INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES RENNES

Development of 3D beam element formulations for nonlinear analysis of composite/hybrid steel/timber-concrete structures

The Structural Engineering Research Group at LGCGM has initiated an in-depth discussion on innovative research direction in the civil engineering sector. It has been decided to investigate structural solutions with lower environmental impact, in order to support the transition of the civil engineering sector towards less carbon-intensive construction that is more respectful of the environment.

Enlarging the scope of research group has already started by exploring structural solutions that combine timber-concrete structural (we can mention the Horizons Bois system), and by prospecting for other bio-based solutions. Nevertheless, and although systems of this type have been used for at least two decades, connection technologies can still be improved; physical behavior models are poorly described; and computational techniques for advanced constitutive models covering the short-term and long-term behavior of bio-sourced materials, here wood in particular, almost inexistent.

This gap in knowledge has a negative impact on the development of the foreseen innovative solutions.

This thesis project aims to fill this gap through an in-depth theoretical research on the physical mechanism taking place in members made of multiple materials. This will involve developing a physically-sound modeling tool, which will allow, among other things, to simulate the experimental tests carried out on the “Civil Engineering Structures ” platform in order to gain a detailed understanding of the observed behaviors, and then extend them to cope with more general situations.

The non-linear 3D beam finite element considered will have to address several scientific obstacles:

- First of all, finite element formulations taking into account the behavior at the interface between different materials and in particular the deformability of the connection, written in a three-dimensional space are completely non-existent. This situation contrasts with the case planar hybrid beams for which several formulations exist including those developed by our group. This limitation does not allow lateral-torsional buckling analysis, yet decisive for structures involving slender beams. Furthermore, taking warping into account complicates the kinematics and in particular the definition of the slip at the interface as a function of the kinematic variables. This results in numerical locking issues.

- There are different models of time related behavior for concrete material and wood material; however, the model predictions are not necessarily representative of reality. It will therefore be necessary, through an exhaustive state of the art, to evaluate existing models, to compare them with a large experimental base from the literature, to discriminate between the most relevant models and to improve them.

The co-rotational approach will be adopted. The local formulation should take into account the slip at the interface induced by internal forces, including non-uniform torsion. Particular attention will be paid to the transformation matrix relating global variables to the local ones. The integration of the constitutive laws will take into account the coupling between damage of the material and the time effects. Model predictions will be compared against experimental results. Time-related instability will also be investigated and design rules will be devised and written in a format compatible with Eurocode 4.

Entry Requirements

A very good graduate degree (5 Years curriculum) in Structural Engineering from a recognized institution is required. A good background in Structural Engineering and strong interest in Computational Mechanics are requested. Applicants must be fluent in English.

Closing date

Applications should be received no later than 27th April 2021.

How to apply

To express your interest, please email your CV, name and contact details of at least two referees and a brief statement of your research interests to Prof. Mohammed HJIAJ (mohammed.hjiaj@insa-rennes.fr) .

Contract

The successful applicants will be employed under a full-time fixed-term contract covering the duration of the PhD (3 years). Exact salary of PhD student will be release by the government soon. It is expected to range between 1700 € and 2300 €. The successful applicant is expected to start early October 2021.