Post-doctoral position in computational mechanics for bridge structural health monitoring

Location: CentraleSupélec | Université Paris-Saclay, France

Keywords: Structural Health Monitoring, Finite Element Method, wave propagation, structural vibration / acoustics, reinforced concrete, signal processing, digital twin.

Starting date: anytime

Duration: until Nov. 2023

Description

This post-doctoral position is open in the framework of the project GEOPONT that aims at developing a reliable and cost-effective technique for the health monitoring of reinforced concrete bridges. The project GEOPONT gathers 2 industrial partners (Bouygues Travaux Publics and SpotLight) and 1 public institution (CentraleSupélec | Université Paris-Saclay). It is financially supported by the CEREMA in the framework of the France 2030 Plan of the French government (https://www.cerema.fr/fr/pontsconnectes).

The post-doctoral researcher will be conducting research to numerically model the propagation of artificially generated seismic waves in reinforced concrete bridge slabs. Bridgology will provide Ground Penetrating Radar (GPR) images from a couple of bridges that are currently in service in the Greater Paris area. SpotLight will then carry out experimental invistigations on these same bridges, generating a source of artificial seismic waves and recording how these waves propagate in the bridge slab using geophone sensors. CentraleSupélec will be developing a numerical model of the bridge decks and of the waves propagation to support the design of experiments and also to support the analysis of the experimental results.

The bridge slabs will be modeled using the finite element method. The initial state of the bridge will be determined from the data collected by the GPR. Uncertainty in the material properties will be introduced using stochastic fields. The experiments carried out on site will be modeled numerically. The main objective is to develop a numerical mechanical model that accurately represents the experimental measures. Such a model can then be used for (i) the interpretation of experimental observations, (ii) the design of new experiments, (iii) the structural health monitoring of a category of bridges. In particular, several questions will have to be investigated:

- How to define the finite element mesh and its boundary conditions?
- Can the slab heterogeneous material (steel rebars, cement paste, aggregates) be considered as homogeneous? How to define a Representative Elementary Volume?
- What are the conditions (if any) for the results obtained from the numerical analysis of a specific bridge to be valid for another bridge?
- How to communicate the results of the computations in terms of quantities of interest for the bridge owner?

- How to develop a learning numerical framework where the results of new experimental campaigns can improve the accuracy of the bridge numerical model? Model updating strategies could be implemented to improve the predictive capabilities of the numerical model towards achiving digital twins of the bridges investigated.

References:

Moustapha M., Marelli S., Sudret B. (2022) Active learning for structural reliability: Survey, general framework and benchmark, *Structural Safety* **96**: 102174.

Fuhg J.N., Fau A., Nackenhorst U. (2021) State-of-the-Art and Comparative Review of Adaptive Sampling Methods for Kriging, *Archives of Computational Methods in Engineering* **28**: 2689-2747.

Shinozuka M., Deodatis G. (1991) Simulation of stochastic processes by spectral representation, *Applied Mechanics Reviews* **44**(4): 191-204.

Mankara A., Bayane I., Sørensen J.D., Brühwiler E. (2019) Probabilistic reliability framework for assessment of concrete fatigue of T existing RC bridge deck slabs using data from monitoring, *Engineering Structures* **201**: 109788.

Conditions of Employment

Monthly gross salary: 3,000 EUR

Included in the salary:

- participation of the employer to the public transportation costs
- social security
- retirement plan (for European citizens only)

About your Future Workplace

The researcher will be appointed in the Laboratoire de Mécanique Paris-Saclay (LMPS) at Université Paris-Saclay. The LMPS (UMR 9026, Université Paris-Saclay / CentraleSupélec / ENS Paris-Saclay / CNRS) is dedicated to research on all aspects of solid mechanics (mechanics of materials and structures, civil engineering, fine experimentation, and efficient numerical modeling). The LMPS has about 220 members, including 110 PhD students and postdocs and 35 engineers, technicians and administrative staff on two sites of Paris-Saclay University: CentraleSupélec and ENS Paris-Saclay, both in Gif-sur-Yvette. The LMPS hosts four research teams.

The researcher will join the OMEIR team – Structures, Materials, Environment: Interactions and Risks (https://lmps.ens-paris-saclay.fr/fr/omeir). The team contributes to the energy, ecological, and digital transitions of all fields related to cities and infrastructures. It brings together the expertise of research groups specializing in construction and natural materials, the modeling of various physical phenomena (mechanical, thermal, hydric, chemical), advanced experimentation, natural risks, large-scale and advanced numerical simulations, and statistical learning.

The associated societal issues in the field of construction in the broadest sense (building, structures, public works, civil engineering, etc.) highlight essential questions related to the ecological and social impacts of human activities concerning not only the resilience of society, but also those

associated with information technologies which are disrupting the practices of the sector. In this respect, three important points can be highlighted: the reduction of the ecological footprints of structures; the evaluation and reduction of the vulnerability of constructions (with economic and human impact) subject to hazards/risks, natural or otherwise; the transition from digital models to true digital twins combining multi-physics simulation, data assimilation, and advanced experiments.

Your profile

PhD in computational structural vibrations or in computational wave propagation or in non-destructive testing methods based on mechanical waves.

The following skills are of particular interest to the project:

- Numerical simulation of mechanical systems (experience with Abaqus, Cast3m or Code_Aster would be a plus)
- Structural mechanics
- Stochastic mechanics
- Signal processing
- Design of experiments

We are looking for highly motivated candidates who are self-driven, have excellent communication and writing skills (fluent spoken and written in English or French is mandatory), and enjoy working in an interactive environment with other PhD students, junior and senior researchers, as well as industrial partners.

How to apply?

We look forward to receiving your application with the following documents:

- Application letter explaining why you think you fit in the position
- Detailed CV
- Recommendation letters

Please email your complete application to: pierre.jehel@centralesupelec.fr (Pierre Jehel, PhD).