Second Call for Proposals (FY15/16)

1. Cool Singapore

Urban fabric materials in buildings, pavements and other impervious surfaces absorb heat due to solar irradiation. These heated urban fabric materials subsequently heat up the surrounding air causing the urban heat island (UHI) effect phenomenon. UHI effect is found to adversely affect comfort and well-being of people in urban areas. This heating effect is often exacerbated by insufficient natural cooling mechanisms (e.g., wind ventilation, vegetation, water bodies, etc.) in urban areas due to highly dense urban developments. As a major metropolis in the tropical region subjected to year-round hot and humid climate, an effective solution to the UHI effect plays an important role to Singapore's continuous urbanisation, sustainability, comfort and well-being as well as energy efficiency.

This project aims to develop a mitigation solution for UHI effect based on the Cool Surface technology. Cool Surfaces are materials that reduce the solar radiation absorption when they are applied on urban surfaces, leading to reduction of urban ambient temperature. A comprehensive modelling and field measurement study will be conducted to formulate the strategy for Cool Surface deployment in Singapore and to provide the scientific foundation for such a strategy. A suite of high-performance Cool Surface materials featuring high solar reflectance, high durability and self-cleaning properties will also be developed to cater for the needs of deployment on different urban surfaces. Real-world performances of the new Cool Surface materials will be examined through field test beddings.

Dr. Wan Man Pun
Assistant Professor
School of Mechanical & Aerospace Engineering
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Nanyang Technological University

Dr. Wan is currently an Assistant Professor in the School of Mechanical & Aerospace Engineering at Nanyang Technological University. Prior to joining NTU, he was an Assistant Professor of Mechanical Engineering at Kyungpook National University, Korea. His research interests cover aerosol sciences, building energy, indoor environmental quality, catalytic oxidation systems and numerical simulations. He has published over 70 international refereed journal and conference articles. Dr. Wan led numerous government and industry funded research projects including Cool Surface projects funded by HDB, BCA and A*STAR, through which he developed new high-performance Cool materials and new modelling methods to analysis the heat transfer characteristics of Cool materials. He served in the editorial board of Building Simulation: An International Journal and is a member of American Society of Mechanical Engineers (ASME), American Chemical Society (ACS) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

2. Technology for cement-treatment of ground in areas obstructed by obstacles

In many large cities, usable space is a premium resource and underground development is often more a matter of necessity rather than choice. Singapore, for instance, has already embarked on underground development in a big way. However, in Singapore and many other large cities, such as Jakarta, Bangkok and Shanghai, soft clayey soil is commonly encountered. In such cases, underground construction often cannot proceed unless the soil is appropriately hardened. A common method is to mix cement into the soft soil to harden it. Current technology does not permit locations which underlie existing infrastructure, utilities, services or obstacles to be improved in a safe and cost-effective manner; this is becoming an increasingly common occurrence as the underground becomes more congested.

The objective of this project is to develop an equipment which will allow cement treatment to be conducted around corners and obstacles, based on a concept developed in a current NRF-funded project. The heart of this development is a computer-controlled mechanism which will allow the shaft of the mixing equipment to bend and thereby skirt around the obstacles in question, while simultaneously rotating and delivering cement into the ground. Preliminary trials to date have indicated that the concept is viable in-principle. The aim of this project is to produce a working prototype of such an equipment. The project will cover the hardware, software, monitoring and quality control aspects of the new technology. If successful, this development will potentially enable cement-treatment to be used in areas currently inaccessible. This enables previously obstructed and inaccessible regions of the ground to be treated by cement. This technology is likely to find application not just in Singapore but also in other congested large cities with areas underlain by soft soils.

