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250421 - GEOMTRENC - Geomechanics of Breakage

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2015
Degree: MASTER'S DEGREE IN GEOLOGICAL AND MINING ENGINEERING (Syllabus 2013). (Teaching unit Compulsory)
MASTER'S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Teaching unit Optional)
MASTER'S DEGREE IN CIVIL ENGINEERING (RESEARCH TRACK) (Syllabus 2009). (Teaching unit Optional)
MASTER'S DEGREE IN GEOTECHNICAL AND EARTHQUAKE ENGINEERING (Syllabus 2009). (Teaching unit Optional)
MASTER'S DEGREE IN CIVIL ENGINEERING (PROFESSIONAL TRACK) (Syllabus 2012). (Teaching unit Optional)
MASTER'S DEGREE IN CIVIL ENGINEERING (PROFESSIONAL TRACK) (Syllabus 2012). (Teaching unit Optional)
MASTER'S DEGREE IN CIVIL ENGINEERING (RESEARCH TRACK) (Syllabus 2007). (Teaching unit Optional)
ECTS credits: 5 Teaching languages: Spanish

Teaching staff

Coordinator: EDUARDO ALONSO PEREZ DE AGREDA

Others: EDUARDO ALONSO PEREZ DE AGREDA, NURIA MERCE PINYOL PUIGMARTI, ANNA RAMON TARRAGONA

Opening hours

Timetable: After class

Degree competences to which the subject contributes

Specific:

8200. The ability to apply knowledge of soil and rock mechanics to the study, design, construction and operation of foundations, cuts, fills, tunnels and other constructions over or through land, whatever its nature and state, and whatever the purpose of the work.

Teaching methodology

The course consists of 3 in-class hours per week in which all available information on the cases will be exposed and then analysed following these steps:
- Description of the case
- Theory used
- Analysis of the case
- Corrective measures
- Lessons learned

Each case will be solved step by step and in detail so that the student will be able to understand the hypotheses accepted, the applied theory pre-established and the theoretical and numerical developments used to understand what happened in each case.

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Learning objectives of the subject

Specialization subject in which knowledge on specific competences is intensified.

Knowledge and skills at specialization level that permit the development and application of techniques and methodologies at advanced level.

Contents of specialization at master level related to research or innovation in the field of engineering.

In geotechnics, as well as in other fields of science and engineering, errors, especially when they have catastrophic consequences, become a valuable experience and frequently a source of inspiration for further study and development of available tools for the analysis and prediction of this kind of events. The failures were key for the development of theories and allowed understanding and determining the essential aspects and their role on the stability of structures and the natural environment. The aim of this course is to apply the basic and essential concepts of soil and rock mechanics to the study of past catastrophes. The term "catastrophe" is used in engineering to indicate that the objectives established were not met, so that it includes not only failures with severe consequences (such as de Vaiont case, which amounted to 2000 casualties) but also those structures that for different reasons do not adequately meet the needs they were designed for (such as the Tower of Pisa, whose tilting was not foreseen in the project.

During the sessions, each of the case stories will be described, from more to less complex, by means of a simple analysis respecting the essential aspects. This first step is in itself already a great geotechnical exercise, in fact it is one of the most important and key to understand a case study, as it requires the definition of a conceptual model based on accepted theories that do not exclude any essential aspect. From there, the basic principles will be applied in order to develop a theory that explains the failure. This will demonstrate how the causes for these catastrophes can be explained with the knowledge on soil and rock mechanics acquired during previous degree studies. This knowledge aims to allow understanding or avoiding possible future geotechnical catastrophes. The use of numerical methods or turnkey programs, such as finite elements, is discouraged because the objective is for the student to be able to follow step by step all the analysis and to understand the concepts and tools used.

Particularly, this course allows the student
- Knowing in detail, from the point-of-view of an expert in geotechnics, well-known catastrophes that were key in the progress of the field.
- Knowing in detail the causes that lead to these failures
- Review and extend those concepts taught during the degree on soil and rock mechanics, calculation, numerical methods, structures and continuous media, and to apply them to case studies.
- Learning to isolate the essential aspects from the complexity associated with case studies and thus be able to focus on the analysis.
- Encouraging the ability to apply the acquired knowledge to different fields as best as possible to achieve the established goal
- Interpreting available data and scientifically justifying these data using the theories accepted by the scientific community and learnt during the degree.

Study load

Total learning time: 125h	Theory classes:	19h 30m	15.60%
	Practical classes:	9h 45m	7.80%
	Laboratory classes:	9h 45m	7.80%
	Guided activities:	6h	4.80%
	Self study:	80h	64.00%

Content

Introduction and generalities

Learning time: 7h 11m

Theory classes: 3h
Self study : 4h 11m

Description:
Presenting an overview of the recent geotechnical history, its paradigms and the role that catastrophes have played in the evolution of knowledge and progress in soil and rock mechanics.

Specific objectives:
Learning and reviewing the key factors in soil and rock mechanics and presenting the case studies that have marked the geotechnical history. The first step to avoid further catastrophes is to know them well.

Settlements

Learning time: 7h 11m

Theory classes: 1h 30m
Practical classes: 1h 30m
Self study : 4h 11m

Description:
Description and analysis of differential and time-deferred settlements observed in the Cathedral of Mexico City, which was built on soft clay.
Analysis of excessive and time-deferred settlements observed during the construction of Kansai International Airport (Japan).

