RESEARCH
in the Faculty of Engineering & the Built Environment

University of Cape Town
Our Purpose

The Faculty of Engineering & the Built Environment is a research-intensive faculty which strives to create, advance and disseminate knowledge that will ultimately benefit society.

In addition to generating new knowledge, the Faculty also exists to develop outstanding graduates and scholars; graduates that are distinctive through their good technical knowledge, understanding of health and safety concerns, social consciousness, critical engagement and professionalism, and scholars of international stature. Ultimately, our purpose is to produce graduates and scholars who can think beyond the obvious to find new solutions to society’s challenges.
7 the number of SARChI (South African Research Chairs Initiative) chairs held by the faculty in 2012. Three of these, having completed its first five-year run, have been renewed.

122 & 9* number of master’s and PhD students, respectively, who graduated from EBE in December 2012.

16 & 5* patents filed and patents granted, respectively.

12 the number of researchers who, in 2011, received ratings from the National Research Foundation.

375* number of peer-reviewed publications.

80 & 6 number of master’s and PhD degrees, respectively, awarded in June 2012.

166 the number of research contracts.

299* number of research contracts.

122 the number of research groupings accredited.

4 the date in May 2012 when the faculty advisory board met to discuss, among other things, research priorities. Also the number of key areas they decided needs focus – energy efficiency, climate change, finite reserves and resource capacity.

24.61* rands, in millions, spent on postgraduate funding.

94.18* rands, in millions, awarded in research contracts.

1.84* rands, in millions, the faculty committed to postdoctoral research funding.

12 accredited research groupings.

166 rands, in million, the faculty committed in 2011 to faculty building projects; this was for work on the Extended Snape Building, the Centlivres Building and the New Engineering Building, each of which will include new research facilities.

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The past couple of years have seen a rapid increase in the number of National Research Foundation-rated researchers, and we are proud to have 45 rated researchers in the faculty. The faculty has appointed three Senior Scholars to assist in the mentoring of younger staff, and also to contribute to the research agenda of the faculty.

Furthermore, three to four postdoctoral fellowships (per annum) have been made available to increase the number of postdoctoral fellows in the faculty. We believe that the role of postdoctoral fellows is critical in promoting research performance.

There has also been a marked increase in publications in peer-reviewed accredited journals, and our publication count is up from 71.36 in 2005 to 94.68 in 2011. With this reputation, the faculty has become the engineering and built environment faculty of choice for a growing number of prospective undergraduate and postgraduate students.

In 2012 alone, 1,040 postgraduate students registered for studies with the faculty.

In engineering and the built environment, challenges and priorities change. Climate change and sustainability are important factors, and hardly a discipline is untouched by environmental concerns. Here at UCT we, too, have had to take cognisance of such far-reaching developments. Sometimes that impacts not only what we research, but also the way we go about conducting our research.
In the tight financial climate, we have had to seek non-traditional and sustainable funding sources. Our approach has been to source and establish industry-funded research chairs, in addition to the national chairs created by state institutions. In 2012, we secured a chair in transport studies in the Department of Civil Engineering, funded by the South African National Roads Agency Limited. ESKOM established two chairs in the faculty: the first in the field of energy efficiency, to be housed in the Department of Mechanical Engineering; the second in materials science, hosted by the Centre of Materials Engineering.

In addition, the faculty was awarded two chairs under the South African Research Chairs Initiative, or SARChI, of the national Department of Science and Technology. The chairs are in reaction engineering in the Department of Chemical Engineering, and in industrial computational fluid dynamics in the Department of Mechanical Engineering.

With the growth came the need for new space. In 2012 construction began on the six-storey New Engineering Building (NEB) and the Teaching and Learning Building (TLB). The NEB will become home to the departments of chemical and civil engineering and the faculty office, with the TLB making space for the Department of Construction Economics and Management, nine multifunctional lecture theatres, a micro-lab, and a satellite campus of the South African Research Chairs Initiative, or SARChI, chair in industrial computational fluid dynamics.

Looking ahead, we foresee that we will need funding for both a few more research chairs and some other long-term positions in a number of designated areas. This would include chairs in structural engineering and energy, perhaps a national centre of excellence in water studies, as well as appointments in safety and risk management, and a focus on postgraduate throughput.

We will continue to find ways to build, in a sustainable manner, our postgraduate enrolment at around 1% to 2% per year.

The years ahead will remain exciting and demanding ones for the faculty’s researchers. This publication allows us to highlight, briefly, the high-quality research work that is happening in the departments.

