

## What we do:

We aim to pioneer the development of sustainable materials with emphasis to carbon and energy whilst also focusing on the longevity of our civil infrastructure, investigating the following fields:

- Metallurgy.
- HotCon – Hot weather concreting and the use of maturity functions for predicting the effect of temperature on early age strength development.
- Geopolymer – Alkali activated binders to replace Portland cement.
- Durability of structures.
- Energy efficient buildings.
- Whole life management.
- BirCON – Blast and Impact Resistant Concrete.

We aim to achieve the above through teamwork – ideas discussed and jointly bid for contracts/projects, actively monitor research income (currently at £1.2 million). We aim to improve our “impact” through establishing contacts with industry, Rilem Technical Committees (including their reports), blog sites for ongoing projects, organisation of conferences (CERI 2014, Concrete Solutions 2014, etc.).

## Who we are:

### Prof. Marios Soutsos



Prof. Marios Soutsos was, prior to his appointment in QUB, a Lecturer/Reader in Structures and Concrete Technology at the Centre for Engineering Sustainability, School of Engineering, The University of Liverpool from 1995 till 2011. Principal research experience is in construction materials and current interests include: high strength concrete, cement replacement materials, chemical admixtures, concrete rheology, the use of recycled demolition aggregate in concrete products, repair materials, heat of hydration effects in concrete structures, as well as alkali activated binders. He is author or co-author of more than 80 technical publications. He the editor for the book entitled Concrete Durability: A Practical Guide to the Design of Durable Concrete Structures, and he contributed chapters to 3 other books.

*“Our challenge is to develop safer, greener, more durable, stronger and affordable building materials for a sustainable built environment.”*

### Prof. Wei Sha



Prof. Sha graduated from the University of Oxford in 1992 with a PhD in Materials Science after completing a Bachelor degree at Tsinghua University, Beijing. He then joined Imperial College as a postdoctoral research assistant and he is currently professor at Queen’s University Belfast. He has never been out of a university since 1981 except for a six-month period in 1997 when seconded to the Steel Construction Institute as a consultant engineer. He authored more than 300 scientific papers and 4 books. He is a Fellow of The Institute of Materials, Minerals & Mining and a Fellow of The Institute of Metal Finishing, and was winner of Engineering Employers’ Federation Trophy and the Royal Academy of Engineering Global Research Award.

*“The long-term priorities for the Civil Engineering Research Centre are research income and research impact. The overall research goals of the School are publications and income. Our group can make a big contribution.”*

### Dr. Sree Nanukuttan



Dr. Nanukuttan started his career by working at an Architectural Consultancy company in 2001 specialising in project management and structural retrofit. He joined Queen’s in 2002 and went on to develop a concrete test instrument that is now commercialised and marketed by Amphora NDT Ltd. After completing his PhD in 2007, he worked alongside optoelectronics researchers in developing fibre optic sensors for concrete structures. He became a lecturer in late 2008. His work specialises on Management of Built Infrastructure. This involves condition assessment and management of bridges, piers, culverts and also developing a management strategy for new structures in extreme environments. He recently completed an industrial secondment with Roads Service Northern Ireland supported by Royal Academy of Engineering.

*“We focus on developing material and construction technologies that will deliver resilient and sustainable infrastructure. We have developed non-destructive tests and imaging systems that help asset managers in developing performance focused maintenance strategies for concrete structures”*

## Prof. Jian Fei Chen

Jian-Fei is Professor of Civil and Structural Engineering at Queen's University Belfast and current president of the International Institute of FRP in Construction (IIFC). He has nearly 300 well cited publications. He has vigorous research activities in two main areas: (a) strengthening concrete structures with advanced fibre reinforced polymer (FRP) composites, (b) particulate solids flow and stresses in silos and materials handling. His research interests include also: analysis and design of complex structural systems under extreme loading; stability and dynamic analysis of continuum and reticulated shells; composite structures in steel-concrete, FRP-concrete and FRP-steel-concrete. The understanding of complex structural behaviour has been pursued using advanced numerical modelling (both the finite element method and the discrete element method), algebraic analysis and experimental verification.



