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CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

CIVIL ENGINEERING

MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT

YEAR 1
SPRING SEMESTER

PROGRAMME SUPERVISORS:
ANNE-LAURE FAUCHILLE, PANAGIOTIS KOTRONIS

Établissement public sous tutelle du ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

GROUPE CENTRALE

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PHYSICAL MODELLING

CIVIL ENGINEERING – MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Luc Thorel, *luc.thorel@ifsttar.fr*, Graham Knapp, *graham.knapp@cstb.fr*

Objectives

Introduction to the use of reduced-scale models in Civil Engineering. We draw upon the exceptional concentration of large-scale test facilities and scientific expertise in the Nantes area (geotechnical centrifuge, wind tunnels, semi-anechoic room, laser interferometry measurement bench). Knowledge of the basics of physical modelling, use of scaling laws, interpretation of experimental results.

Course contents

The course starts with an overview of scaling laws and similitude problems, followed by a presentation of the main tools used for their analysis and by specific applications in the following fields:

- Geotechnics
- Aerodynamics
- Acoustics
- Geophysics

Course material

Keywords

Physical modelling, scaling laws, geotechnical centrifuge, wind tunnels, semi-anechoic room, laser interferometry measurement bench

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

CONSTITUTIVE LAWS

CIVIL ENGINEERING – MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Giulio Sciarra, *giulio.sciarra@ec-nantes.fr*

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Use thermodynamics to get restrictions on the constitutive laws
- Describe the inelastic behaviour of materials and structures
- Model the elastoplastic response of materials within the framework of continuum mechanics
- Calculate the response of elastoplastic structures
- Describe the main aspects of (brittle) fracture
- Calculate stress singularities in linear elasticity

Course contents

These lectures aim to present the main aspects of modelling irreversible processes within the framework of continuum mechanics. The thermodynamics of irreversible processes (TPI) is introduced as a fundamental tool to obtain a proper characterization of constitutive laws, then plasticity theory and fracture mechanics are presented in detail.

The lectures will cover the following:

- TPI: conservation laws, the first and the second principle of thermodynamics
- Rheological models
- Modelling the elastoplastic behaviour of materials, main postulates and principles
- Perfect plasticity and hardening plasticity
- Plasticity of structures
- The static and the kinematic theorem
- Basic formulation of fracture mechanics
- Stress singularities in prototype problems

Course material

- J. Lemaitre, J.L. Chaboche Mechanics of solid materials, Cambridge University Press, 2000
- J.-J. Marigo Plasticité et Rupture https://cel.archives-ouvertes.fr/cel-00549750v1
- P. Suquet Rupture et Plasticité http://perso.enstaparistech.fr/~mbonnet/mec551/mec551.pdf
- J. Lubliner Plasticity theory, Dover publications 2006

Keywords

Plasticity, Loading-Unloading cycles, Yield condition, Normality rule, Hardening, Structural Hardening, Brittle Fracture, Energy Release Rate

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

IMAGING IN CIVIL ENGINEERING

CIVIL ENGINEERING – MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Anne-Laure Fauchille, anne-laure.fauchille@ec-nantes.fr

Objectives

At the end of the course, the students will be able to:

- Grasp the theory of a few imaging techniques commonly used in civil engineering
- Use the basics of ImageJ software in image data analysis
- Calculate the displacement and deformation field of a sample deformed in the laboratory, using digital image correlation (2D)
- Choose the most compatible method in a range of imaging techniques for different civil engineering applications.

Course contents

Imaging techniques are used to an ever-increasing extent in academic and private research to understand and optimize the mechanical behaviour of various materials (concrete, rock, soil, glass etc). This course provides an overview of the main imaging techniques that master students may encounter during their research internships. The advantages and drawbacks of such methods will be presented, as well as their combination with classical techniques in civil engineering.

The course will focus on digital image and volume correlation in particular, with direct applications in deformation monitoring in underground structures.

At the end of the 32 hours, the students should have a preliminary background and training on image techniques and data analysis of civil engineering materials. As a rough guide, the course is broken down into the following parts:

- Why use imaging techniques? Introduction to non-destructive and destructive imaging techniques
- Definition of an image and overview of image acquisition techniques (camera with simple pictures, x-ray tomography, electron microscopy etc)
- Continuity of techniques from 2D, 3D (laboratory experiments) to 4D (time-resolved Synchrotron imaging)
- Combination of imaging techniques with classical techniques in civil engineering (deformation in triaxial conditions under x-ray tomography for example)
- Overview of image analysis techniques to extract quantitative data (optical full measurement techniques, segmentation, filtering)
- Advantages and drawbacks of imaging techniques (resolution, scale, combination with other methods etc)
- Applications in civil engineering, petroleum and nuclear waste contexts

Homework and lab sessions will provide an understanding of the major processes used in the composites industry.