Professor Francis Petersen
Dean: Faculty of Engineering and the Built Environment

Signature themes

UCT’s framework for signature themes, approved in December 2004, sets out to build on existing research strengths within the university while developing standards and capacity in prioritised areas. All six signature themes aim to build competitive advantage for UCT in their fields by operating at a level that produces “more than the sum of their component parts”. These themes are able to demonstrate the impact of world-class research on their immediate environment and also more broadly on the global South.

The Faculty of Engineering & the Built Environment hosts two signature themes.

• African Centre for Cities

Research in the African Centre for Cities (ACC) concentrates on well-governed and sustainable cities, particularly in the developing world. Its aims are two-fold. Firstly, to partner closely with policy-making centres in the public sector in South Africa (national, provincial, local), and then to generate, more broadly, an alternative perspective on dealing with critical urban issues; and, secondly, to provide an intellectual base and home for interdisciplinary, urban-related research at UCT. This is critical as rapid urbanisation raises questions on food supply, shelter, employment, water and waste management, public transportation, crime and disease, and environmental degradation and climate change.

These challenges intertwine with critical social concerns such as exclusion and conflict, which require the political management of institutions and processes.

• Minerals to Metals

Established by the University Research Committee in 2007 as a signature research theme, the Minerals to Metals (MtM) initiative was expanded in 2012 with the renewal of a South African Research Chairs Initiative, or SARChI, chair in minerals beneficiation research. These challenges have been set aside for a surface-science laboratory that will house, among other things, state-of-the-art electron microscopes. We are confident that these and other new building projects that we have in the pipeline will serve us well and sufficiently for at least the next ten years.

Overall, we have also done well in finding financial support for the business of the faculty. Contracts from industry remain a major driver, and have steadily trended upwards over the past years. In 2011, the faculty was awarded 299 contracts to the value of over R194 million, and in 2012 a total of 268 contracts were awarded, valued at R138.62 million.

In addition to its research activities, the initiative coordinates the South African component of the Anglo American Safety Risk Management Programme (SRMP). The SRMP, developed by Professor Jim Joy of the University of Queensland, Australia, trains Anglo American staff – from company executives to entry-level employees – in safety risk management. The course is part of a worldwide initiative involving ten leading universities in South Africa, Australia, Brazil, Canada, Chile, England and the US. With the SRMP entering the ‘post-Anglo’ phase in 2012, it will now be offered to the world’s mining industry as a whole as part of the Global Minerals Industry Risk Management programme.
National Centres of Excellence and Competence

UCT hosts two of the seven national Centres of Excellence awarded by the Department of Science and Technology (DST) through the National Research Foundation (NRF). The aim is for these Centres to act as hubs of research and development in fields identified as strategically important to South Africa. The University is also home to a DST Competence Centre. While centres of excellence focus on basic science and research, centres of competence concentrate on applied science, technology development and technology transfer.

HySA/Catalysis

HySA/Catalysis, which is co-hosted by Mintek, South Africa’s national mineral research organisation, is one of three national competence centres established under the DST’s National Hydrogen and Fuel Cell Technologies (HFCT) Flagship Project, better known as Hydrogen South Africa or HySA. Together with HySA/Catalysis, the other two centres – HySA Infrastructure, co-hosted by North-West University (NWU) and the Council for Scientific and Industrial Research; and HySA Systems, hosted by the University of the Western Cape and located at the South African Institute for Advanced Materials Chemistry – established ‘hub-and-spoke’ collaborations with additional institutions of higher education. HySA/Catalysis’ mandate is to build the country’s competence base, improving its capacity to create homegrown products in the early part of the HFCT value chain, particularly around catalysts and catalytic devices. This would, in turn, attract investment to South Africa by setting up businesses that use our mineral wealth to create higher, value-added opportunities. The centre already has more than 20 projects underway, the majority of which are based at UCT, and has formed an extensive network of international academic and industrial partnerships. In 2012, HySA/Catalysis, in partnership with UCT’s Centre for Catalysis Research, acquired two more pieces of state-of-the-art equipment, which are set to beef up the development and testing of catalysts. The machines are an Isynth catalyst-preparation robot, produced by Swiss company Chemspeed; and the Flowrence high-throughput 16 parallel fixed-bed reactors, a piece of equipment developed by Dutch company Avantium. 

