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://blogs.napier.ac.uk/scebe-research/available-phd-student-projects/

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. Lina Khaddour (Email: L.Khaddour@napier.ac.uk)
- 2ND SUPERVISOR: Prof. Robert Hairstans

Subject Group: Built environment

Research Areas: Architecture, Building & Planning

Project Title: A systematic comparison of multiple building structures in steel, concrete, and timber: combining energy signatures, building energy simulations and archetype approach

Project description:

Purpose:

Buildings and the construction industry are top contributors to climate change, and structures account for the largest share of the upfront greenhouse gas emissions. Nearly 40% of global CO2 emissions are linked to buildings and construction. Out of which, the operation of buildings is responsible for 28% of global CO2 emissions with a further 11% attributable to the construction industry, including the manufacture of building materials and components. Therefore, the relative

environmental merits of concrete and steel structural systems have been debated for at least 20 years. But engineered timber, such as glulam and cross-laminated timber (CLT), is increasingly recognized as a viable alternative, with examples of up to 14 stories already realized, 24 stories under construction, and even taller buildings planned.

The wide body of research in this area have used different integrated energy assessment models to evaluate building structures environmental and carbon footprint. Some previous research findings confirmed the widely held assumption that timber structures and buildings are likely to have lower Whole-Life Embodied Carbon (WLEC) than their steel and concrete counterparts. Other research demonstrated that the broad interest in mass timber has been based on incomplete carbon accounting that treats wood as inherently carbon-neutral. This research will address the need for systematic comparison for multiple building structures in steel, concrete, and timber alternatives considering different energy assessment models. In this research, comparisons will be made between multi buildings mass, operational energy and WLEC emissions of building superstructures using identical frame configurations in steel, reinforced concrete, and engineered timber frames.

Aim and objectives:

The aim of the PhD project is for a candidate to investigate the integrated energy assessment models (e.g. the Integrated Environmental Solutions Virtual Environment (IESVE), Rhino, Ladybug) in comparison of multiple building structures (steel, concrete, and timber). Archetyping will specifically help to accelerate the uptake in Scotland multiple building structural configurations across all three typologies providing a satisfactory compromise between accuracy and speed of simulation. There are three main objectives:

1. Evaluate how integrated assessment models are used to compare between mass, operational energy and WLEC for the key archetypes within the multiple building stock in Scotland using identical frame configurations in steel, reinforced concrete, and engineered timber frames.
2. Assess the representativeness of archetypes, testing and checking suitability using different simulations.
3. Develop comprehensive model combining energy signatures and building energy simulations using archetype approach.

Expected outcomes:

Despite the considerable research efforts into the life cycle impacts of buildings over the years, this work is unique in its approach and systematic coverage of structural frames in steel, concrete, and timber. As such, it provides a valuable contribution to construction stakeholders attempting to

minimize environmental impacts both through design and procurement, thereby reducing life cycle GHG emissions and justifying the preferment of materials, specifications, and suppliers that can collectively make the best contribution to this objective. This project will combine energy signatures and building energy simulations of various measures in order to evaluate their potential outcomes in terms of energy savings and emissions reductions. Therefore, a methodology calibrated engineering models will be combined with building energy simulation tools to enable reliable simulations to be derived with this PhD and published for the wider benefit of the UK construction industry.

References:

[1] Climate Change Committee
[2] Environmental Audit Committee

[3] British Standards Institution. (2014). BS EN 16449-2014: Wood and wood-based products – Calculation of the biogenic carbon content of wood and conversion to
[4] carbon dioxide. 8.
[5] Grubb, M., Wieners, C., & Yang, P. (2021). Modeling myths: On DICE and dynamic realism in integrated assessment models of climate change mitigation. Wiley Interdisciplinary Reviews: Climate Change, 12(3), e698.
[6] Hart, J., D'Amico, B., & Pomponi, F. (2021). Whole-life embodied carbon in multistory buildings: Steel, concrete and timber structures. Journal of Industrial Ecology, 25(2), 403-418.
[7] https://www.wri.org/insights/mass-timber-wood-construction-climate-change

Candidate characteristics

Education:

A first-class honours degree, or a distinction at master level, or equivalent achievements in Built Environment subject i.e. Civil / Structural Engineering; Architecture; Construction management; Architectural Technology; Sustainable Built Environment or equivalent

Subject knowledge:

The candidate should have fundamental knowledge of sustainability, timber in construction and the built environment.

Essential attributes:

- Knowledge of timber as a material
- Capable of collecting and analysing data sets and undertaking complex predictive modelling
- Competent communicator capable of engaging with industry and external stakeholders
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:

- Supply chain management
- Risk management
- Building performance