Dr. Lee Fook Hou
Professor
Department of Civil & Environmental Engineering
National University of Singapore

Fook Hou is currently a professor in the Department of Civil & Environmental Engineering at the National University of Singapore (NUS). His teaching and research experience at NUS spans over more than 30 years. His current research interest is underground construction in urban areas. Between 2005 and now, Fook Hou has been principal investigator of research grants totalling roughly $11 million. Fook Hou is also a registered Professional Engineer (Civil) as well as Professional Engineer (Geotechnical Specialist) and has consulted for more than 70 engineering projects. He is a Fellow of the Singapore Academy of Engineering.

Fook Hou's research works have led to the publication of more than 100 research papers, about 60 of which are in international peer-reviewed journals. He has, to date, graduated more than 40 PhD students and Master of Engineering students. Fook Hou is editor for several international scientific journals. He also serves as reviewer for many international journals and has received awards for doing so, including the Top 12 Reviewers award from Computers and Geotechnics in 2009, 2013, 2014 and 2015. He is a member of the UK Engineering & Physical Sciences Research Council College of Reviewer, which reviews research funding proposals submitted to the Engineering and Sciences Research Council of UK, and has served as reviewer for the Swiss National Science Foundation and for the Chinese Ministry of Education. Dr Lee has been invited as Visiting Professor to several Chinese institutions of higher learning. He is also a member of World Federation of

Engineering Organization Committee Engineering and The Environment Task Group on Disaster Risk Management.

3. Hybrid reflective, catalytic and pyroelectric nanocomposite for holistic solar heat gain, air quality and energy sustainability solution

The urban heat island (UHI) effect in built-up populated areas has adversely increased the annual mean air temperature by a few degrees Celsius. One of the major factors that contribute to the UHI effect in Singapore is the geometric effect of tall and densely-packed buildings. These buildings unfavorably provide multiple surfaces for sunlight absorption and reflection. Other implication includes blocking of wind that leads to reduced convection cooling and air pollutants dissipation. Elevated ambient temperature can affect the community's environment and quality of life, resulting in1) Increased energy consumption: Higher ambient temperature increases energy demand for cooling especially during peak periods. 2) Increased air pollutant and greenhouse gases emission: Increased energy demand consequently results in higher air pollutant and greenhouse gas emission. 3) Compromised human well-being: Warmer ambient along with higher air pollution levels can lead to general discomfort and other heat/pollution related sickness.

In view of the UHI effect, this proposal aims to develop hybrid nanocomposite for integrated cooling and waste heat-to-energy conversion technology. The nanocomposite consists of heat reflective nanostructures and polymer composites that capture and utilize reflected heat for electricity generation. Additionally, the nanocomposite also functions as photocatalytic material capable of degrading volatile organic compound pollutants for improved indoor air quality.

The proposed technology offers multiple benefits, including improved human health and comfort, reduced energy usage, and lower greenhouse gas emissions. In this project, NUS will be working in close collaboration with the Building and Construction Authority (BCA) to develop an integrated functional material that seamlessly coordinates building efficiency and performance for sustainable urban solutions.

Dr. Ho Ghim Wei
Associate Professor
Electrical and Computer Engineering
Engineering Science Programme
National University of Singapore

The Principal Investigator, Ho Ghim Wei is currently an Associate Professor of Electrical & Computer Engineering at the National University of Singapore (NUS). She is also one of the pioneer faculty associates of the Engineering Science Programme (ESP) at NUS. She graduated with a BSc and MSc from the National University of Singapore in 2000. She worked as an Engineer at Chartered Semiconductor Manufacturing (CSM), Singapore from 2000-2002, before embarking her PhD at the University of Cambridge. She has received several solar-to-energy conversion research grants from MOE, A*Star and NRF. She has published more than 90 papers in international refereed journals. Her research interests include photo/electrocatalysis, photo/electrochromism, nanoenergy generator and storage. In 2014, she was awarded the L'OREAL UNESCO for Women in Science Fellowship. In 2015, she was awarded the Honoree Winner in JCI's Ten Outstanding Young Persons (TOYP) Award in the Science and/or Technological Development category.