## Dr. Rory Doherty

Rory is an environmental engineer who is interested in resource management. He sits on the scientific and technical committee of the Chartered Institute of Wastes Management, and is a UK member of the NORM4Building network. Rory has extensive experience in the remediation of brownfield sites. He has worked on projects that have developed anionic clays and modified flyashes to sorb contaminants in Permeable Reactive Barriers, and novel methods for monitoring natural attenuation (biogeophysics or bioelectrical systems). He is also interested in microbial and abiotic mechanisms to stabilise contaminants and to sequester CO<sub>2</sub> and leads the Stable Isotope Facility at QUB



## Prof. Ruth Morrow

Ruth has been recognised for innovative approaches within Architectural Education and Research. She is an engaged contributor to strategic discussions about the nature of architectural education and research within the profession. Over the last few years she has focused on applied research based on an understanding of creative processes, inclusive strategies and pedagogical methodologies. Despite a strong commitment to theoretical and revisionist thinking, her research is invariably project based with a variety of outputs, across product, exhibition, printed text and e-media. Her professional skills are underpinned by an activist and collaborative instinct. Research Areas are driven by an ethos that seeks to strengthen the connections between people and design and are currently focused on the interconnections and potentials between people, place, pedagogy and the socialisation of technology.



## Dr. Desmond Robinson

Desmond is a graduate of the University of Edinburgh where he also completed his PhD on Structural Optimisation. He is currently a Senior Lecturer with the School of Planning Architectures and Civil Engineering at Queen's University Belfast. His specialist area is finite element analysis and has been working in this area for the last thirty years. Over that time he has applied finite element to a variety of applications including the shakedown of granular soils. He is currently undertaking finite element modelling of composite strengthened reinforced concrete structures; skew masonry arches and high velocity impact damage of fibre reinforced concrete. He is also an investigator on a US-Ireland grant on developing B-WIM health monitoring systems to extend bridge life. He has over 85 technical publications.



## Prof. Adrian Long

Adrian is a Professor Emeritus with over 350 technical publications. His research is mainly on the Shear of RC and PC structures and the Durability of Materials – assessing in-situ strength and transport properties of concrete. He patented a sustainable and rapid method of constructing arches in 2004 and assisted Macrete in the development of the FlexiArch. Since 2007 over 50 FlexiArch bridges, with spans from 4m to 15m, have been installed in UK and Ireland. At Queen's University, he has been Head of Civil Engineering (1977 - 1989), Director of School of the Built Environment (1989 - 1998), Dean of the Faculty of Engineering (1988 - 1991) and (1998 - 2002). Moreover, he has been the 138<sup>th</sup> President of the Institution of Civil Engineers (2002 - 2003).



## Research Fellows and Research Assistants:

### Dr. Jacek Kwasny



Jacek received his BSc Eng degree (2004) and the MSc degree (2006), both in Civil Engineering, from the Silesian University of Technology, Gliwice, Poland, and the PhD degree (2013) in Civil Engineering from QUB, Belfast, UK. He has over six years of professional research experience working as a research assistant (2008-2011) and as a research fellow (2011-present) in industry-oriented research projects. Since Feb 2014 he has been working with banah UK Ltd, within the Invest NI funded project. His research interests include: sustainable lightweight construction materials with low thermal conductivity, normal weight and lightweight vibrated and self-compacting concretes, early age CO<sub>2</sub> curing and CO<sub>2</sub> sequestration in cement-based materials, recycling of industrial by-products in concrete, and rheology of construction materials.

### Miss Teresa McGrath



Teresa graduated from Civil Engineering University College Dublin in 2010 and completed a Masters of Environmental Engineering in QUB in 2011. She has recently finished working on SUS-CON EU FP7 project and has started worked on an EPSRC funded project with a SME developing a decision making tool for energy efficient retrofit of domestic buildings. Her research interests include energy efficiency, sustainable materials, life cycle assessment & building performance monitoring.

### Dr. Raffaele Vinai



Raffaele graduated from the Turin Institute for Technology (Italy) in 2002 and obtained a PhD in Geo-Environmental Engineering in 2006 from the same institution. He has been Academic Visitor at the University of Oxford in 2004 during his PhD and lecturer at the International Institute for Water and Environmental Engineering in Burkina Faso in 2010-2011. He joined QUB in 2013, working on a EU FP7 project on the development of sustainable concrete made with recycled waste materials. His research interests include sustainable construction materials, waste recycling, geo-materials.

