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: Assoc. Prof. Nirodha Fernando (Email: N.Fernando@napier.ac.uk)
- 2ND SUPERVISOR: Dr. Timothy Olawumi and Dr. Mina Jowkar

Subject Group: Built environment

Research Areas: Built Environment

Project Title: Optimising Building Morphology Parameters and Lowering Embodied Carbon in Buildings Through Multi-Objective Optimisation

Project description:

The construction sector is widely recognised for producing significant carbon emissions, significantly impacting its environmental and economic viability and the substantial expenses incurred throughout a building's lifespan (Y. Zhang et al., 2022). As a significant industry, the construction industry is responsible for approximately 30% to 40% of the total carbon emissions generated by all sectors collectively (Lu et al., 2019). As a result, to achieve energy-saving goals and meet emission reduction targets, the building industry worldwide has prioritised reducing

CO_2 emissions from buildings, recognising the crucial need to minimise energy consumption (Yuan et al., 2020).

Carbon emissions can be categorised into two primary groups which are, embodied carbon emissions and operational carbon emissions. Embodied carbon emissions result from activities like extraction and manufacturing, product assembly, and transportation of raw materials (Chau et al., 2015). Conducting an assessment for embodied carbon is more complex than evaluating operational carbon, which can be relatively straightforward. While embodied carbon comprises 10 to 20% of a building's overall life cycle carbon, the potential for its reduction should not be overlooked (Dixit et al., 2013). The embodied carbon emissions in the production stage mainly come from the embodied energy used in manufacturing building products. Utilising building materials with lower carbon demands during manufacturing can decrease embodied carbon emissions (Yohanis & Norton, 2006). Reducing the need for carbon-intensive materials through the optimisation of building structures is a key strategy to decarbonise the production stage (Liang, et al, 2023). Accordingly, building morphology parameters have a role in reducing buildings' carbon footprint. Building morphology parameters are building orientation, plan shape, building size, story height and total height of the building, wall: floor ratio and circulation space etc. Optimising the parameters of building morphology stands as a fundamental principle in mitigating the use of carbon-intensive materials during the construction phase. Thus, the study seeks to investigate how building morphology parameters affect embodied carbon of buildings and aims to identify the optimal design solution through Multi-objective Optimisation to reduce embodied carbon.

References:

[1] Chau, C. K., Leung, T. M., & Ng, W. Y. (2015). A review on life cycle assessment, life cycle energy assessment and life cycle carbon emissions assessment on buildings. In Applied Energy (Vol. 143, Issue 1, pp. 395–413). Elsevier Ltd. https://doi.org/10.1016/j.apenergy.2015.01.023

[2] Dixit, M. K., Culp, C. H., & Fernández-Solís, J. L. (2013). System boundary for embodied energy in buildings: A conceptual model for definition. In Renewable and Sustainable Energy Reviews (Vol. 21, pp. 153–164). Elsevier Ltd. https://doi.org/10.1016/j.rser.2012.12.037

[3] Liang, Y., Li, C., Liu, Z., Wang, X., Zeng, F., Yuan, X. and Pan, Y., 2023. Decarbonization potentials of the embodied energy use and operational process in buildings: A review from the life-cycle perspective. Heliyon.

[4] Lu, K., Jiang, X., Tam, V. W. Y., Li, M., Wang, H., Xia, B., & Chen, Q. (2019). Development of a carbon emissions analysis framework using building information modeling and life cycle assessment for the construction of hospital projects. Sustainability (Switzerland), 11(22). https://doi.org/10.3390/su11226274

[5] Yohanis, Y. G., & Norton, B. (2006). Including embodied energy considerations at the conceptual stage of building design. Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy, 220(3), 271–288. https://doi.org/10.1243/095765006X76009

[6] Yuan, Z., Zhou, J., Qiao, Y., Zhang, Y., Liu, D., & Zhu, H. (2020). BIM-VE-based optimization of green building envelope from the perspective of both energy saving and life cycle cost. Sustainability (Switzerland), 12(19). https://doi.org/10.3390/SU12197862

[7] Zhang, Y., Jiang, X., Cui, C., & Skitmore, M. (2022). BIM-based approach for the integrated assessment of life cycle carbon emission intensity and life

cycle costs. Building and Environment, 226. https://doi.org/10.1016/j.buildenv.2022.109691

Candidate characteristics

Education:

A first-class honours degree, or a distinction at master level, or equivalent achievements in Built Environment

Subject knowledge:

- The carbon footprint of the building

Essential attributes:

- Experience in fundamental academic writing and critical analysis
- Competent in carbon footprint calculations
- Knowledge of IT, computer-based modelling techniques, analytical skills and research methods
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management