Course unit English denomination	**Advanced monitoring and modelling in geotechnical engineering**
SS	**08/CEAR-05/A (ex ICAR07)**
Teacher in charge (if defined)	Gabrieli Fabio (12 ore), Brezzi Lorenzo (12 ore)
Teaching Hours	24
Number of ECTS credits allocated	4
Course period	between december 2025 and july 2026
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	english
Mandatory attendance	☒ Yes (60% minimum of presence) ☐ No
Course unit contents	The first part of the course will cover the main techniques of geotechnical surveying and monitoring, with a particular focus on landslides (slow-moving landslides, rapid flows, rockfalls), earth structures (embankments, earth dams), and retaining structures (retaining walls, anchors). Both traditional methods and instruments (e.g., inclinometers, piezometers, extensometers) and advanced technologies (e.g., fiber optics, geophysical surveys, radar technologies, photogrammetry, including the use of drones) will be considered. These tools enable continuous and precise monitoring of geotechnical works and at-risk areas, providing real-time information that can be integrated into early warning systems to support risk management strategies. For each method, the basic principles, potential, and challenges will be discussed, along with the analysis of case studies. In the second part of the course, numerical approaches for analyzing the behavior of soils and rocks under various load conditions will be explored. This will include both methods based on discrete media mechanics, starting from the micromechanical description of contact laws between particles, and those based on continuum mechanics, also considering the multiphase characteristics of porous media. Fundamental elements of constitutive modeling of geomaterials will be introduced, with a particular focus on elastoplastic models and critical state soil mechanics. The course will also include practical activities using participants' personal computers and the available geotechnical instruments. Additionally, a field trip will be proposed to test some instruments and conduct a real data analysis and processing activity.

Learning goals	The candidate will develop advanced knowledge in the field of geotechnical investigation and monitoring techniques, as well as geomaterial modeling. They will need to become familiar with innovative surveying and monitoring methodologies through a scientific and methodological approach and be able to critically assess the potential and limitations of each method in order to select the most suitable techniques for the context. Furthermore, the candidate will need to acquire knowledge in the field of constitutive modeling of geomaterials and multi-body modeling from the micro to the macro scale. They must be able to independently evaluate the most appropriate numerical models for defining and describing geotechnical problems. All these skills will shape the profile of a researcher capable of managing complex issues in the analysis and simulation of geotechnical problems, in risk management for geotechnical infrastructures, and in the development of innovative study technologies and methodologies.
Teaching methods	The course will include not only theoretical lectures but also practical activities aimed at strengthening the technical skills acquired during the theoretical sessions, offering participants the opportunity to apply firsthand the concepts and methodologies discussed. Each participant will use their own PC, employing specific software for geotechnical modeling and analysis, such as numerical calculation programs based on the finite element method (FEM), discrete element method (DEM), as well as software for processing and visualizing data collected from monitoring instruments. Targeted exercises will be provided to apply these software tools, simulating real-world geotechnical scenarios. Students will also have the opportunity to become familiar with the geotechnical instruments available in the laboratory through practical demonstrations on the use of inclinometers, piezometers, extensometers, load cells, and fiber optics for monitoring deformations, pore pressures, and ground movements. They will gain a detailed understanding of how these instruments function, from field installation to data acquisition and interpretation. A field trip will also be organized, allowing participants to put their acquired knowledge into practice in a real-world context. During the excursion, participants will have the chance to directly test some of the geotechnical monitoring instruments discussed in class. Survey and monitoring scenarios for landslides, unstable slopes, or retaining structures will be simulated, enabling participants to assess the geotechnical conditions of the site and collect meaningful data useful for proposing risk mitigation solutions.
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No

Prerequisites (not mandatory)	
Examination methods (if applicable)	The exam will consist of a written report and an oral presentation based on data collection in the field, data processing, geotechnical problem simulation, and the proposal of risk mitigation measures.
Suggested readings	Course slides and other materials and documentation will be distributed during the course
Additional information	