## Academic collaborations outside SPACE

### Dr. Peter Nockemann



Peter is a graduate of the University of Cologne, Germany where he also completed his PhD. He is currently a Lecturer with the School of Chemistry and Chemical Engineering at Queen's University Belfast (RCUK Fellow). His research interests include Ionic liquids (use of ionic liquids as media for the synthesis and design of coordination complexes which cannot be obtained from conventional solvent systems), Nanomaterials (novel pathways to obtain highly stable dispersions of nanoparticles in ionic liquids), Coordination chemistry, Lanthanide Luminescence, Structural Chemistry (design and synthesise f-d-solid-state architectures from metal-containing ionic liquid as precursors and building blocks that self-assemble to afford two- and three-dimensional networks). He has over 110 technical publications.

### Dr. Małgorzata (Gosia) Swadźba-Kwaśny



Małgorzata (Gosia) Swadźba-Kwaśny graduated with an MSc Eng from Silesian University of Technology, Poland. In 2009 she obtained PhD (supervised by Prof K.R. Seddon) from the QUILL Research Centre, Queen's University Belfast, UK, where she currently works as a Research Fellow. She is interested structural studies of advanced fluids (ionic liquids, liquid coordination complexes or deep eutectic solvents), in particular liquid-state speciation of metal complexes, as well as Brønsted and Lewis acidity. In parallel, Gosia has a strong interest in applied chemistry, working on the integration of advanced fluids into petrochemical processes in collaboration with industrial partners (BP, Petronas, Evonik). Gosia has 20 journal publications, and 3 international patent applications.

## Current PhD students

### Geopolymer – Alkali activated binders to replace Portland cement

Mr. Anastasis Hadjierakleous



(Cyprus)

**Development of Cementless Concrete (Geopolymer)**

Supervisors: Prof. M. Soutsos and Dr. A. Boyle (Univ. Liverpool)

Mr. Andrew McIntosh



(Northern Ireland)

**Development of a geopolymer binder from the interbasaltic laterites of Northern Ireland**

Supervisors: Prof. M. Soutsos, Dr. S. Nanukuttan and Prof. D. Cleland

Mr. Ali Rafeet



(Oman)

**The development of eco-friendly and cost-effective geopolymer concrete**

Supervisors: Prof. M. Soutsos and Prof. W. Sha

Mr. Timothy Aiken



(Northern Ireland)

**Microstructural characterisation of cementless geopolymer concrete**

Supervisors: Prof. W. Sha and Prof. M. Soutsos

### BirCON – Blast and Impact Resistant Concrete

Mr. Samuel English



(Northern Ireland)

**Shear performance of Ultra High Performance Fibre Reinforced Concrete (UHPFRC) for bridge applications**

Supervisors: Prof. J.F. Chen, Dr. D. Robinson and Prof. M. Soutsos

Miss Siti Norhafilah Haji Aji



(Brunei)

**The development and optimisation of Ultra High Performance Fibre Reinforced Concrete (UHPFRC) in Thin Elements**

Supervisors: Prof. M. Soutsos, Prof. J.F. Chen and Dr D. Robinson

Mr. Efstathios Polydorou



(Cyprus)

**Impact and blast resistant structures made with Ultra High Performance Fibre Reinforced Concrete (UHPFRC)**

Supervisors: Prof. M. Soutsos, Dr. D. Robinson and Prof. J.F. Chen

### HotCon – Hot weather concreting

Mr. Fragkoulis Kanavaris



(Greece)

**Thermal stresses, strength and temperature development in safety critical concrete structures**

Supervisor: Prof. M. Soutsos, Prof. J.F. Chen and Dr. S. Nanukuttan

### Metallurgy and steel structures

Mr. Mayanglambam Franco



(India)

**Microstructure, tribological and electrochemical corrosion behaviour of electroless Ni-P-SiC coatings on aluminium for cylinder liner applications**

Supervisors: Prof. W. Sha and Dr. S. Malinov

Mr. Ross McKinstry



(Scotland)

