School of Computing, Engineering, and the Built Environment
Edinburgh Napier University

PHD STUDENT PROJECT

Funding and application details

Funding status: Self-funded students only

Application instructions:
Detailed instructions are available at https://www.napier.ac.uk/research-and-innovation/research-degrees/how-to-apply

Prospective candidates are encouraged to contact the Director of Studies (see details below) to discuss the project and their suitability for it.

Project details

Supervisory Team:
- DIRECTOR OF STUDY: Dr Aamir Khokhar (Email: A.Khokhar@napier.ac.uk)
- 2ND SUPERVISOR:

Subject Group: Built environment

Research Areas: Civil Engineering, Structural Engineering, Structural Mechanics, Timber Engineering

Project Title: Advances in Sustainable Structural Materials – An Experimental and Numerical Investigation to Assess the Structural Performance of Timber Concrete Composites

Project description:

In an age where climate change is at the top of the agenda, engineers have been pushed to find novel techniques of constructing not only for a global population with exponential growth, but in such a manner to ensure sustainably throughout the whole construction process. With this growing demand for sustainable engineering solutions, Engineering Wood Products (EWP) such as Cross Laminated Timber (CLT) has become increasingly popular [1] . The current application of CLT ranges from domestic dwellings to mid-rise structures. The scope of CLT is further

increased by using CLT to concrete composite beams and panels (floors) and expanding structural applications of CLT to high-rise structures and large spanning bridges and thus will push the boundary of truly large-scale sustainable construction [2].

For CLT to concrete composites to be successfully adopted, structural properties (stiffness and strength), the configuration of connectors between CLT and concrete and the slip modulus of the composite must be determined. However, very little research work is available and information on the structural performance of CLT to concrete is not fully explored. The slip modulus is required to determine various structural properties and for the design of the composites[3]. However, the Eurocode 5 has limitations and drawbacks to determine the slip modulus [3] and there is an urgent need to address this. This is what the proposed research will address.

The aim Investigate the performance of connections in CLT-concrete composites through experimental and numerical research with a focus on impact factors such as:

1. What penetration depth, screw inclination and geometry have on the performance of connections in CLT Concrete Composites.
2. Create a FEM which can be used to validate laboratory data and model connections with more complex geometry.

The research will consist of experimental and numerical research. Initially, a full comprehensive testing programme, testing various types of connections used in CLT Concrete Composites will be undertaken. Push-out and three-point bending tests will be conducted to assess and identify the suitability of different types of connections. Various specimens comprising beams and small-scale composite floor members will be fabricated and used for testing, as this is what CLT Concrete Composites are most commonly used for. In addition to the experimental work, a finite element model of the beams and floor members will be developed to verify laboratory work as well as model more innovative connections which would be time-intensive to manually produce.

Fundamentally, this research will aid with the understanding of the behaviour of connections used in CLT Concrete Composites and will ultimately hope to provide insight with which connections are optimum for use. Additionally, this research will highlight the possible drawbacks of the current guidance for calculating the slip modulus in Timber Concrete Composites prescribed by Eurocode 5. This research will prove beneficial to various stakeholders, including sustainable construction advocates, who wish to see the scope for timber engineering pushed beyond its current boundaries, practicing design engineers, who will be able to design beyond current limits with timber and those in academia who wish to continuously improve timber design standards.

References:

[1] Karacebeyli E, Douglas B. CLT Handbook -US Edition. Quebec, Canada: PInnovations and Binational Softwood Lumber Council, Point-Claire; 2013.

[2] Mai KQ, Park A, Lee K. Experimental and numerical performance of shear connections in CLT–concrete composite floor. Materials and Structures 2018;51:84. https://doi.org/10.1617/s11527-018-1202-3.

[3] Mirdad MAH, Chui YH. Strength Prediction of Mass-Timber Panel Concrete-Composite Connection with Inclined Screws and a Gap. Journal of Structural Engineering 2020;146:04020140. https://doi.org/10.1061/(ASCE)ST.1943-541X.0002678

Candidate characteristics

Education:

A second class honour degree or equivalent qualification in Civil Engineering or Timber Engineering

Subject knowledge:

- Structural Mechanics
- Structural Analysis
- Finite Element Modelling

Essential attributes:

- Experience in fundamental experimental work
- Competent in structural analysis, structural mechanics
- Knowledge of timber as an engineering material, Eurocodes
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes: