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: Andrew Livingstone (Email: A.Livingstone@napier.ac.uk)
- 2ND SUPERVISOR: Robert Hairstans

Subject Group: Built environment

Research Areas: Civil Engineering

Project Title: Development of a deconstructable timber system to optimise design for manufacture, assembly & disassembly (DfMA+D)

Project description:

The construction sector is a linear economy: finite resources are extracted to manufacture products which are disposed of come their end of life. The extraction and manufacturing of virgin construction materials account for approximately 10% of the worldwide emissions [1]. In 2018, construction and demolition in Scotland was responsible for 5.8 million tonnes of waste, equating to 51% of Scotland's total waste [2]. Not only is this take-make-waste approach entirely unsustainable, it places significant strain on the environment. A circular economy model is one way in which the sector can look to tackle its emissions: materials and components are kept in a continuous lifecycle where, when they reach the end of their use, they are

either reused or repurposed. In Scotland, the salvaging and reuse of components is not common practice. Complex and irreversible connection types paired with lack of consideration for end of life have been cited as significant challenges which prevent the uptake of building deconstruction [3, 4, 5, 6]. Design for deconstruction has been highlighted as a way in which these challenges can be overcome [3, 7], however, few studies have proposed alternative technical details which enable disassembly. Deconstructable connections are not a new concept to the construction sector. Erman [8] carried out a study which highlighted the suitability of traditional carpentry joints for deconstruction. They discussed the deconstructability of different types of traditional joints and concluded that an inherent trait of traditional joinery is deconstructable potential, however, traditional joints will require modification and greater design considerations to align with the current practices. Studies relating specifically to deconstructable timber frame systems are in their infancy, however, there has been research more broadly relating to timber. Authors have been developing deconstructable solutions in the form of mass timber composites i.e., glulam-concrete, LVL-concrete or CLT-steel [9, 10, 11]. The majority of these studies involve the use of dowel type connectors, such as screws and bolts, which aid in the disassembly of components. Similarly, timber fastener companies, such as Rothoblaas, have produced connectors which allow CLT panels to be dismantled, these are in the form of corner connector plates fixed with screws that are then bolted together to join the panels [12]. Although the discussed connection techniques have not been applied to lightweight timber frame, it can be seen that dowel type fasteners are the most suitable approach to deconstruction, which aligns with what has been suggested by proposed previously [3]. As well as this, there is still significant potential for traditional jointing techniques to have a role in aiding deconstruction, therefore both of theses aspects will be investigated further.

References:

[1] United Nations Environment Programme, “Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector,” Nairobi, Tech. Rep., 2020.

[2] Scottish Environment Protection Agency, “Waste from all sources - summary data 2018,” Tech. Rep., 2020.

[3] C. Morgan and F. Stevenson, “Design and Detailing for Deconstruction SEDA Design Guides for Scotland : No . 1,” SEDA, Tech. Rep., 2005.

[4] M. Adams, V. Burrows, and S. Richardson, “Bringing embodied carbon upfront: Coordinated action for the building and construction sector to tackle embodied carbon.,” Tech. Rep., 2019.

[5] J. Kanters, “Design for deconstruction in the design process: State of the art,” Buildings, vol. 8, no. 11, 2018, issn: 20755309. doi:10.3390/buildings8110150.

[6] D. D. Tingley and B. Davison, “Design for deconstruction and material reuse,” Proceedings of Institution of Civil Engineers: Energy, vol. 164, no. 4, pp. 195–204, 2011, issn: 17514223. doi: 10.1680/ener.2011.164.4.195.

[7] D. Whittaker and M. Jones, “Identification of Circular Economy Opportunities in the Scottish Construction Sector,” Tech. Rep. April, 2017.

[8] E. Erman, “Demountable timber joints for timber construction systems,” Architectural Science Review, vol. 45, no. 2, pp. 133–143, 2002, issn: 17589622. doi: 10.1080/00038628.2002.9697501.

[9] M. Derikvand and G. Fink, “Deconstructable connector for TCC floors using selftapping screws,” Journal of Building Engineering, vol. 42, 2021, issn: 23527102. doi:10.1016/j.jobe.2021.102495.

[10] A. Ataei, M. A. Bradford, H. R. Valipour, and A. A. Chiniforush, “Extended end plate semi-rigid composite joints with CLT panels and demountable shear connectors,” in World Conference on Timber Engineering, Seoul, 2018.
[11] N. Khorsandnia, H. Valipour, J. Sch¨anzlin, and K. Crews, “Experimental Investigations of Deconstructable Timber–Concrete Composite Beams,” Journal of Structural Engineering, vol. 142, no. 12, 2016, issn: 0733-9445. doi: 10 . 1061 / (asce) st . 1943 -541x.0001607.
[12] A Angeli, A Polastri, E Callegari, and M Chiodega, “Mechanical characterization of an innovative connection system for CLT structures,” in World Conference on Timber Engineering, Vienna, 2016.

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 / Architectural Technology;

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
- Structural engineering and analysis
- 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:

- Architectural detailing