1SC4590 – Design of a bridge in a seismic zone

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Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 27,00

Description

This challenge week aims at putting students in the position of an engineer in charge of designing a railway bridge. More specifically, students will have to design a preliminary project for a railway bridge built in a seismic zone so that it meets certain constraints and a certain level of performance.

As a starting point, students will be given an example of a digital model containing the geometric data and mechanical properties of a bridge as well as specifications presenting the point to be designed and the performance criteria to be met. The partner company of this challenge week plays the role of the client of the design mission in front of teams made up of 5 students.

At the end of this challenge week, each team will present to the client (the partner company) its design project for the bridge as well as its advances in the development of automated and integrated engineering design approach. The client will then evaluate the various solutions proposed.

Quarter number

ST4

Prerequisites (in terms of CS courses)

The course *Continuum Mechanics* would be a plus.

Syllabus

1) Day 1:

- Presentation of the bridge project by the client commissioning the mission: geometry, materials, densities, photos or 3D model if available. Data recovery on the bridge.
- Statistical analysis of a database of bridge projects already completed. Methods such as linear regression, random forest, or neural networks can be considered to learn physical and non-physical data collected during projects already completed and to give

indications on the choices to be made in the case of the mission to be carried out.

2) Day 2:
Geometric, mechanical, and seismic modeling of the bridge with digital continuity. The following developments are expected:

- a parametric modeling of the bridge geometry from CAD tools,
- a seismic modeling of a bridge from a finite element analysis software, and
- an interface making it possible to export the geometries generated by the CAD software in a format that can be used directly by the numerical simulation software.

3) Day 3:
Recovery of seismic data and estimation of the seismic hazard:

1. measurements of the seismic intensity, probability of occurrence of an earthquake, dimensioning spectrum adapted to the considered hazard,
2. selection of accelerograms compatible with a design spectrum,
3. critical analysis of uncertainties in seismic loading (variability of seismic forces as a function of the seismic signal considered).

4) Day 4:
Synthesis of the 3 previous days, improvement of the weak points identified, production of a first version of the final presentation of the project.

5) Day 5:

- Morning: design of the bridge (calculation of the data of interest for the design engineer, comparison with limit states, iterative approach for optimizing the bridge geometry towards meeting the expected performance criteria).
- Afternoon: final jury (presentation of the bridge project to the client).

Class components (lecture, labs, etc.)

- Work in a team of 5 students.
- Work in project mode.
- Reminders or introductions of theoretical elements (3h in the week).
- List of daily expectations distributed to the teams at the beginning of each day.
- Progress report to be produced at the end of each day.
- Supervision by a multi-disciplinary team.

Grading

1) Evaluation Jury:At the end of the integration course, each team presents its project to a jury.20 minutes of presentation followed by 10 minutes of exchanges with the jury.The jury is made up of the client who is the sponsor of the completed mission and a teacher-researcher.The jury evaluates the teams.

2) Continuous assessment: Each day concludes with the writing of a short report (1 or 2 pages) showing the successful acquisition of the skills expected to be developed.

Course support, bibliography

Bibliography and materials distributed according to the progression of the course.

Resources

1) Software :

- Rhinoceros3D Grasshopper for CAD
- Pythagore for the numerical simulation of the dynamic behavior of civil engineering structures with the finite element method
- Python / Matlab

2) Databases:

- Bridge projects
- Seismic demands

3) Teaching materials:

- Course to remind or introduce useful theoretical elements (3h total in the week)
- List of daily expectations distributed to the teams at the beginning of each day
- Research, technical or vulgarization articles

4) Multi-disciplinary team:

- Faculty members
- Engineers-architects experts in Rhinoceros3D and Grasshopper software
- Engineers developers of the Pythagore software
- Structural engineers from a bridge design company

Learning outcomes covered on the course

- Hold a design engineer position adapted to the collaborative context in a digital setting (identification of the actors, understanding of the respective responsibilities / perimeters of action, adapted communication / respect of a certain protocol).

- Analyze and process the geometrical and mechanical information from the digital model of the bridge to propose a simplified but relevant mechanical model at a pre-project stage.
- Analyze and process statistical information from databases.
- Manipulate CAD tools.
- Manipulate numerical and analytical tools for modeling dynamic structural behavior.
- Initiate a process of automating the design of a bridge.

