PhD Proposals 2014 for China

1) Optimization of binder choice in recycled Hot mixed Asphalt

The preservation of a successful road network requires the construction of new roads but also the maintenance of existing roads; one of the most known and most used techniques is the hot mixed asphalt, strongly developed in France, appreciated for its ease of laying and its comfort with the road users. However it comes up against the requirements of the sustainable development which demands reduction of energy or economy of renewable raw materials. Optimizing these techniques to answer the current environmental challenge is a priority research axis in this domain: they have to answer an economy of materials but also a reduction of the energies and greenhouse gases.

To answer this demand, the recycling of hot mixed asphalts (HMA) is one way widely investigated for more than 30 years and applied to the road construction sites. Classically 10 even 20 % of RA (Recycling asphalt) is introduced into formulations of HMA allowing the economy of new aggregates but also bituminous binder, more and more expensive and energy-consuming raw material. The development of these recycled HMA requires however the control of its characteristics both at the level of the laying (workability and compaction) and during its serviceable life in particular the guarantee of the final performance of the product: resistance to rutting and stripping (water resistance), fatigue …. These conditions are amplified for increasing recycling rates. One of the major parameters in spite of its low content (5%w) for the performance of asphalt is the binder, viscoelastic material, composed of the binder of RA and the new binder. This mixture of binders requires to be homogeneous in the industrial manufacture, to evolve classically so in the short term (ageing during the manufacturing) as in the long term (ageing in situ), to guarantee characteristics of adhesion with all the aggregates (recycled and new) of the asphalt formulation. To reduce the energy, it could be envisaged reducing the manufacturing temperature.

The objective of thesis is to define the influence of the new binder on the final properties of the recycled HMA according to variable parameters which it will take place to define (recycling rates, type of asphalts, type of RA, reducing temperature…). The new binder can be various natures (animal, vegetable). An important experimental part is envisaged through tests of characterization of binders before and after ageing and of asphalt made in laboratory. Physico-chemical characterization (rheology, FTIR, DSC will be used as well as usual tests of characterization on HMA (workability with gyratory shear compactor, water resistance, rutting…).

Required skills :

Knowledge of materials science, strong interest in laboratory and experimental activities, analysis sense, autonomy and good English level.

Supervisor :

Anne DONY,
Institut de Recherche en Constructibilité,
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
Email : adony@adm.estp.fr
Phone : +33(0)1 49 08 03 37

Application :

Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).
If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.

PhD Proposals 2014 for China

2) New Responsive Building Elements – thermal behaviour modelling and control systems development

This PhD research proposal concerns the field of building physics and new technologies for efficient buildings.

It will focus on Responsive Building Elements (RBE) and especially on new solutions for thermal mass activation. The PhD foresees the use of advanced computational and experimental methods and the development of numerical methods for energy and thermal behaviour of buildings.
Research and technological innovation, over the last decade, have determined a significant improvement of performances of specific building elements like the building envelope – including walls, roofs and fenestration components - and building equipment - such as heating, ventilation, cooling equipment and lighting. Whilst most building elements still offer some opportunities for efficiency improvements, the greatest future potential seems to lie with technologies that promote the integration of dynamic and adaptive building elements with building services.

Responsive Building Elements are defined as building construction elements which are actively used for transfer and storage of heat, light, water and air.
They've to be combined and integrated with building service functions such as heating, cooling, ventilation and lighting.
RBEs are, thus, building components that assist to maintain a perfect balance between optimum interior conditions and energy performance by reacting in a controlled and holistic manner to outdoor and indoor environment changes and to occupants requirements.

The dynamic and adaptable conception require more sophisticated investigations to properly design new components (based on new materials or new philosophy concept) according different requirements (heating/cooling, higher/lower ventilation, …) and boundary conditions (meteorological, internal heat/pollution loads, …) and to efficiently design their control system.

The ideal candidates, with a Diploma or Masters degree in Mechanical, Civil or Material Engineering, are communicative scientists with a strong background in heat and mass transfer, strong experimental skills, with experience in programming and modelling of physical phenomena.

Capacity of working in team is mandatory.

