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

MRes Student Project

Application instructions:
Detailed instructions are available at :
https://www.napier.ac.uk/research-and-innovation/doctoral-college/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 Ahmed Mohamed (Email a.mohamed2@napier.ac.uk)
- 2ND SUPERVISOR: Dr Roshan Dhonju

Subject Group: Built Environment

Funding status: Self funded

Project Title: Development of High-Strength Self-Compacting Concrete Incorporating Recycled Aggregates and Pozzolana

Project description:

The construction industry is rapidly advancing, with increasing emphasis on sustainability, strength, and efficiency. High-strength self-compacting concrete (HSSCC) plays a pivotal role in this evolution, offering significant advantages for modern infrastructure. Self-compacting concrete (SCC) is designed to flow easily and consolidate under its own weight, eliminating the need for mechanical vibration and reducing labour costs and time. However, traditional SCC may not always meet the high strength and durability requirements necessary for modern infrastructure projects.
To address these challenges, this project explores the incorporation of pozzolana as a supplementary cementitious material in the development of HSSCC. Pozzolana, including materials such as fly ash and silica fume, has been shown to improve the performance of concrete by enhancing its mechanical properties and durability.

These materials react with calcium hydroxide produced during cement hydration, forming additional calcium silicate hydrate (C-S-H), which contributes to strength and durability.
The primary objective of this research is to meticulously optimize the mix design of HSSCC to achieve superior mechanical properties while retaining essential self-compacting characteristics such as excellent flowability and resistance to segregation. By carefully selecting and proportioning pozzolana, the study aims to address critical issues related to mix stability and workability, ensuring optimal performance both in the fresh state during pouring and in the hardened state after curing.
Additionally, the project will conduct a comprehensive evaluation of the environmental impact associated with incorporating pozzolana in concrete. This assessment will highlight potential benefits, including reduced cement consumption and lower carbon emissions compared to conventional concrete mixtures. A comparative analysis between HSSCC with pozzolana and conventional concrete will provide valuable insights into the sustainability and long-term performance of these materials in construction applications.

Objectives:
The objectives of the project include:

1. Investigating the properties of different types of pozzolana and their impact on SCC.
2. Optimizing mix proportions to achieve high strength while maintaining workability and self-compacting characteristics.
3. Evaluating the fresh properties of HSSCC, including flowability, passing ability, and segregation resistance.
4. Assessing the hardened properties such as compressive strength, durability (such as resistance to chloride ingress and freeze-thaw cycles), and shrinkage.
5. Comparing the environmental sustainability of HSSCC with pozzolana against conventional concrete.

Methodology:
The methodology involves a structured approach to achieve the project objectives:

Characterization of Materials:
Conduct detailed analyses of recycled aggregates and pozzolanic materials to understand their chemical compositions, particle size distributions, and specific surface areas.

Mix Design Optimization:
Utilize advanced mix design techniques to optimize the proportions of cement, recycled aggregates, pozzolana, and glass fibre. Employ trial mixes to evaluate and enhance the workability and mechanical performance of HSSCC.

Experimental Testing:
Perform a series of laboratory tests including Slump flow, L-box, J-Ring, according to relevant standards (e.g., EFNARC) to assess the fresh and hardened properties of HSSCC mixes. Additionally, perform compressive, tensile, and flexural strength tests to determine the mechanical properties.

Photogrammetry for Displacement Evaluation:
Utilize the photogrammetry approach to evaluate the displacement of concrete samples under the flexural test. Photogrammetry involves capturing high-resolution images of the concrete samples during testing and using specialized software to create a detailed 3D model. This model allows for precise measurement of displacement and deformation over the entire surface of the sample.
This approach is particularly useful as it provides comprehensive data that traditional single-point measurement tools might miss, ensuring a more accurate assessment of the material's behaviour under stress. Furthermore, it enables non-contact measurement, reducing the risk of influencing the sample's performance during testing.

Candidate characteristics

Education:

A second class honour degree or equivalent qualification in a suitable area.

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.

Application checklist:

- Statement no longer than 1 page describing your motivations and fit with the project
- Recent and complete curriculum vitae. The curriculum must include a declaration regarding the English language qualifications of the candidate.
- Supporting documents will have to be submitted by successful candidates.
- 2 academic references, using the Postgraduate Educational Reference Form (download)