Description of the skills acquired at the end of the course

C4 – Having a sense of value creation for your company and its customers
C6 – Being operational, responsible, and innovative in the digital world
C7 – Knowing how to convince
C8 – Leading a project, a team

ST4 – 46 – ENERGY AND CLIMATE

Dominante : ENE (Energy)
Langue d'enseignement : French
Campus où le cours est proposé : Paris-Saclay

Engineering problem

In the face of climate change, the energy transition is now inevitable. CentraleSupélec engineers can contribute to these challenges by contributing their skills in processing huge quantities of data. Indeed, the acquisition, statistical analysis and integration of climate data into predictive models make it possible to assess the impact of GHG emissions on the climate and the measures to be implemented to limit these changes. The same applies to economic data used to anticipate the economic consequences of climate change.

At the same time, the digitalisation and computerisation of energy systems (e.g. smart meters) is resulting in an increase in the volume of data collected, the exploitation of which opens up new opportunities for optimising the production of renewable energy and controlling consumption.

This thematic sequence is an opportunity for the future CentraleSupélec engineer to apply data processing and analysis tools to respond to specific climate and energy issues: modelling climate change and its economic impacts, identifying and analysing uses to control electrical energy consumption, or estimating the production of an offshore wind farm.

Adviced prerequisites

No CentraleSupélec course is required. It is recommended to have taken the elective courses Electrical Energy and Transfer Sciences.

Context and issue modules:

The conferences and round tables will provide an opportunity to take stock of climate change and the need to reduce GHG emissions, particularly in the field of energy, as well as the major economic consequences that must be anticipated and managed. They will be addressed by academic experts in climatology and economics, industrial experts on the production of renewable energy, and entrepreneurs in the energy sector.

Specific course (60 HEE) : Climate and Energy Transition

Brief description: The objective of this course is :

- to present the potential of systems using renewable energy sources. A first part is dedicated to the main devices of energy production from renewable sources. The second part deals with the integration and management of energy within transmission and distribution systems. The conversion and storage elements used in this context will be discussed.

- The physical basis of the energetics of the global climate system (role of the vertical temperature profile in the atmosphere, effect of water vapour, albedo, feedback mechanisms). It will also focus on aspects related to weather prediction: wind patterns, sunshine patterns.

- to master the operation and models of electrical system components, notably in the production of renewable energy and in domestic use: generators, converters, loads.

Challenge week n°1: Prediction of climate change and its economic impacts

- Associated partners: IPSL

- Location: Paris-Saclay campus

- Brief description: the objectives of this integration course are to

- understand the issues related to climate change: impact on energy needs (air conditioning, new modes of transport, etc.), societal and economic impact

- implement global models integrating fluid dynamics and energy balances

- analyse meteorological databases

- analyse and understand the economic, societal, environmental and human impacts on certain regions of the world that the students will choose according to their interests

Challenge week n°2: Analysis of electricity consumption by Data Science

Associated partner: EDF

- Location: Paris-Saclay campus

- Brief description: To achieve the energy transition, it is essential not only to develop renewable energy sources but also to know how to control consumption and save energy. Managing the consumption of a site (factories, buildings, etc.) requires knowledge of uses and connected loads to facilitate the deployment of energy management methods. However, for economic reasons, it is not possible to place measurement sensors (voltage, current) on each of the loads. In this context, the proposed work is to identify the connection status and individual consumption of each electrical appliance (radiator, washing machine, chargers for electronic equipment, etc.), based solely on measurements at the main switchboard at the entrance to the site. This could be done by relying on the individual signature of the appliances and using signal processing methods, in particular those of Machine Learning. The work during the IE allows students to :

- Implement modelling for the analysis of energy use in a building

- Implement digital signal processing tools (Matlab Simulink)

- Implement an identification approach based on models and simulation

- Confront the methods with the conditions of signal measurements on real cases

Challenge week n°3: Estimation of the production of an offshore wind farm

- Associated partner: EDF

- Location: Paris-Saclay campus

- Brief description: This integration course aims to :

- Understand a complex dataset (context, scales, accuracy, limitations, security)

- Graphically analyse a dataset (univariate/bivariate graphical analysis, graphical link between several variables)

- Analyse a dataset statistically (independent/matched t-test, time series, cycles and trends)

- Estimate the production of a wind farm and the associated revenue