Université Gustave Eiffel

PhD fully-funded position

Pre-screening of candidates

3 years, starting October 2024

Subject :	Enhancing Long-Term Resilience in Road Pavements through the Contribution of "Bio-Binder" Materials
Organisation :	**University Gustave Eiffel** - https://www.univ-gustave-eiffel.fr/
Scientific section:	Solid Mechanics/Physics, Materials science
Keywords :	Viscoelasticity, fracture, coupled problem, modelling
Laboratory :	Département « Matériaux et Structures » (MAST), Laboratoires (MIT) et (LAMES)
Location :	Université Gustave Eiffel, Campus de Nantes (Bouguenais, 44)
Supervisors :	Olivier Chupin, researcher at LAMES laboratory Tél. : (+0/33)2 40 84 57 86, Mél. : olivier.chupin@univ-eiffel.fr Ferhat Hammoum, senior researcher at MIT Laboratory Tél. : (+0/33)2 40 84 57 67, Mél. : ferhat.hammoum@univ-eiffel.fr

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Project and job description

The increasing demands for mobility, questions related to environmental preservation and climate change, necessitate the development of transport infrastructure that is not only more sustainable but also less emission of greenhouse gases, preservation of natural resource and energy-efficient, and demonstrates greater resilience. To meet the future transportation needs, two external factors must be considered: the integration of fully automated vehicles and truck platooning as promising solution to optimise road transportation platoon heavy vehicles.

Recent years, one observe as accelerated climate warming, marked by unusually high temperatures recorded in France and more temperature variations during cold seasons. The existing pavement structure calculation tool, designed for a 30-year lifespan, lacks considerations for aging evolution and damage regarding the temperature variations, self-healing during rest period, and the high dissipation properties of some specific binders. Understanding the mechanical behaviour and evolution of these materials over time is crucial to enhance our design tools. To address the impact of climate warming on road infrastructure, bridging the gap between laboratory-driven damage evolution laws and "prospective" studies is essential. This thesis aims to refine our methodology by incorporating damage considerations associated with temperature and complex loads.

Definition of the project: From previous research on crack propagation in a viscoelastic medium under isothermal conditions (I. Santos, 2020), there is a need to extend the study to standard and alternative materials. This extension will allow for an exploration of the relationship between damage and temperature. The goal is to increase our knowledge and to refine our understanding of fatigue cracking in asphalt mixtures regarding various fatigue test types.

In this context, MIT and LAMES laboratories are actively seeking a doctoral candidate to contribute to collaborative research. The focus is on developing low-carbon footprint materials and studying their performance in laboratory settings and pavement structures. The objective is to assess the long-term thermomechanical behaviour of materials preserving energy and resource, including recycled materials. The enhancement of structural calculation tools requires the integration of material characteristics with environmental conditions.

Scientific Challenges: The thesis identifies three scientific challenges within its scope:

-Identify the thermo-viscoelastic behaviour of non-standard materials.

- Evaluate the dependence of damage with the temperature.

-Propose a methodology or model to estimate fatigue resistance within a specific temperature range to take into account climatic variability and rest period.

Thesis work: the thesis work concerns both material and structural scales. At the material scale, the focus is on identification of viscoelastic behaviour and understanding thermomechanical fatigue under different loading conditions and temperatures. The candidate will use laboratory testing methods, including a new hydraulic press, to contribute to the characterization of materials. Building upon previous work, the candidate will propose and validate a fatigue test damage model incorporating imposed temperature.

At the structural scale, numerical calculations will be performed on a typical pavement structure subjected to variable temperature and imposed loading. Subsequent analysis of the results will validate the damage law determined at the material scale. The integration of both scales is crucial to effectively address the outlined scientific challenges.

Thesis Problem: Previous research on crack propagation in a viscoelastic medium under isothermal conditions (*I. Santos, 2020*) led to an intrinsic modelling of fatigue cracking in asphalt mixtures, aligning various fatigue test types. This initial study on a model material requires extension to standard and alternative materials. Leveraging the gained knowledge will enable an exploration of **the relationship between damage and temperature**.

In this context, MIT and LAMES laboratories seek to recruit a doctoral candidate to reinforce a collaborative research theme, combining the development of low-carbon footprint materials with a study of their performance in both laboratory settings and pavement structures. The goal is to assess the long-term thermo-hydro-mechanical behaviour of energy and resource-efficient materials (recycled materials, incorporating "bio-sourced" materials, or industrial by-products). Enhancing structural calculation tools necessitates coupling material characteristics with environmental conditions.

Keywords: viscoelasticity, Bio-binder, bituminous mix, fatigue, damage law, intrinsic parameters, modelling, digital image correlation, displacement field, temperature field.

Qualifications: Applicants must hold either a Master's degree or equivalent in mechanics of materials for civil engineering in the large sense, with experience in numerical development and experimentation, the proposed multidisciplinary projects will require broad interests and a willingness to explore new topics, acquire new skills and the capacity to exchange with colleagues from different disciplines.
Knowledge of the viscoelasticity behaviour and soft material and/or coding will be a plus. Specific useful skills (but not essential pre-requisites) include thermal measurements and imaging analysis
Candidates must be curious and intellectually ambitious. The successful candidate will work independently and contribute effectively to team efforts. She/he will communicate well in French and/or English (oral/written). Knowledge of French (or willingness to learn) will be useful.

Application and selection procedure: *This fellowship is conditional to the successful completion of a two-step selection, the first step of which is advertised here. If you are interested in the project, please submit your application by e-mail to Olivier Chupin (Olivier.chupin@univ-eiffel.fr) and Ferhat Hammoum (ferhat.hammoum@univ-eiffel.fr) no later than March 20th, 2024. Apply early, as shortlisted candidates will be selected for interviews every week, to be interviewed on-line or on-site (depending on the candidate's location) in March or early April, until suitable candidate is found. After these interviews, the candidate will be preselected and will then compete in the SIS doctoral School selection (Nantes ED SIS 602) around May 13th-17th, 2024, for the second and final round of selections.*
The application, in English or in French, must include:
- The candidate's CV (no more than 2 pages)
- A short letter explaining her/his motivation for this position and project
- Grades from Masters Courses (the two last year of studies)
- A recommendation letter from someone who supervised the candidate's laboratory work (for example the supervisor of the Masters project/internship) – please ask the referee to send the recommendation letter directly by e-mail to ferhat.hammoum@univ-eiffel.fr
The name, e-mail address and telephone details of one additional referee.