Specific objectives:
Knowing the tilting case of the Cathedral of Mexico. Understanding the effect of the initial state of the land, the sequence of construction of two near or overlapping buildings (both at once, one after the other and one after building and demolishing the other) and logarithmic-linear stress-strain behaviour of soils in the site of both structures.
Knowing the case of the differential settlements of Kansai International Airport. Engineering work designated as one of the "Monuments of the Millennia" by the American Society of Civil Engineers. Extending and applying the knowledge of the consolidation theory and the observational method procedure to predict settlements.

Leaning instability

Learning time: 3h 35m

Theory classes: 1h 30m
Self study : 2h 05m

Description:
Description of the famous case of the inclination of the Tower of Pisa, Italy, and the actions undertaken to prevent its collapse. Explanation of the inclination of the tower and defining practical rules to predict problem of leaning instability in structures.

Specific objectives:
Detailed presentation of the famous case of the inclination of the Tower of Pisa. An understanding of the possible causes that cause the inclination of towers or buildings in general. Extending and applying the knowledge on the theories of stress-strain behaviour of soils.

Bearing capacity	Learning time: 18h Theory classes: 6h Practical classes: 1h 30m Self study : 10h 30m

Description:
Description of the famous case of collapse of a grain elevator built in Transcona (Canada) due to the failure of its foundation.
Description of the failure of the caissons build for the new entrance of the Barcelona Harvour, which occurred in 2001 due to the collapse of its foundation. The case is analyzed analytically and the results compared to those obtained numerically with a commercial program.

Specific objectives:
Analysing the case of failure of a grain elevator built in Trancona. Understanding the causes that led to the collapse and the importance of a good geological and geotechnical characterization of the foundation materials. Extending and applying the knowledge on the theorems of the upper bound.
Presenting the procedures currently used in dyke construction by placing prefabricated caissons. Technique used in the Barcelona harbour. Reviewing, extending and applying the knowledge on bearing capacity theories, the concepts of safety factor, limit equilibrium theorems and liquefaction phenomenon with analytical and empirical solutions.

Landslides	Learning time: 21h 36m Practical classes: 9h Self study : 12h 36m

Description:
Description of the famous case of the Vaiont landslide, which occurred in 1963 in North Italy, in one of the reservoir sides of the same name, being the reservoir almost at its maximum level.

Specific objectives:
Applying the knowledge on landslide translational stability, balance equations and safety factor. Clarifying and extending the knowledge on the effect of submerging the foot of a potential landslide with regards to its stability. Reviewing and extending the knowledge on the effect of temperature in a saturated porous medium and applying it to translational landslides. Showing the possible causes of acceleration of translational landslides that may involve a high risk with catastrophic consequences. Understanding practical rules to estimate the potential acceleration of translational landslides. Reviewing and applying the knowledge on programming and numerical calculation to solve differential equation systems.

Excavations	Learning time: 12h Theory classes: 2h Practical classes: 3h Self study : 7h

Description:
Description and analysis of the collapse of the vault of a tunnel during its excavation and before the support was fully built.
Description and analysis of the collapse of La Floresta tunnels face during their excavation and structural solutions applied to continue with its construction.

Specific objectives:
Presenting the causes that may lead to the failure of a tunnel from the vault forming a cavity due to the collapse of the support installed. Presenting and implementing analytical solutions and considering the limit state methods (upper bound theorem).
Applying and extending the knowledge on the structural stability of the face of shallow tunnels excavated in soils and possible structural solutions to safely perform the excavation. Reviewing, extending and applying the knowledge on analytical solutions and their deduction, continuous media and structures.

Embankments and dams	Learning time: 9h 36m Theory classes: 4h Self study : 5h 36m

Description:
Description of the collapse of a compacted embankment due to rainfall. Presentation of the development of an elastoplastic constitutive for unsaturated soils. Evaluation and calculation of the volumetric deformation observed in the field for the analysed case and estimation of the potential collapse.

Specific objectives:
Understanding and extending the concepts of unsaturated soil mechanics and applying them to a case study of collapse of a compacted embankment. Reviewing the fundamental properties of compacted soils and knowing which ones are suited to avoid problems of volumetric collapse due to rainfall.

Evaluation	Learning time: 14h 23m Laboratory classes: 6h Self study : 8h 23m

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Qualification system

The course will be evaluated taking into account two tests taken during the course and a practical exercise.

There will be two tests: one at mid-term (E1) and another one by the end of the term (E2). Both tests will evaluate the knowledge of the students with regards to what has been taught by the time of the test is scheduled.

The final result will be the maximum score of the second test plus the weighted mean of both tests (the first test will weight 40% and the second test will weight 60%).

Final test result = max. (0.4 * Result of E1 + 0.6 * Result of E2 ; ResultE2)

The final score will be calculated from partial scores above 4 over 10.

The report will be evaluated independently and will be 1 point over 10 of the final score.

Regulations for carrying out activities

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

Bibliography

Basic:

Puzrin, A.M., Alonso, E.E. and Pinyol, N.M.. Geomechanics of Failures. Springer, 2010.

Alonso, E.E., Pinyol, N.M. and Puzrin, A.M.. Geomechanics of Failures. Advanced Topics.. Springer, 2010.

Complementary:

A. Verruijt. Soil Mechanics. 2004. ISBN http://geo.verruijt.net.

Muir Wood, D. Soil behaviour and critical state soil mechanics. Cambridge, UK: Cambridge University Press, 1990. ISBN 0521337828.