Supervisor:
Andrea KINDINIS
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
akindinis@adm.estp.fr
Phone : +33(0)1 49 08 03 36

Application :
Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).
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PhD Proposals 2014 for China

3) 3D modeling through a relationships model: Application to the characterization of utilities networks

Background:
To ensure the proper functioning of cities, a good knowledge and good management infrastructure (water, electricity, gas, telecommunications) are essential. The GIS or the geographic information systems, which are the tools dedicated to the management and treatment of spatial data, appear as the suitable tools. However, their basic model, founded on: points, lines and polygons, handicaps them to integrate the third dimension.
A recent study conducted among the network managers shows interest in 3D. However, it is currently more formal than operational. This is partly explained by the lack of true 3D data and by the lack of appropriate software for processing. There are many works to adapt tools from the world of CAD to geographical field. Others are working on interfacing these tools with GIS.
The research proposed here envisages a complementary approach to mathematical modeling, geometric, 3D, as developed in software solutions. It focuses on a relational modeling to describe the relationships that exist between 3D objects.
At first, it will categorize the different types of relationships that may exist between 3D spatial objects in the domain of distribution networks. This categorization will take the form of a pattern of relationships. In a second step, it will be integrated in the model used by GIS. This work will validate the relevance of a relational modeling of 3D in GIS.
This work thus proposes a complementary approach to other solutions to manage 3D in GIS. A first application is already envisaged. It focuses on the development of descriptive rules of 3D aspects of the distribution networks. These rules established from actual information could then be tested on data bases from network managers for better understanding of these networks. In collaboration with the researches on the interface between GIS and 3D modeling tools like BIM (Buiding Information Modeling), they could also be studied for audit of quality processes.
Subject:
In this work, we propose to develop a classification of topological relationships 3D and their formalization for integration into existing GIS tools.
This formalism will be particularly studied in the context of the observation of distribution networks. It will be tested as a mean to acquire new knowledge on these networks and their spatial interactions. Finally, as part of research work carried out in collaboration with research on the interface between BIM and GIS, it can also be tested as part of the data consistency validation.
More precisely :
- The research will begin with a study of the various solutions and tools to support 3D, and with a comparison with actual configurations. This will categorize the different types of relationships that may exist between 3D spatial objects in the domain of distribution networks
- This categorization will be translated into a formalism that will adapt to the specific model of GIS.
- Tests will be done to validate the operational nature of this approach. In particular, it will develop the first relational queries on 3D and their implementation in a GIS.

Required skills:
- Skills in GIS and DBMS, possibly in civil engineering of utilities networks.
- Capacity for abstraction
- Knowledge of any programming language

Supervisor :
Patricia BORDIN
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
pbordin@adm.estp.fr

Application :
Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).
If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.

PhD Proposals 2014 for China

4) Using BIM/GIS/CFD technologies for a sustainable development of a city

Research field: Geo-Informatics, Geomatics, GIS, CFD, Civil engineering

The **objective** of this thesis is to develop a model able to represent a numerical analysis with an accuracy close to reality 3D model of the city (buildings, infrastructure, topography, etc.) using the technology of 3D modeling BIM (Building Information Modeling) and GIS (Geographic Information Systems) on the one hand, and secondly the risks threatening natural or technological (spread of pollution, radiation, flow wind, dam failure, flooding urban lakes or rivers, etc.) based on CFD modeling (Computational Fluid Dynamics).
There is a growing interest in the combination of these three technologies: GIS (very powerful tools for spatial data analysis and statistics), BIM and CFD. However, most research is limited to importing BIM data in GIS applications and / or CFD into BIM applications and vice versa. Real integration of these technologies into a single model can be a powerful tool for decision support for the construction and sustainable development of a city.

Keywords: GIS, BIM, CityGML, CFD, sustainable development

Required skills: BIM, GIS, programming skills in C++ or equivalent, CFD simulation tools (ANSYS CFX, ANSYS Fluent), 3D modeling tools

Supervisors:
Rani EL MEOUCHE
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
relmeouche@adm.estp.fr
Phone : +33(0)1 49 08 07 96

Mehdi REZOUG
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
mrezoug@adm.estp.fr
Phone : +33(0)1 49 08 24 47

Application :
Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).
If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.

PhD Proposals 2014 for China

5) Study of CO2 gas carbonation through the cementitious materials

The aim of this research is to investigate the chemo-physical phenomena during CO2 carbonation through the cementitious materials. For the CO2 gas geological sequestration problem, the cement concrete shield must withstand against either the CO2 gas or specific geological conditions, e.g. high temperature, high humidity and high pressure. It is no guaranteed about long term durability of this material under the very different conditions comparing to atmospherics ones while this material must keep this gas more than one thousand years. Unfortunately, the petroleum-natural gas companies have been starting to inject CO2 gas into the geological sites that were selected according to earthquake stability and impermeable rock conditions like clay to prevent CO2 gas escaping up to the surface. It is of great importance to understand how this material reacts on such a tough condition within long time.

