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Department	School of Engineering and the Built Environment
Supervisors	Dr Aamir Khokhar (Director of Studies), Professor Robert Hairstans
Funding Status	Funded PhD Project (Worldwide)
Application Deadline	14/04/2022
Project Title	Advances in Sustainable Structural Materials – An Experimental and Numerical Investigation to Assess the Structural Performance of Cross Laminated 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) have 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 expand structural applications of CLT to high rise structures and large spanning bridges and thus will push the boundary of truly large-scaled sustainable construction [2].

For CLT to concrete composites to be successfully adopted, structural properties (stiffness and strength), 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 structural performance on 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 the drawbacks to determine the slip modulus [4] and there is an urgent need to address this. This is what proposed research will address.

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

1. 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.
3. Investigate the application of slip modulus calculation method given in Eurocode 5

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 type of connections. Various specimens comprising of 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.

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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.

Academic qualifications

A first degree (at least a 2.1) ideally in Civil Engineering with a good fundamental knowledge of Timber structures.

English language requirement

IELTS score must be at least 6.5 (with not less than 6.0 in each of the four components). Other, equivalent qualifications will be accepted. Full details of the University's policy are available online.

Essential attributes:

- Experience of fundamental experimental work
- Competent in structural analysis, structural mechancis
- 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:

Knowledge of structural performance of composite structures, FEM modelling

Indicative Bibliography	[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. [4] Dias AMPG, Kuhlmann U, Kudla K, Mönch S, Dias AMA. Performance of dowel-type fasteners and notches for hybrid timber structures. Engineering Structures 2018;171:40–6. https://doi.org/10.1016/j.engstruct.2018.05.057.
Funding notes	This project may be funded by a scholarship of the School of Engineering and Built and Environment. Please see School-funded PhD scholarships - RESEARCH AND INNOVATION (napier.ac.uk) for information on the scholarships and how to apply for them.

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Enquiries	For informal enquiries about this PhD project, please contact Dr Aamir Khokhar, Email: a.khokhar@napier.ac.uk
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process

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