Energy Geostructures – Civil 444

Personal projects – Tuesday, 11:15 –12:00

1. Objective of the projects:

The objective of this project is the application of the acquired knowledge during the course to design an energy geostructure following current standards through appropriate procedures.
You have to choose a building and the stratigraphic profile on which it is built. You should develop the optimal performance-based design of the piles at both ultimate and serviceability limit states considering, when appropriate, the influence of the temperature variations ($\Delta T_k = \pm 10$ °C) associated with the geothermal operation of the energy piles during heat extraction and injection periods, respectively. In this context, the design of the energy piles is intended to consider the most critical results of the design approaches predicted by the Eurocode (EN 1990 2002) for the ultimate limit states and serviceability limit states. As a preliminary approach, only the verifications for the stress and displacement limitations are requested to be carried out at serviceability limit states. Although not all of the design verifications are requested in this context, there is the need to specify all of the verifications that should be performed in real practice for the energy piles as single isolated elements and elements in a group.

In details the objectives of this work are

1. To define the number of piles required according to the design approaches predicted by the Eurocode (EN 1990 2002)
2. To design the typical cross section of one energy pile at ultimate limit state (Eurocodes EN 1990 2002, EN 1992 2004)
3. To perform the geotechnical and structural design at serviceability limit states (SLS stress development, SLS vertical displacement) (Eurocodes EN 1990 2002, EN 1992 2004)
4. To perform the energy design of the foundations estimating the number of piles that are to be equipped with absorber piles (SIA D0190-2005, SIA 384/6 2010) based on your estimation of the building thermal needs (SIA 380/1, see Annex)
5. To determine the temperature variation in the ground surrounding the activated piles. Comment on the influence of the results on the energy piles spatial disposition.
6. To present the executive drawing of the pile
7. To perform an environmental and technoeconomic analysis including:
    - Capital Expenditure (CAPEX) estimation for the installation of energy piles
    - Operational Expenditure (OPEX) assessment
    - Return on Investment (ROI) calculation based on energy savings
    - CO_2 emissions analysis and comparative analysis with state-of-the-art renewable energy technologies in terms of efficiency, sustainability, and cost-effectiveness.

2. Deliveries:

The groups are to be finalized by February 25th, 2025. The projects are intended to be developed in groups of maximum 3/4 people. The deadlines and scope of each of the different aspects of your project are as follows:

May 13th, 2025: Oral presentation
You should present to the class the results of your project. The purpose of the presentation is to inform other students about your project. The oral presentation of your project will represent 10% of your final mark while the report will represent 20% of your final mark.

June 3rd, 2025: Technical report
Technical report with calculations. You should submit your report to Prof. Laloui and Elena Ravera in electronic format.

Please make sure that your technical report includes:

Technical report contents

1. Introduction
2. Standards
3. Building description
4. Durability
   4.1 Durability class
   4.2 Concrete cover
5. Materials
   5.1 Concrete
   5.2 Steel
6. Actions
7. Soil stratigraphy
8. Pre-Dimensioning
9. Geotechnical design - Ultimate limit states
10. Structural design - Ultimate limit states
11. Geotechnical and structural design - Serviceability limit states
12. Energy design
13. Executive drawings
14. Environmental and techno-economic evaluation
15. Conclusion

Annex
https://www.epfl.ch/campus/library/collections/standards/
Assumptions

Assumptions related to SIA 380/1

1. Assume that the reference conditioned surface (“surface de reference énergétique”) corresponds to 80% of the total floor area.
2. Consider that there is 1700 hours of heating operation during a year
3. Consider that a month corresponds to approximatively 30.5 days
4. The heating operation corresponds to 6 months.