Advanced monitoring and modelling in geotechnical engineering

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Program:

Environmental and structural monitoring, together with numerical modelling, are very important in engineering for different purposes that ranges from optimization of design, to safety evaluation of existing structures, and planning of maintenance works. In geotechnical engineering, traditional techniques like inclinometers, strain gauges, and pressure sensors are very common and can be used in combination with advanced methods, such as optical fiber sensors and image analysis techniques. The fields of application of the monitoring techniques are the most varied: from the small scale, in the laboratory, with collapse tests, deformation tests of resistant elements and photo interpretation of physical phenomena, to the real scale with monitoring of structures, unstable slopes and buildings.

The program of the course will initially discuss traditional sensors, such as inclinometers and pressure sensors, examining the main characteristics, fields of application and obtainable results. A specific exercise will be held in the classroom for the management and interpretation of the results. Next, the course will cover two innovative monitoring techniques. The fiber optic sensors for the measurement of deformations will be described in their operation and contextualized in different application scenarios. Some image analysis techniques will then be presented, in order to measure displacements in the image plane, three-dimensional displacements, evaluate evident changes in the scene following material collapses, segment the colorimetric contents to identify and measure the objects present in the image.

Finally, numerical modelling is introduced and it will be discussed how field data from monitoring campaigns can be used to implement a realistic numerical model. Numerical tools will be presented and used in the course with particular reference to a practical case of slope stability.

Practical exercises using Matlab and finite element codes will be solved and a technical excursion will be possibly organized.

References:

- Cola, S., Schenato, L., Brezzi, L., Tchamaleu Pangop, F. C., Palmieri, L., & Bisson, A. (2019). Composite anchors for slope stabilisation: Monitoring of their in-situ behaviour with optical fibre. Geosciences, 9(5), 240.
- Bado, M. F., & Casas, J. R. (2021). A review of recent distributed optical fiber sensors applications for civil engineering structural health monitoring. Sensors, 21(5), 1818.
- Stanier, S. A., Blaber, J., Take, W. A., & White, D. J. (2016). Improved image-based deformation measurement for geotechnical applications. Canadian Geotechnical Journal, 53(5), 727-739.
- Thielicke, W., & Sonntag, R. (2021). Particle Image Velocimetry for MATLAB: Accuracy and enhanced algorithms in PIVlab. Journal of Open Research Software, 9(1).

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- Chan, A. H., Pastor, M., Schrefler, B. A., Shiomi, T., & Zienkiewicz, O. C. (2022). *Computational geomechanics: theory and applications*. John Wiley & Sons.

Examination and grading:

The evaluation of the course is based on the delivery of a report containing the solution of a practical exercise.