**Sustainable design optimisation of single story steel buildings**

Supervisors: Prof. W. Sha, Prof. G. Hutchinson and Dr. J. Lim

Miss Ying Lian



(China)

**Web crippling behaviour of cold-formed steel and stainless steel channel sections with web openings**

Supervisors: Prof. W. Sha, Dr. G. Abdelal and Dr. J. Lim

## Energy efficient buildings

Mr. Neil Campbell



(Northern Ireland)

Miss Teresa McGrath



(Republic of Ireland)

**Sustainable low embodied and consumed energy buildings**

Supervisor: Dr. S. Nanukuttan

**Comprehensive study of retrofitting practices for improving the energy efficiency of houses**

Supervisors: Dr. S. Nanukuttan, Prof. P.A.M. Basheer and Dr. Dani Soban.

## Durability of concrete

Miss Colleen Green



(Northern Ireland)

Mr. Junjie Wang



(China)

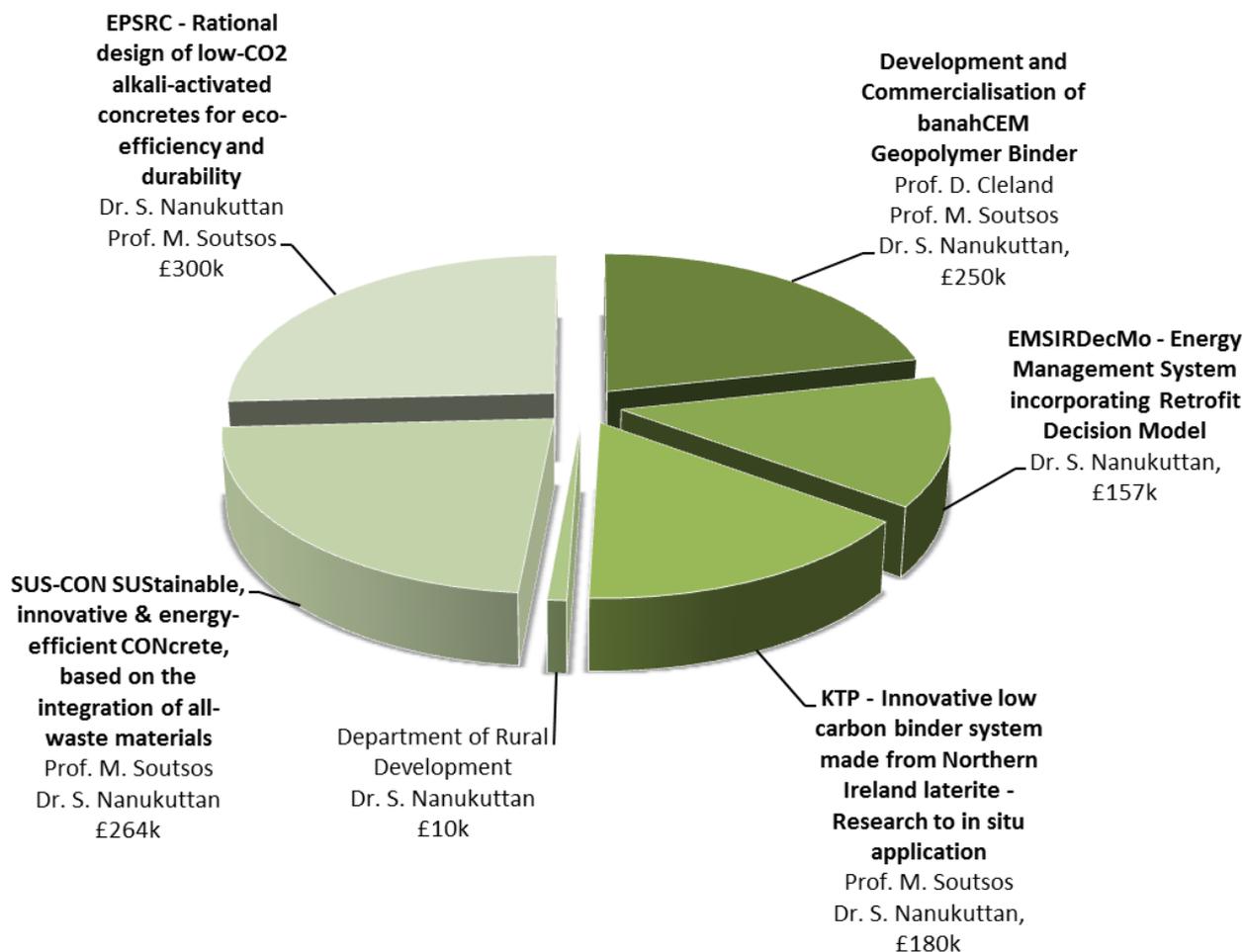
**The development of service life design strategies for structures in chloride environments**

Supervisor: Dr. S. Nanukuttan and Prof. P.A.M. Basheer.