Regarding to the CO2 gas carbonation on the cementitious materials, most of research studies have been performed under the low carbon dioxide concentration conditions (< 50%). Some analytical models have been proposed in very simple forms based on the time square law to estimate the carbonated zone. However, these analytical solutions do not contain all chemo-physical phenomena during the carbonation. Moreover, the shrinkage of the cementitous materials under carbonation action has not been taken into account at all even if the mentioned phenomenon could influence a lot on the stability of the whole concrete structure inside the geological site.

A new analytical approach and numerical solution on CO2 carbonation phenomenon under high CO2 gas concentration (> 50%) will be proposed and examined in the present research work. The forthcoming model will take into account not only the continuous hydration process of anhydrous compounds but also deformable porous cement matrix during the shrinkage phenomenon. One-dimensional solution will be primarily done at the first stage using Matlab. Afterwords, three-dimensional simulations will be performed using Matlab/Comsol or Comsol at the samples scale and then the real concrete cylinder tube scale. The carbonation experiments will be carried out by means of the CO2 vacuum incubator at laboratory.

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- Bary and Sellier, “Coupled moisture-carbon dioxide-calcium transfer model for carbonation of concrete”, Cement and Concrete Research, vol.34 (2004), 1859-1872

Supervisor:
Jena JEONG
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
jjeong@adm.estp.fr
Phone : +33(0)1 49 08 23 03

Application :
Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).
If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.

PhD Proposals 2014 for China

6) Nanopozzolanic materials and their effects on reducing GFRC aging

Context

Glass Fibers Reinforced Cement (GFRC) is a composite material consisting of a mortar of hydraulic cement and fine aggregate reinforced with glass fibers (AR). The GFRC may contain additional filler materials, pozzolanic materials and admixtures. The fiber contents are typically 3% to 5% by weight depending on product application and production method employed. The properties of GFRC depend on a wide range of variables. These include method of manufacture, mix formulation, fiber product type, length and orientation, admixtures used, etc. Glass fibers improve cement mortar tensile strength and ductility, while cement mortar avoids buckling of glass fibers when compressing them. Therefore, through merging both materials a composite material with improved ductility and tensile strength with respect to the cement mortar mechanical properties and high compressive strength is obtained. Unfortunately, the mechanical properties of GFRC deteriorate with time. The ductility of GFRC decreases heavily, with it becoming a brittle material and tensile strength hence being reduced as time passes. Such a phenomenon (known as GFRC aging) has been previously observed in different studies [1-3].

Objectives

This thesis has as objectives to find ways in order to reduce the effects of time on GFRC aging by adding nanopozzolanic materials (nan-clays, nano silice fume,…). For simulating GFRC aging, two methods will be use: no-cyclic method and cyclic method. For manufacturing GFRC materials, two processes will be used with power spray machine: the spray-up process and the premix" process. In the spray-up process, cement/sand mortar and chopped glass fibers are simultaneously pre-mixed and deposited from a spray gun onto a mold surface. The GFRC architectural panel industry sets an absolute minimum of four percent glass fibers by weight of total mix as a mandatory quality control requirement. The premix process consists of mixing cement, sand, chopped glass fiber, water, and admixtures together into a mortar, using standard mixers, and casting with vibration, press-molding, extruding, or slip-forming the mortar into a product. Finally, numerical model which take in account fibers: percentage, position and orientation will be proposed.

Mission

The Candidate has to do:

- A literature search on the subject of the point of view experimental and theoretical (modeling and simulations);
- Writing on a regular basis a report of 40 -50 pages every two months and an oral presentation with different partners;
- Production compulsory articles in international scientific journals with an impact factor greater than 1.3;
- Participation in international conferences and writing the patents if they will take place

Profile

The candidate must have:

- Master research or equivalent university degree obtained by the graduate school concerned
- Knowledge in civil engineering, mechanics and structure of cementitious materials
- Knowledge about using instruments to characterize mechanical properties (compression, flexural,…), structural properties (XRD, SEM, ...) and physicochemical properties (IRF, Calorimetry, TGA, DSC, FRX ..)
- Knowledge in the field of modeling (Ansys, ...)

Application :

Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).

If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.