4. Web-based 3D GeoData Modelling and Management System (GeM2S)

The main objective of this project is to establish a Web-based three-dimensional (3D) Geological and Geotechnical Data Modelling and Management System (GeM2S) to reduce construction cost and increase productivity for future underground construction projects in Singapore. A huge amount of geological and geotechnical data has been collected in the past. This project is to develop a system to use these data for future underground construction. A 3D model and database for both geological and geotechnical data will be established using the existing borehole data as well as validated in-situ and laboratory data. This model can be updated with new geological and geotechnical data available in the future.

By using this system, virtual borehole and cross-section can be created online as part of the BCA's Geoscience Information Sharing Portal; the geological conditions at a site can be evaluated together with the geological or geotechnical model established. In this way, the uncertainties involved in the design parameters can be reduced, the design can thus be reliable without being too conservative. A method will also be provided to allow the data to be transferred to a platform compatible with Building Information Modelling, so that the data can be easily used for construction projects. This will help further in reducing construction cost and increasing productivity. The proposed 3D GeM2S system will be used by both government agencies and industries for either underground space planning or infrastructure developments such as for construction of buildings, roads, MRTs, or underground caverns.

Dr. Chu Jian
Professor
School of Civil and Environmental Engineering
Co-Director, NTU-JTC Industrial Infrastructure Innovation Centre
Nanyang Technological University

Dr Chu Jian is Professor in Geotechnical Engineering at NTU. He is the Director of the Centre for Usable Space and the Interim Director of the NTU-JTC Industry Infrastructure Innovative Centre at NTU. He has more than 25 years' research and consulting experience in the proposed area of research, and has led several large scale research projects in the past. He is the Vice Chair for Technical Committee TC217 on Land Reclamation under the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) and a Member for ISSMGE Technical Committee TC211 on Ground Improvement. He was the Chair for ISSMGE TC39 on Geotechnical Engineering for Disaster Mitigation and Rehabilitation from 2005 to 2009. Professor Chu has published over 300 technical papers in international journals and conferences and delivered over 50 keynote or invited lectures at international conferences. He received the R. M. Quigley Award in 2004 from the Canadian Geotechnical Society for publishing the best paper in the Canadian Geotechnical Journal in 2003.

5. Augmenting Urban Soundscapes (AUS) : Design Tools, Noise Mitigation System, and Evaluation of the Urban Sound Environment

The key objective of this project is to develop a demonstrator of a software system for simulation and creation of the sound environment that allows designer to generate sound objects (of noise sources and natural sound sources), which can be placed in a 3D space.

Soundscape is a new concept that explores and evaluates sound/noise in the environment in a holistic manner. The proposed soundscape approach utilises active noise mitigation techniques that maintain natural ventilation in residential areas. Ambient noise reduction can be achieved based on psychoacoustic masking approaches that are perceptually more soothing and relaxing to the residents, and also trigger positive physiological responses.

User can perceive the soundscape through a pair of augmented reality (AR) headsets to listen and see how different sound objects will interact with each other, and preference of the sound attributes can be evaluated by human subjects. Arising from these findings, we can develop soundscape masking techniques to improve the aural comfort of residents in public areas.

Dr. Woon-Seng Gan
Associate Professor
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Woon-Seng Gan is currently an Associate Professor in the School of Electrical and Electronic Engineering at the Nanyang Technological University. He is also the Director for the Centre of Infocomm Technology in NTU. His research has been concerned with the connections between the physical world, signal processing and sound control, which resulted in the practical demonstration and licensing of spatial audio algorithms, directional sound beam, and active noise control for headphones. He has published more than 260 international refereed journals and conferences, and has been granted seven Singapore/US patents. He has also co-authored three technical books (published by Prentice Hall, IEEE, and Wiley) related to his research work. He is currently a Fellow of the Audio Engineering Society(AES), a Fellow of the Institute of Engineering and Technology(IET), and a Senior Member of the IEEE. He is also widely consulted in the industry, and has successfully completed several research grants from NRF, MOE, and A-STAR.