**Influence of structural cracks on transport properties and chloride-induced corrosion of concrete**

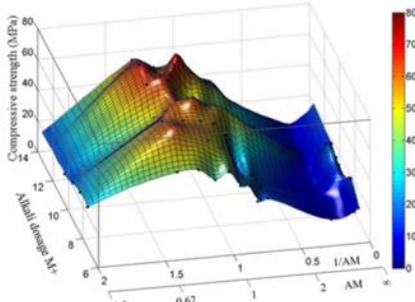
Supervisors: Prof. P.A.M. Basheer, Dr. S. Nanukuttan, Dr. Yun Bai and Dr. Hailong Wang

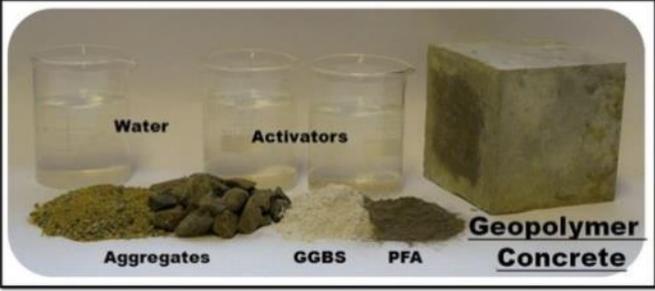
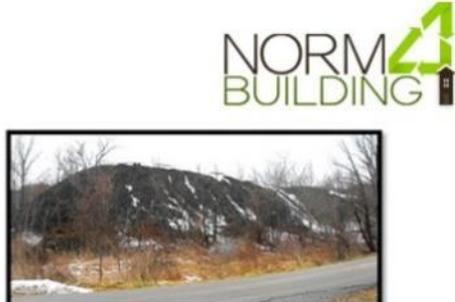
## Research income from projects:



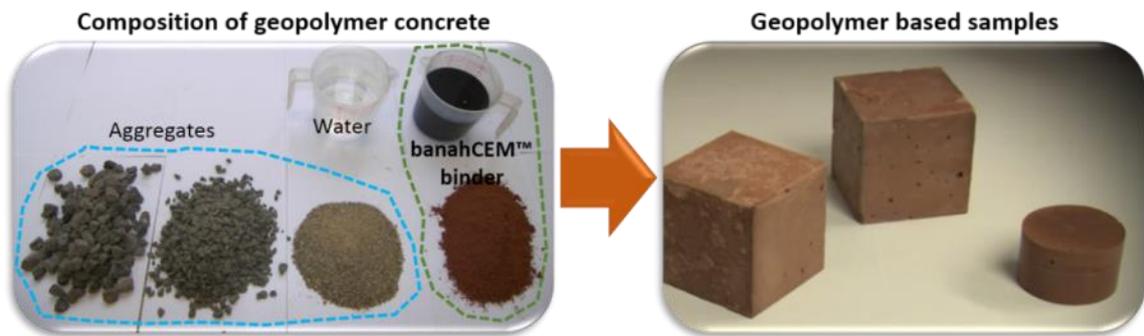
**Total income from projects: £1.16M**

## Ongoing research projects

Title	Budget	Funding Body	Partners
<b>Sustainable, Innovative and Energy-Efficient Concrete, based on the Integration of All-Waste Materials – (SUS-CON) – 2012/2015</b>	EUR 340,764	EU FP7 Collaborative research funds	14 European partners (both from academia and industry) and 1 Taiwanese partner
			