PhD Proposals 2014 for China

- Ability to work with a team of scientific and technical supervisors and maintain professional relationships with industry
- A high level in scientific and technical English language

References

[1] P. Purnell, J. Beddows, Durability and simulated ageing of new matrix glass fiber reinforced concrete, Cement & Concrete Composites 27 (2005) 875–884
[2] Alejandro Enfedaque, David Cendón, Francisco Gálvez, Vicente Sánchez-Gálvez, Analysis of glass fiber reinforced cement (GRC) fracture surfaces, Construction and Building Materials 24 (2010) 1302–1308
[3] M. Butler, S. Hempel, V. Mechtcherine, Modelling of ageing effects on crack-bridging behaviour of AR-glass multifilament yarns embedded in cement-based matrix, Cement and Concrete Research 41 (2011) 403–411.

Supervisors:

Rabah HAMZAOUI
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
relmeouche@adm.estp.fr
Phone : +33(0)1 49 08 03 34

Mehdi REZOUG
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
mrezoug@adm.estp.fr
Phone : +33(0)1 49 08 24 47

Application :
Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).
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PhD Proposals 2014 for China

7) Nano-pozzolans obtained by high energy ball mill and their uses in concrete: Properties and Applications

Context

Concrete is a construction material most used in the world. Several types of concrete have emerged in recent years than ordinary concretes (OC) such: the high performance concretes (HPC), self-compacting concrete (SCC) and eco-concrete. The cement industry plays a significant role in this scenario. Concrete is the world's most important construction material, and for each tonne of Portland cement (an essential component of concrete) produced, approximately one tonne of CO2 is emitted to the atmosphere [1]. The increasing of CO_2 emission due to the calcination process in producing of cement clinker has led to an increased use of pozzolanic materials as replacement of cement. Nanomaterials (also known as: nanocrystalline, nano-scale, nanostructured or nanophase materials) are used to describe those materials that have a majority of scale size in the typical range from ~1 to 100 nm. Whether it can be called a revolution or simply evolution, the nanomaterials have received much attention as advanced engineering materials with unique physical, chemical and mechanical properties. Generally the nanomaterials have exceptional properties in comparison than those of micro-materials ones [2-4]. Nanomaterials are very reactive because of the particles' small size and large surface area and have great potential in improving concrete properties such as compressive strength, workability (ouvrability) and durability [5]. High ball milling is one of the methods that produce the nanomaterials. It is an intensive energy process of mechanical grinding for the preparation of alloyed powders or composites in powder form. It involves a repeated fracturing and rewelding of particles, leading to size reduction and particle shape change [2-4].

Objectives

The objective of this research is to develop high planetary ball mill method to obtain nanomaterials (nano-clay, nano-silice fume,…) as pozzolanic materials in order to obtain the high performance concrete with concern to environmental problems. The target of research is to find high value uses for nanomaterials (nano-clay, nano-silice fume,…). Rather than using the materials as cheap fillers or materials replacement of cement, this research aims to use the nanomaterials for their intrinsic physical properties in high value concrete applications and novel solutions. To achieve this aim, some studies will be done as below:

1. Studying the effect of milling conditions on nanomaterials properties by using some instruments, such as: structural properties (XRD, SEM, ...) and physicochemical properties (IRF, Calorimetry, TGA, DSC, FRX ..).
2. Comparing the properties of nanomaterials between calcination process and high planetary ball mill process.
3. Replacing some of the cement by nanomaterials obtained by mechanical milling (mechanical activation) or by mechanical alloying (mecanosynthesis) and obtaining the optimum percentage of replacing in mechanical properties of concrete.
4. Observing long-term performance of concrete (creep and shrinkage) and durability testing.
5. Proposing numerical model which relay milling conditions and concrete properties (prediction model by using network neuron method).

Profile

The candidate must have:

- Master research or equivalent university degree obtained by the graduate school concerned
- Knowledge in civil engineering, mechanics and structure of cementitious materials

Application :

Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).

If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.

