

# List of IC@N Research Projects and Supervisors

<b>School of Civil and Environmental Engineering (CEE)</b>	
<b>Name of Supervisor</b>	<b>Research Project Description</b>
<b>A/P Robert Tiong</b> <a href="mailto:CLKTIONG@ntu.edu.sg">CLKTIONG@ntu.edu.sg</a>	<p><b>A Study on BIM-based models for construction performance and productivity evaluation of PPVC construction technologies/ methods</b></p> <p>Prefabricated, Prefinished, Volumetric Construction (PPVC) technique represents a very attractive solution under DfMA approach and is considered as new game-changing construction technology that being adopted in Singapore construction industry which provides significant advancement for building constructions. For PPVC, modules complete with internal finishes, fixtures and fittings are manufactured in factories, and are then transported to construction site for installation in a Lego-like manner. The objective of this research is to study on BIM-based performance and productivity evaluation of PPVC construction technologies/ methods. Furthermore, this study strives to study on NTU PPVC projects, carry out Post-construction analysis and provide lessons learnt report in order to share learning points gained from NTU PPVC projects. This study will contribute to improve the construction productivity by evaluating the use of Building Information Modelling for Prefabricated Pre-finished Volumetric Construction.</p>
	<p><b>A study on BIM based models for underground construction productivity</b></p> <p>BIM application in construction has recently gained attention from industry practitioners. Therefore, there is a need for further research in this field of how it enhances construction productivity for underground construction and tunnelling works. As a result, this study is aimed to investigate how BIM can benefit the construction industry in terms of productivity of underground construction projects. Student will visit and interview construction firms who have installed BIM and find out the relationship between BIM implementation and productivity improvement for underground construction works. A brief study on Cost and benefit analysis will be carried out. Student should have interest in BIM and exposure to construction works especially in underground construction.</p>

<p><b>A/P Robert Tiong</b>  <a href="mailto:CLKTIONG@ntu.edu.sg">CLKTIONG@ntu.edu.sg</a></p>	<p><b>BIM based interoperability common data platforms</b></p> <p>Student will study BIM softwares and models and research into the interoperability of model across different BIM models and platform</p>
<p><b>A/P Leong Eng Choon</b>  <a href="mailto:CECLEONG@ntu.edu.sg">CECLEONG@ntu.edu.sg</a></p>	<p><b>An expedient method for estimating soil-water characteristic curves</b></p> <p>Soil-water characteristic curve (SWCC) is a basic property of unsaturated soils and has been used to estimate a number of other engineering properties such as permeability function and shear strength. However, determining the SWCC is a laborious and time consuming process. For application in geotechnical engineering, it may be necessary to get an estimate of the SWCC quickly so that some preliminary study can be performed. In this project, an expedient method of estimating SWCC from pedotransfer functions is evaluated for a soil database.</p> <p><b>Mapping soil classification systems</b></p> <p>A number of soil classification systems is in use within the same discipline and across disciplines. The unified soil classification system (USCS) is the standard soil classification used in civil engineering. With the emergence of unsaturated soil mechanics, theories and practices in soil science, agronomy and agriculture becomes highly relevant. A number of soil databases in these disciplines contain valuable information for unsaturated soil mechanics. However, use of these databases is hampered by the different soil classification systems used. Soil science, agronomy, and agriculture commonly used the US Department of Agriculture (USDA) soil triangle for classifying soils. The objective of this project is to establish a mapping between the USCS and the USDA soil triangle so that the knowledge accumulated in soil science, agronomy and agriculture can be applied in civil engineering.</p>
<p><b>Asst/P Qian Shunzhi</b>  <a href="mailto:SZQian@ntu.edu.sg">SZQian@ntu.edu.sg</a></p>	<p><b>Speedy self-healing cementitious materials via genetic modification of bacteria</b></p> <p>Cementitious materials are commonly used in civil infrastructures. Despite of many advantages, cracking related problems persist, such as leakage, loss of stiffness, and even structural failures, which are more severe for underground structures. With many caverns and tunnels, Singapore is particularly vulnerable to this problem. This kind of problem will be addressed in this proposal via genetically modified bacteria based self-healing concrete (SHC).</p>

Unlike manual repair, when concrete is cracked, the embedded bacteria will be activated automatically due to exposure to natural environments, therefore releasing calcium carbonate via metabolic conversion of nutrients to heal concrete without external intervention. Compared to expensive, labor intensive and sometimes dangerous manual repair, bacteria-based self-healing concrete has great advantages due to low cost and no labor requirement. In previous study, researchers applied *Bacillus* to improve healing efficiency with certain success. However, their wild type bacteria still suffers from too long healing time, vulnerable to high pH environment in cement and no recovery of mechanical strength. Our novel approach is to apply transposon mutagenesis method to the *Bacillus* bacteria so that a fast growing and better resistance to high pH strain can be obtained, therefore allowing for more robust and speedy self-healing in novel bendable concrete. The student will be guided by an experienced research staff in addition to supervision of Prof Qian Shunzhi.