Course material

- Mesures en mécanique par méthodes optiques, Brémand et al., (2011). Techniques de l'Ingénieur
- Les techniques optiques de mesure de champ; essai de classification, 2005 Y.Surrel.
- Full field measurements and identification in solid mechanics, Mechanical engineering and solid mechanics series, Ed. Wiley (2013)

Keywords

Geomaterial, Imaging, Deformation and Fracturing Monitoring, Non-destructive methods, optical full field measurement, digital image and volume correlation, Research

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	16 hrs	0 hrs	10 hrs	6 hrs	0 hrs

GEOTECHNICAL ENGINEERING

CIVIL ENGINEERING – MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Giulio Sciarra, *giulio.sciarra@ec-nantes.fr*

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Describe the particle-scale interactions in granular materials
- Identify the link between microscale interactions (forces) and macroscopic behavior (stresses) in granular media
- Describe the principles behind numerical simulations with the Discrete Element Method
- Describe the macroscopic behaviour of soils
- Identify the experimental set-ups necessary to provide a characterization of the constitutive response of soils
- Identify the peculiar states which characterize the behaviour of soils (dilatancy, shear bands formation, liquefaction etc.)
- Use enhanced constitutive model of soils.

Course contents

These lectures aim to present two different approaches to geotechnical engineering: the first based on the micro-scale description of granular materials (in particular soils) and the second based on a macro-scale approach to the same problem. Links between these two viewpoints are presented and discussed.

The lectures will cover the following:

- Introduction to the physics of granular materials (compaction, segregation, pattern formation, flows and instabilities)
- Granular micromechanics: contact laws, discrete element modelling
- Granular statics: packing properties, from contact forces to macroscopic stresses
- Granular rheology: experimental and numerical evidence on granular flow, rheological models & boundary conditions
- Tests and experimental results on sands and clays
- The stress path concept: application in the description of drained and undrained conditions
- Peculiar behaviours of soils: dilatancy, shear band formation, liquefaction
- Constitutive model of soils

Course material

- R. Nova Soil mechanics Wiley, 2010
- R. Lancellotta Geotechnical engineering Taylor & Francis 2009
- Andreotti, Forterre & Pouliquen, Les Milieux Granulaires, EDP Sciences, 2011
- Nedderman, Statics and Kinematics of Granular Materials, CUP, 1992

Keywords

Micro-scale analysis, Macro-scale analysis, Triaxial test, Drained & Undrained Conditions, Stability

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

CONCRETE AND STRUCTURES

CIVIL ENGINEERING – MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Panagiotis Kotronis, *panagiotis.kotronis@ec-nantes.fr*

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Describe the elastic and inelastic behavior of concrete and steel
- Understand the principles of hydrostatic-pressure-independent yield surfaces
- Understand the principles of hydrostatic-pressure-dependent yield surfaces
- Describe the main properties of a proper yield criterion for steel
- Describe the main properties of a proper failure criterion for concrete
- Give examples of plasticity models for steel
- Give examples of plasticity and damage mechanics models for concrete
- Criticize the results of non-linear static and dynamic calculations of reinforced concrete structures

Course contents

These lectures aim to present the main aspects of the non-linear behaviour of steel, of concrete and of civil engineering structures. The lectures will cover the following:

- Examples of non-linear calculations of reinforced concrete structures
- Yield criteria for steel
- Failure criteria for concrete
- Numerical implementation

Course material

- Inelastic Analysis of Structures, M. Jirásek and Z. Bažant, Wiley, 2002.
- Plasticity in reinforced concrete, WF. Chen, J. Ross Publishing, 2007
- Engineering damage mechanics. J. Lemaitre, R. Desmorat, Springer 2005.
- Computational Inelasticity. J.C. Simo and T.J.R. Hughes, Springer, 2000.

Keywords

Plasticity, damage mechanics, yield criteria, failure criteria, non-linear behaviour

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

CONFERENCES AND INITIATION TO RESEARCH

CIVIL ENGINEERING – MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT

YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Anne-Laure Fauchille, *anne-laure.fauchille@ec-nantes.fr*

Objectives

At the end of the course, the students will be able to:

- Read (efficiently) a scientific paper on civil engineering research
- Establish the reasoning of scientific papers
- Present orally and clearly scientific data in the context of civil engineering
- Participate in a scientific debate on civil engineering research

Course contents

The goal is to prepare graduate students to start a PhD or any relative research activity (academic or industrial) in the context of civil engineering. The course is composed of three main parts:

- Part A: Conferences (10 hours)
- Part B: Scientific paper reading and writing (10 hours)
- Part C: Oral presentation (10 hours)

These parts represent how to organize and publish (Part B), how to communicate (Part C) and how to discuss scientific data (Part A). Applications are given for civil engineering works.

