Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

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Polytech name	Clermont Ferrand
University name	Université Clermont Auvergne
Country	France

PhD information	
Title	Development of Lime Based Carbon Negative Concrete from Vegetal Aggregates

Main topics regards to CSC list (3 topics at maximum)	IV-7. Matériaux pour l'environnement et l'écologie Materials for environment and ecology IV-10. Bio-matériaux et matériaux polymères Biomaterials and polymer materials V-10. Variation d'environnement écologique et conception écologique Ecological variation of environment and ecological design
Required skills in science and engineering	An excellent background in materials science and technology is recommended, but civil engineers are accepted too.

Subject description (two pages maximum)

Problem to be addressed: Rising carbon emissions due to the operation of buildings and manufacture of materials for the construction industry needs to be curbed. Alternate technologies for replacement of cement-based construction materials are needed, as the manufacture of such materials is carbon intensive and the operation of buildings erected from such materials accounts for approximately 40% of total energy consumption. This project addresses the environmental problem as well as a social problem, by encouraging agricultural and biomass products, which shall help uplift the livelihoods of the farmers in India. The developed thermally efficient building material will also reduce the energy consumption in buildings.

Objectives of the project

The objective of this project is to develop a product and process technology for the manufacture of vegetal concrete for non-load bearing as well as partially load bearing applications as a carbon negative replacement of conventional walling materials such as autoclaved aerated concrete (AAC), cellular light weight concrete (CLC), concrete masonry units, etc. The project shall entail the development of a mix design for batching bio-based concrete from vegetal shives and casting it in a mechanical compression die, which also shall either be developed or derived from existing machinery.

The developed vegetal concrete shall be lightweight and durable, have adequate compressive strength, low thermal conductivity and desired hygrothermal properties such that the displayed characteristics are similar to those of a phase change material. In addition, the mineral binders that shall be used for manufacture of vegetal concrete shall incorporate industrial wastes such as fly ash, ground granulated blast furnace slag (GGBS) etc., without the inclusion of Portland cement. The end product will also have negative carbon dioxide emissions.
The proposal includes experimental study and modelling of the impact of environmental ageing on the performances of hemp concretes using a multiscale and pluridisciplinary approach.

Novelty of the project

Recently, a new criteria for choosing building construction materials has emerged. Indeed, the materials have to allow living in a healthy and environmentally friendly habitat, which provides acoustical, thermal and hygrothermal comfort. To address those challenges, **bio-based materials are increasingly used** for new constructions and for renovation. **This material has good thermal and acoustical insulating properties and its hygrothermal behaviour is expected to enable a natural moisture regulation**. Consequently, vegetal concrete falls under the ethos of the novelty of bio-aggregate concretes. **.**

Methodology

After a State of the art and acquiring the raw materials we will start by the characterisation of raw materials. Once the characterisation stage is crossed, a suitable mineral binder shall be formulated using lime and pozzolanic additives such as fly ash, GGBS, natural pozzolana, pumice, etc. A standard mortar made using the formulated binder will have a targeted compressive strength.
Specimens of several vegetal concrete formulations shall be made with variations in respect of size of shivs, vegetal to binder ratios and water to binder ratios. The determining parameters for selection of suitable formulations for further studies shall be the compressive strength and

flexural strength. The chosen formulations shall then be subjected to tests of thermal conductivity, hygrothermal analysis and fire resistance. Carbon footprint of the formulated vegetal concrete also shall be determined and ensured that the carbon emissions are negative. Simultaneously, a manufacturing process also shall be developed where the required compaction compression stresses and devices shall be explored. Also, to enable the manufacturing process development existing machinery shall either be retrofitted or repurposed for casting of vegetal concrete. The vegetal concrete resulting from the adopted manufacturing processes shall be characterised and the processes shall be fine-tuned accordingly.

The success of this thesis will also improve our knowledge about the durability of functional properties of vegetal concretes, by experimentally characterising and modelling the possible mechanisms leading to the evolution of these properties during ageing.