- Knowledge about using instruments to characterize mechanical properties (compression, flexural,…), structural properties (XRD, SEM, ...) and physicochemical properties (IRF, Calorimetry, TGA, DSC, FRX ..)
- Knowledge in the field of modeling (Ansys, ...)
- Ability to work with a team of scientific and technical supervisors and maintain professional relationships with industry.
- A high level in scientific and technical English language

References

[1]. Duda, W. H. 1977. "Cement data-book. International process engineering in the cement industry", 2nd ed., Berlin, Germany.311-317
[2] R.Hamzaoui, O.Elkedim, N.Fenineche, E.Gaffet and J.Craven, "Structure and magnetic properties of nanocrystalline mechanically alloyed Fe-10%Ni and Fe-20%Ni" Materials Sciences and Engineering A 360 (2003) 299-305
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[5] R. Hamzaoui, A. Bennabi, S.Guessasma, R. Khelifa, N. Leklou, Optimal Carbon NanoTubes concentration incorporated in mortar and concrete, Advenced Material Research Journal, Vol. 587 (2012) pp 107-110

Supervisor:

Rabah HAMZAOUI
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
relmeouche@adm.estp.fr
Phone : +33(0)1 49 08 03 34

Application :
Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).
If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.

PhD Proposals 2014 for China

8) Natural Fibers reinforced Concrete: Comparative study and Applications

Context

Concrete is a construction material most used in the world. Several types of concrete have emerged in recent years than ordinary concretes (OC) such: the high performance concretes (HPC), self-compacting concrete (SCC) and eco-concrete. Cement, an essential component of concrete, can produce approximately 500 kg of CO_2 per tonne of cement produced. To reduce the environmental impact of concrete, cement substitution with natural fibers is envisaged with the maintaining of the high compression strength and good durability of the material.

Objectives

This thesis has as objectives to find ways to reduce the environmental impact and cost of concrete construction. The current challenge is to reduce emissions of greenhouse gases and improve the recyclability of materials. In this reason, it is decided to replace some of the cement by nanomaterials and the plant fibers (hemp, shives,…). Then, to study the influence of this change on the concrete composite obtained. To propose numerical model which take in account fibers: percentage, position and orientation [1]. The main goal of the thesis is to provide eco-concrete using local plant fibers (hemp, shives, ...) [2] with adding a small percentage of nanomaterials as: nano-Fe_2O_3 nano-SiO_2, NTC, nano-clays [3]. Finally, to propose smart eco-concrete with high thermal and acoustic performance, good environment impact and high compression strength.

Mission

The Candidate has to do:

- A literature search on the subject of the point of view experimental and theoretical (modeling and simulations);
- Writing on a regular basis a report of 40 -50 pages every two months and an oral presentation with different partners;
- Production compulsory articles in international scientific journals with an impact factor greater than 1.3;
- Participation in international conferences and writing the patents if they will take place.

Profile

The candidate must have:

- Master research or equivalent university degree obtained by the graduate school concerned;
- Knowledge in civil engineering, mechanics and structure of cementitious materials;
- Knowledge about using instruments to characterize mechanical properties (compression, flexural,…), structural properties (XRD, SEM, TEM, ...) and physicochemical properties (IRF, TGA, DSC, FRX ..);
- Knowledge in the field of modeling and numerical simulation (Monte-Carlo method, neuron network method, Ansys, ...);
- Ability to work with a team of scientific and technical supervisors and maintain professional relationships with industry.
- A high level in scientific and technical English language

References

Application :

Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).

If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.

PhD Proposals 2014 for China

[1] : S. Guessasma, HD. Bassir, Comparing heuristic and deterministic approaches to optimise mechanical parameters of biopolymer composite materials, Mechanics of Advanced Materials and Structures, 16, 2009a, 293-299
[2] : R. Hamzaoui, S.Guessasma, A. Bennabi, R. Khelifa, N. Leklou, Effet des fibres naturelles sur la tenue mécanique des bétons, BIOMAT (MAROC- AGADIR) 15-18 Juin 2012.
[3] : R. Hamzaoui, A. Bennabi, S.Guessasma, R. Khelifa, N. Leklou, Optimal Carbon NanoTubes concentration incorporated in mortar and concrete, Advenced Material Research Journal, Vol. 587 (2012) pp 107-110.

Supervisors:

Rabah HAMZAOUI
Institut de Recherche en Constructibilité
ESTP, 28 avenue du President Wilson, 94230 Cachan, France
relmeouche@adm.estp.fr
Phone : +33(0)1 49 08 03 34

Sofiane GUESSASMA
INRA Nantes

Application :
Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Prof. Jean-Lou LEBRUN (jllebrun@adm.estp.fr), Ms. Maddy VONG (mvong@adm.estp.fr) and Yvon VELOT (yvon.velot@ensam.eu).
If selected, you should then apply for scholarship to the Chinese Scholarship Counsil (CSC) through your University International Office.