<p>The main objective of the project is to develop innovative light-weight, eco-compatible and cost-effective all waste concrete solutions. The sustainable concrete should be applicable for ready-mixed and pre-cast building applications – reduced embodied energy systems having improved thermal performance while maintaining all other performances. SUS-CON will provide each of the proposers with a detailed fundamental scientific understanding and make their wide scale commercial application feasible.</p>			

Title	Funding Body
<b>NORM4Building</b>	EU COST Action
	
<p>The main objective of the COST Action is the exchange of multidisciplinary knowledge and experiences (radiological, technical, economical, legislative, ecological) to stimulate the reuse of NORM (Naturally Occurring Radioactive Material) residues in new tailor-made sustainable building materials in the construction sector while considering exposure to external gamma radiation and the resulting indoor air quality. NORM Residues include the raw materials for many geopolymer and concrete products e.g Flyashes, Slags, Red muds, mining wastes, phosphogypsum tailings etc.</p>	

<b>Title</b>	<b>Budget</b>	<b>Funding Body</b>	<b>Partners</b>
<b>Development and Commercialisation of banahCEM Geopolymer Binder – 2014/2016</b>	GBP 230,252	Invest Northern Ireland	banahUK



The main objective of the project is to provide a strong proof to designers, specifiers, clients and developers, *via* extensive testing programme, that the novel geopolymer-based binder system (banahCEM™) developed by banah UK Ltd. can be produced and placed with similar ease as to what they are used with Portland cement concretes and mortars. Low energy geopolymer based concrete and mortar mixes will be optimised to produce products similar to those currently used in construction, providing reassurance that the new binder will have the required fresh, mechanical and durability properties at least as good, if not better, than that of Portland cement. Concrete mix design and quality control system will be developed to assist in the larger scale production of banahCEM and commercialisation of the geopolymer based concretes for a range of products.

## Recent events

- *During the last summer, visiting students from France and Brazil, as well as a student from the Nuffield Research Placements programme, joined the EEM team for their internships. A lot of craic in the lab!*



- Open days at QUB, the EEM team organised a stand with examples of the research activities and results.



## Recently published papers

Franco M., Sha W., Malinov S., Liu H., (2014). Micro-scale wear characteristics of electroless Ni-P/SiC composite coating under two different sliding conditions. *Wear*, 317, 254-64.

\*McIntosh J. A., Kwasny J., Soutsos M., (2014). Evaluation of Northern Irish laterites as precursor materials for geopolymer binders. 34<sup>th</sup> Cement and Concrete Science Conference, 14-17 September 2014

Rafeet A., Vinai R., Sha W., Soutsos M., (2014). Alkali activated fuel ash and slag mixes: optimization study from paste to concrete building blocks. 34<sup>th</sup> Cement and Concrete Science Conference, 14-17 September 2014

\*\*Green C., Nanukuttan S., Basheer P.A.M., (2014). A new performance based method for design and maintenance of reinforced concrete structures. Civil Engineering Research in Ireland (CERI) conference, 28-29 August 2014 Belfast (UK)

McIntosh J.A., Soutsos M.N., (2014). Development of a geopolymer binder from the interbasaltic laterites of Northern Ireland. Civil Engineering Research in Ireland (CERI) conference, 28-29 August 2014 Belfast (UK)

Kwasny J., Basheer P.A.M., Russell M.I., Doherty W., Owens K., Ward N., (2014). CO<sub>2</sub> sequestration in cement-based materials during mixing process using carbonated water and gaseous CO<sub>2</sub>. 4<sup>th</sup> International Conference on the Durability of Concrete Structures, Purdue University, West Lafayette, IN, US, 24–26 July 2014, pp. 72-79.

Lawane, A., Vinai, R., Pantet, A., Thomassin, J., Messan, A. (2014). Hygrothermal Features of Laterite Dimension Stones for Sub-Saharan Residential Building Construction, *J. Mater. Civ. Eng.*, 10.1061/(ASCE)MT.1943-5533.0001067, 05014002.

\* The paper was awarded with the prize for best presentation at the 34<sup>th</sup> Annual Cement and Concrete Science Conference, 14-16 September 2014 - University of Sheffield.

\*\* The paper was awarded with the prize for best student paper on Concrete at the Civil Engineering Research in Ireland (CERI) conference, 28-29 August 2014 – Queen's University Belfast.