In part A, researchers from the GeM laboratory at ECN and external researchers are invited to give keynote lectures followed by a discussion or debate. Keynote lectures mostly concern experimental and modelling studies on deformation and fracturing of civil engineering materials (rocks, soils and concrete) subjected to various stresses (mechanical loadings, temperature and humidity loadings, chemical alteration etc), from large scale (building scale, or gallery scale for underground works) to small scale (micrometre scale).

In part B, students learn how to efficiently read scientific papers on experiments, constitutive modelling, numerical analysis and review in civil engineering works. Five different papers are carefully analysed to identify quick and efficient ways to read scientific papers, to improve the understanding of the paper, and the skill of summarizing each section's highlights in the paper.

In part C, students learn how to prepare a short scientific talk (typically 10 to 20 min) in terms of content, vocal, verbal and visual communication, and gesture. In particular, communication techniques to arrange quantitative data are given.

Part C is composed of lectures, videos and practice.

Course material

- Hedan, S., Fauchille, A.L., Valle, V., Cabrera, J. and Cosenza, P., 2014. One-year monitoring of desiccation cracks in Tournemire argillite using digital image correlation. International Journal of Rock Mechanics and Mining Sciences, 68, pp.22-35.
- Hedan, S., Cosenza, P., Valle, V., Dudoignon, P., Fauchille, A.L. and Cabrera, J., 2012. Investigation of the damage induced by desiccation and heating of Tournemire argillite using digital image correlation. International Journal of Rock Mechanics and Mining Sciences, 51, pp.64-75.
- Hedan, S., Hubert, F., Prêt, D., Ferrage, E., Valle, V. and Cosenza, P., 2015. Measurement of the elastic properties of swelling clay minerals using the digital image correlation method on a single macroscopic crystal. Applied Clay Science, 116, pp.248-256.
- Guide pratique du mémoire et autres TFE : rédaction et soutenance, Bonnechère & Bouancheaux Zuckermandl, 2016
- Les fondamentaux de la négociation, Lionel Bellenger, ESF Ed, 2004
- L'essentiel de la gestion de projet, Roger Aïm, Gualino Ed, 2017
- Réussir mémoire, thèse et HDR, Mementos LMD, Constant & Lévy, Gualino Ed, 2017
- http://doctorants-chercheurs.blogspot.fr/2015/12/conseils-pour-faire-une-bonne.html, Fabrice Prat (2001)
- Les 6 règles de base en communication visuelle, 2015 http://evolutiongraphique.com/les-6-regles-de-base-en-communication-visuelle/
- 1001 trucs publicitaires, Luc Dupont, 3e ed, Les Ed transcontinental

Keywords

Civil Engineering, Conference, Scientific Paper, Oral communication, material deformation, fracture

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	2	16 hrs	0 hrs	14 hrs	0 hrs	2 hrs

MODERN LANGUAGES - FRENCH

CIVIL ENGINEERING – MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Silvia Ertl – *silvia.ertl@ec-nantes.fr*

Objectives

The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources. Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture. At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels.

Course contents

Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Gving and obtaining factual information:
    - personal information (e.g. name, address, place of origin, date of birth, education, occupation)
    - non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:
    - meeting people and making acquaintances
    - extending invitations and reacting to being invited
    - proposing/arranging a course of action
    - exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and

environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:
   - making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
   - making purchases
   - ordering food and drink

Course material

Course material: Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

Keywords

reception (listening and reading), production (spoken and written), interaction (spoken and written), knowledge, skills, linguistic competence, sociolinguistic competence, pragmatic competence, register, cultural differences, non-verbal communication

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
French	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

MODERN LANGUAGES - CULTURAL AND COMMUNICATIONAL ENGLISH

CIVIL ENGINEERING – MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Spencer Hawkridge- *spencer.hawkridge@ec-nantes.fr*

Objectives

Interview techniques and communicational English:

- Understand the general concepts of interactive communication
- Build a media project
- Acquire interview techniques
- Understand the process of sourcing and checking facts and figures
- Understand issues related to plagiarism
- Create a bibliography
- Behavioral skills in an inter-cultural environment:
- Strengthen self-confidence and capacity for interaction
- Develop active listening and reformulation skills
- Develop networking skills

Course contents

Cultural and Communicational English: exercises to explore in practice the areas of culture and communication.
Media project (for example: prepare, conduct and promote interviews for a radio programme: *L'Heure Centralienne* (http://www.euradionantes.eu/emission/l-heure-centralienne), with the contribution of professors, PhD students, industrial partners, industry players at fairs, etc.

Course material

Written and televised press, information and digital tools, general documents business environment and company strategies.
Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).
Our own eZoomBook template for the Intercultural project.

Keywords

Culture and communication, inter-cultural environment, team-building, digital tools, etc.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	0 hrs	30 hrs	0 hrs	0 hrs	2 hrs