#### **Multi-scale mechano-electrical design for bendable concrete based self-sensing composite material**

Improper design, construction and/or deterioration of concrete structures, e.g. large cracking, may lead to loss of structural stiffness, strength, or even collapse in some extreme cases, such as the tragic 1986 Hotel New World Collapse in Singapore and 2004 Charles de Gaulle Airport Collapse in France, killed 33 and 4 people, respectively. The challenge to maintain the safety of concrete structures will become even greater as Singapore strives to build much higher and deeper to cater for its increasing population, which involves much more complicated designs, constructions, loadings and environments (e.g. underwater/undersea infrastructure/city).

To address this long-lasting concern, a more prudent method is to use self-sensing concrete to automatically monitor structural health condition to greatly improve its safety and help save human lives. Proposed is the development of fundamental understanding on the multiple-level mechanical/electrical coupled behaviour of self-sensing phenomena in bendable concrete material. This is accomplished through systematic redesign of bendable concrete incorporating conductive raw materials via refined micro-level mechanics design tools, multiple-level modelling of the self-sensing behaviour by linking the micro-level of fibre, matrix and their interactions, meso-level of single crack behaviour with macro-level concrete behaviour, followed by experimental studies on the mechanical loadings, physical

	<p>properties, and environmental exposure conditions that is optimal for self-sensing to occur.</p> <p>It is expected that this research will produce a set of guidelines for achieving reliable bendable concrete based self-sensing and create a set of materials design tools to meet these strict requirements, ultimately resulting in concrete which improve the overall health and safety of countless concrete structures. Specifically, the proposed work will focus on the following objectives:</p> <ol style="list-style-type: none"> <li>1. Design bendable concrete based on micro-level mechanics model;</li> <li>2. Develop multiple-level model for self-sensing behaviour of above material.</li> </ol> <p>Investigate mechanical/physical/environmental effects on the self-sensing concrete.</p>
<p><b>Assoc Prof Lim Teik Thye</b>  <a href="mailto:cttlim@ntu.edu.sg">cttlim@ntu.edu.sg</a></p>	<p><b>Graphene-based adsorbents and carbocatalysts for synergistic adsorption-oxidation of antibiotics and pesticides in wastewater</b></p> <p>Non-metal, carbon-based catalysts such as activated carbon (AC), graphene oxide (GO), reduced graphene oxide (rGO), carbon nanotubes (CNTs) and graphitic carbon nitride are alternative catalytic materials for application in water decontamination. They provide a potential solution to the metal leaching problem associated with the metal-based catalysts. Besides, they also demonstrate good adsorption capacity for organic pollutants due to their large surface areas and large density of active surface sites. This research will focus on development of functionalized graphene for water decontamination. It comprises two parts: (1) synthesis of various rGO and GO and functionalize them to create adsorption and catalytic active sites, and (2) conducting experiments to evaluate the performance of the functionalized rGO and GO to illustrate the synergistic adsorption and catalytic oxidation processes for pollutant removal. The oxidants to be applied include persulfate, peroxymonosulfate, hydrogen peroxide or ozone. The students will be trained to use TEM, FESEM, XPS, XRD, AFM, etc for material characterizations. If time allows, the student can also incorporate density functional theory (DFT) into the research program. The students with adequate academic training in the fields of material science, chemistry or chemical engineering, and proven research enthusiasm, are preferred for this internship research.</p> <p><b>Duration:</b> 6 months, or equivalent to a typical duration for a master degree's research project</p>

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**Materials for environmental protection and monitoring**

Protection and monitoring of natural waters for toxic components is essential for human well-being. Since the content of pollutants occurring in natural ecosystems should be kept as low as possible, there is an ongoing search for analytical methods with ever lower detection limits for detection of pollutants as well as constant search for new technologies for removal of toxins from the environment.

Thus, the project will be devoted to exploration of novel materials for environmental protection and monitoring in order to develop more efficient and more sensitive environmental sensors and pollutant removal platforms. Those materials, among many, will involve, e.g. different papers and textiles, conducting and non-conducting polymers and nano particles. Primarily use of the material will be towards water based analysis and removal of pollutants, however, gas sensors and air pollutant removal platforms will be also considered. The development of the new materials will be possible owing to the utilization of state-of-art instrumentation at NTU and support from national and international collaborators.

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**Catastrophe risk modelling and management**

The Objective Of The Project Is To Develop State-Of-The-Art Concepts And Practices In Managing Catastrophes Such As Earthquakes, Floods, With A Focus On The Development Of Innovative Methodologies In Risk Modelling And Management Such As Flood Risk Mapping, Damage Evaluation And Mitigation Management. The Project Also Aims To Investigate The Effects Of Climate Change On Flood Magnitude And Frequency, And Evaluate The Possibilities Of Reducing Economic, Financial And Social Losses By Adopting Scientific Decision-Support Tools. The Research Outputs Are Also Expected To Help Better Understand The Role Of Uncertainty In Evaluating Flood Risks As Well As The Sources Of Risk And Their Quantification, And Improve Flood Forecasting And Warning, Long-Term Mitigation Planning, And Emergency Management Response In South-East Asia.

The objectives of this project may also include identifying the financial engineering methodologies and analytics that are suitable for modelling alternate risk transfer mechanisms such as catastrophe bonds and other financial and insurance instruments. It also aims to develop the framework on catastrophe insurance as well as the application of catastrophe micro-insurance for selected developing areas. It will investigate how sustainable and long-term risk reduction

solutions and innovative products in finance and insurance could be developed to assist in transferring and spreading the risks for the benefit of Asian countries.