COURSE DESCRIPTION
RESILIENCE OF GEOTECHNICAL SYSTEMS

SSD: GEOTECNICA (ICAR/07)

DEGREE PROGRAMME: TRANSPORTATION ENGINEERING AND MOBILITY (D42)
ACADEMIC YEAR 2025/2026

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE
MODULE: NOT APPLICABLE
TEACHING LANGUAGE: INGLESE
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: II
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER II
CFU: 6

REQUIRED PRELIMINARY COURSES

None

PREREQUISITES

None

LEARNING GOALS

The resilience of any engineering system against extreme environmental events can be defined based on four properties: robustness, redundancy, rapidity, and resourcefulness. Robustness refers to the strength of systems to withstand a given level of demand without suffering a loss of functionality. Redundancy indicates the presence of elements designed to fail without significant effects on the system's overall performance. Rapidity is the capacity to recover the properties of the engineering system timely to contain losses. Resourcefulness is the capacity to identify damages, establish priorities, and mobilize resources for the interventions. Resilient based-design strategies of geotechnical systems (i.e., those made by soil or interacting with it) aim to improve

their robustness and redundancy. Real-time monitoring systems can quickly assess their performance after an extreme event, hence improving the rapidity and resourcefulness. The course focuses on the key aspects of the performance of some geotechnical systems typically employed in the road and railway infrastructures, such as embankments, retaining structures and foundations of viaduct piers, against extreme meteorological and seismic events. The technologies currently suitable to monitor their performance and the interventions to improve it are illustrated and discussed regarding robustness, redundancy, resourcefulness, and rapidity.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The course aims to provide students with specialist knowledge on the resilience of geotechnical systems typically used in road and railway infrastructures under extreme weather and seismic events.

Applying knowledge and understanding

Following the performance-based approach for assessing resilience, the parameters that quantify the performance of the different systems and correlate it to the intensity measure of the event will be discussed.

COURSE CONTENT/SYLLABUS

Engineering Resilience -
Definition: the concept of resilience applied to infrastructures; robustness, redundancy, rapidity and resourcefulness.
- Resilience assessment methods: system functionality function: basic concept; definition of intensity measures for extreme natural events and engineering demand parameters; fragility curves.

Earth structures: embankments and slopes
- Construction: geometrical features of embankments and slope cuts; compaction, preloading and excavation procedures.
- Stability: mechanisms and kinematics of natural or artificial slope instability; role of pore pressure; Limit Equilibrium Methods of analysis. - Performance and interventions: settlements due to self-weight and additional loads; effects on pavements; mitigation techniques.
- Monitoring: use of inclinometers and optical fibers; pore pressure measurements for stability; use of ground surface levelling and satellite surveys for settlements; monitoring of seismic or hydrological intensity measures to estimate the expected damage.

Retaining structures
- Construction: earth pressure: basic concepts; gravity structures (masonry or unreinforced concrete walls, r.c. cantilever walls); embedded structures (cast-in place cantilever walls, pre-cast bulkheads); anchors and props.
- Stability: Rankine earth pressure theory; forces equilibrium-based solutions; role of pore pressures; mechanisms and kinematics of rigid and flexible wall ultimate states; Limit Equilibrium Methods of analysis.

- Performance and interventions: empirical and simplified methods for predicting settlements and horizontal displacements; effects on roads and railways; mitigation techniques.
- Monitoring: use of inclinometer and ground surface levelling surveys for horizontal and vertical displacements; monitoring of seismic or hydrological intensity measures to estimate the expected damage.

Foundations of viaduct piers: caissons and piles
- Construction: construction technologies of caisson and piles and their effect on the stress state mobilized in the soil.
- Stability: foundation bearing capacity under vertical or horizontal loads in drained and undrained conditions.
- Performance and interventions: displacements and rotations due to self-weight and additional loads; effects on the viaduct; mitigation techniques.
- Monitoring: use of strain gauges or optical fibers in piles, monitoring of seismic intensity measures to estimate the expected damage.

READINGS/BIBLIOGRAPHY

Slides, lecture notes, technical papers.

TEACHING METHODS OF THE COURSE (OR MODULE)

Lectures and exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- [ ] Written
- [x] Oral
- [ ] Project discussion
- [ ] Other

In case of a written exam, questions refer to

- [ ] Multiple choice answers
- [ ] Open answers
- [ ] Numerical exercises

b) Evaluation pattern