic unit is present between the ground level (g.p.) and 4.20/8.00 m below g.p.;
- Lithotype B: Gravel in silty-sand matrix, this soil shows a grain seize behaviour. This stratigraphic unit is present from 4.20/8.00 m below g.p..

The Multichannel Analysis of Surface Waves identifies, according to N.T.C. 2018, a C underground category: medium thickened coarse-grained or medium fine-grained soils with substrate depths of more than 30 m and Vs eq including between 180 and 360 m/s.

The Lefranc permeability proves in variable load characterize a low permeable soil that doesn't permit the correct work of the lamination tubs.

The results of this analysis permit to recreate an appropriate geological, stratigraphic and geotechnical conditions but, it was also necessary impose some constraints due to the heterogeneous sedimentary environment that could present lateral and vertical variations.

Dr. Giordana Zocco

Update of the geological and geotechnical model of the Monte Soresano landslide in the municipality of Tavernola Bergamasca (BG - Italy)

Internship at Studio Griffini s.r.l. (Milano - IT)

This work updates the geological and geotechnical model of the Monte Soresano landslide located on the western shore of the Iseo Lake, in the municipalities of Tavernola Bergamasca and Vigolo (BG).

The Monte Soresano landslide has been known since the 1960s and estimates an amount of unstable rock equal to about 1.5-2 million cubic meters. The risk of detachment is due to the position of the mountainside, that lies in the near proximity of a cement factory, the provincial road SP78 (already abandoned once due to a rockfall) and the western shore of the Iseo Lake. This instability process has been extensively documented in previous studies that discuss several hazard scenarios. The worst scenario would take place in the event of a global collapse of the entire mobilizable volume of rock, or of a significant portion of it, which, after having invested the industrial zone and the infrastructures located at the base, would propagate into the lake causing the formation of a freak wave which, potentially, could reach the inhabited areas on the opposite shore of the lake.

The development of the landslide movement occurred in different phases in different positions, but overall, the kinematics have been characterized as a "rigid unitary body" movement.

Following widespread instability, such as the Pinnacles landslide, depressions, subsidence of the ground, the formation of dugouts and escarpments and the damage of the provincial road, a system of monitoring instruments was created and located within the landslide perimeter in order to monitor both surface and deep movements.

Despite the number control instruments installed and previous analyses, within the landslide perimeter there is little objective data from direct investigations that directly study the mass of rock underground and on the surface. The study was therefore conducted starting from the analysis of bibliographic data of the Monte Soresano landslide, integrated by a novel series of geognostic investigations, laboratory tests and ground surveys, that aim at updating the geological and geotechnical model that supports the feasibility study of landslide hydrogeological-risk-mitigation interventions.

The investigation plan was created to both acquire data from direct surveys and to compare these with the previous ones in order to carry out a cross-validation of the data and to allow for a more precise interpretation of the kinematics in progress and its causes.

The work carried out during the Master's internship aimed at supporting the technicians of Studio Griffini in planning the investigation campaign, works management, Security Coordination during Investigation Execution (CSE), execution of the on-site surveys, analysis of the collected data and updating of the relevant geological and geotechnical model to design landslide risk mitigation interventions.

Via Vetri Vecchi, 34 - 52027 - San Giovanni Valdarno (AR)- Italy
Tel. +39 055 911.94.1
Fax +39 055 911.94.39
geotecnologie@unisi.it
C.F.: 80002070524 - P.iva: IT00273530527
www.geotecnologie.unisi.it

On today's date, despite site testing are accomplished, the final documentation to proceed with the updating of the geological and geotechnical model is not yet available, but it is possible to provide results in the geological, geotechnical and geo-mechanical fields that can be used for the next planning phase.

From the data in possession and the ones acquired from the supplementary investigations it was possible to confirm in broad outline the geometric and kinematic characteristics of the landslide with different states of activity and movement rates. A landslide produced by movement surfaces can be identified, among which a wide and deep quiescent surface and two active surfaces can be distinguished, one of which with a depth of approximately 50 meters and a more superficial one of about 15 meters, which today is the most mobilized.

Once the documents of all the laboratory tests carried out in this study have been compiled, all the data necessary to update and integrate the geological and geotechnical model will be available to support the design of interventions to mitigate the risk of landslides.

Via Vetri Vecchi, 34 - 52027 - San Giovanni Valdarno (AR)- Italy
Tel. +39 055 911.94.1
Fax +39 055 911.94.39
geotecnologie@unisi.it
C.F.: 80002070524 - P.iva: IT00273530527
www.geotecnologie.unisi.it