

CIV_ENV_395_27
Energy Geostuctures and Geosystems – EGG
Spring Quarter 2020

This course focuses on energy geostuctures and geosystems: novel multifunctional earth-contact technologies that can provide renewable energy supply and structural support to any built environment. The course comprises theoretical and practical sessions. The theoretical sessions expand on the competence needed for the analysis and design of energy geostuctures and geosystems from energy, geotechnical and structural perspectives. The practical sessions involve the development of a project devoted to the subsurface characterization of cities for energy harvesting and structural support purposes, considering the city of Chicago as a case study. The project of this course will be developed through the compilation from the literature and other public sources of relevant data about the subsurface of a selected district in Chicago (hydrogeology, underground structures, etc.), and will involve a field visit to install wireless sensors in selected underground environments for a successive monitoring of the subsurface conditions. The project will be presented at the end of the course through an oral presentation, which will be supported by a portfolio and a poster.

Specific learning objectives of this course are as follows:

- Understand the phenomena governing the behavior and performance of energy geostuctures and geosystems, with a focus on the deformation, heat transfer and mass transfer phenomena involved with their operation
- Apply the previous knowledge to the analysis of the behavior and performance of energy geostuctures and geosystems constituted by energy piles, energy walls and energy tunnels
- Master the performance-based design of energy geostuctures

This course targets students interested in energy, environmental sustainability, structures, geosystems, and urban planning. It has been structured with civil, environmental, energy and mechanical engineers in mind.

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Class times	Tuesday and Thursdays, from 12:30 to 1:50 pm
Location	To be defined
Suggested textbook	Laloui, L. and Rotta Loria, A. F. (2019) <i>Analysis and Design of Energy Geostuctures</i> , Elsevier Academic Press, p. 1098
Pre-requisites	Familiarity with the fundamentals of the mechanics of materials as well as with the essentials of heat and mass transfers
Course Assessment	Research project, to be performed in groups – 40% Research project portfolio, presentation and poster, to be performed in groups during the last day of class – 10% Final written exam, to be performed individually – 50%
Deliverables	The presentation, portfolio and poster of the project developed by each group. A temporary exhibition of the projects will be organized at Northwestern University at the end of the course.

Course content

Week 1	Subject
Lecture 1	Introduction: energy geostructures and geosystems
Lecture 2	<i>Project: subsurface characterization – soil stratigraphy and material properties</i>
Week 2	
Lecture 3	Fundamentals: heat and mass transfers in the context of energy geostructures
Lecture 4	<i>Project: subsurface characterization – soil stratigraphy and material properties</i>
Week 3	
Lecture 5	Fundamentals: deformation in the context of energy geostructures
Lecture 6	<i>Project: subsurface characterization – geometry of subsurface structures</i>
Week 4	
Lecture 7	Observations: thermo-hydro-mechanical behavior of energy piles
Lecture 8	<i>Project: subsurface characterization – identification of field locations to be monitored and planning of field visit</i>
Week 5	<i>Field visit to be organized outside of the class hours</i>
Lecture 9	Observations: thermo-hydro-mechanical behavior of energy walls, slabs and tunnels
Lecture 10	<i>Project: surface characterization – uses of buildings and infrastructures</i>
Week 6	
Lecture 11	Observations: thermo-hydro-mechanical behavior of soils and soil-structure interfaces
Lecture 12	<i>Project: surface characterization – uses of buildings and infrastructures</i>
Week 7	
Lecture 13	Analysis: analytical and numerical modelling of single and groups of energy piles
Lecture 14	<i>Project: subsurface monitoring – data collection and interpretation</i>
Week 8	
Lecture 15	Analysis: analytical and numerical modelling of energy walls and tunnels
Lecture 16	<i>Project: subsurface monitoring – data collection and interpretation</i>
Week 9	
Lecture 17	Design: determination of design parameters for energy geostructures
Lecture 18	<i>Project: schematic design development of an energy geostructure</i>
Week 10	
Lecture 19	Design: performance-based design of energy geostructures
Lecture 20	Oral presentation of research projects and exposition