Dr Olaf Conrad is the director of the National Hydrogen Catalysis Competence Centre at UCT, or HySA/Catalysis, whose objectives include producing a set of home-grown catalysts.

c*change

The DST/NRF Centre of Excellence in Catalysis, or c*change, is hosted by the Centre for Catalysis Research at the Department of Chemical Engineering. Its academics and researchers concentrate on four specific research areas – synthesis gas conversion, paraffin activation, value addition to unique olefinic feedstocks, and the underdeveloped small-volume chemicals sector. The role of the centre is also one of a multi-institutional virtual network, and the national programme currently brings together more than 60 postgraduate students from various universities around South Africa, with UCT hosting the lion’s share of these projects. In 2012, the centre received a national SARChI chair in the field of preparation and characterisation of nano-materials. The chair is expected to further boost scientific output in the centre. In addition to conducting robust research, c*change has contributed funding for proof-of-concept work on Direct Liquefaction of Micro-algae Biomass, a so-called c*STAR Project that forms part of a larger Micro-algae to Energy initiative. The c*STAR Project sets out to utilise the c*change network and resource capacity to demonstrate proof-of-concept studies. The centre also hosted the 2012 SYNGAS Convention, themed Fuels and Chemicals from Synthesis Gas: State of the Art, a first-of-its-kind meeting dedicated to synthesis gas conversion.

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Faculty highlights for 2012

The state-of-the-art Gleeble 3800 was installed in the Centre for Materials Engineering, courtesy of a special equipment award from the National Research Foundation (NRF). Valued at $1.05 million, the Gleeble 3800 (on which, in picture above, Dr Sarah George is seen conducting an experiment) is a fully integrated digital closed-loop control thermal and mechanical testing system, able to very closely simulate industrial metal processes, including hot rolling, forging and extrusion.

The African Centre for Cities (ACC) co-hosted a workshop with the Stockholm Resilience Centre, aimed at gathering an African perspective for inclusion in a series of publications known as the Cities and Biodiversity Outlook. These are produced as part of the Convention on Biological Diversity of the United Nations Environment Programme.

The DST-NRF Centre of Excellence in Catalysis, or c*change, hosted the Syngas Convention, in association with Sasol and PetroSA, a first-of-its-kind convention dedicated to synthesis gas conversion.

Emer Prof Heinz Rüther received a fellowship from the International Society for Photogrammetry and Remote Sensing, in recognition of his sustained and excellent service to the ISPRS and its aims.

Prof Alison Lewis received the Distinguished Women in Science Award in the category for physical and engineering sciences. These awards go to women scientists and researchers who have made outstanding scientific contributions to advancing science and building the knowledge base in their disciplines.

Postgraduate students from UCT, the Cape Peninsula University of Technology (CPUT) and Stellenbosch University presented their research in mechanical, manufacturing and materials engineering at the Mechanical, Manufacturing and Materials Engineering Conference, hosted at CPUT’s Bellville campus. Prof Rob Knutsen was part of the organising committee.

The ACC and the City of Cape Town launched the Mistra Urban Futures (MUF) Knowledge Transfer Project, which sets out to increase capacity in sustainable urban development. Flagship research for the MUF will be conducted by the researchers Anton Cartwright, Robert McGaffin, Saul Roux and Anna Taylor, all working from the ACC.

Prof Sue Harrison organised a research workshop to discuss what it would take to raise the level of research in EBE, whether its impact, profile and outputs. Robust discussions took place around a number of issues, including the logistics of making time available for research, sustainable funding opportunities, the alignment and mentoring of new staff, and the distribution of postgraduate coursework.

Company Aurecon SA committed R2 million over the next five years to support UCT postgraduate students doing civil engineering at UCT.

The DST presented fellowships to doctoral students Joyce Mwangama (far right in picture) and Gladwell Nganga, and master’s student Lombe Mutale. The awards recognise outstanding ability and potential in research.
Against a backdrop of fundamental changes to South African cities, the School of Architecture, Planning and Geomatics aims to contribute to international knowledge through addressing the development, planning and design problems raised by the evolving Southern African context. Its concerns are broad, covering a host of areas and disciplines under architecture, conservation, geomatics, landscape architecture, planning and urban design.

In Architecture and Planning, areas of current research expertise among staff include the making and restructuring of urban settlements in developing contexts, informal settlements, low-income housing policy, heritage and its conservation, sustainable development and ecologically sustainable cities, the history and theory of architecture and urbanism, small business promotion, urban transport planning and policy, and urban management and governance.

In the Geomatics division, the staff members working on geo-information sciences are exploring developments in geographical information systems (GIS). That involves developing expertise in GIS technology; looking into the application of GIS regionally, nationally and on the continent; and contributing to capacity building in GIS technologies in Africa. Work continues in geodesy, the science that deals with the measurement and representation of the Earth, while the Cape Urban Observatory, a project of the African Centre for Cities, aims to facilitate more holistic municipal and local government decision-making processes by providing a web-based spatial data analysis platform. In addition, scholars in the Division conduct research on photogrammetry and remote sensing, where they calculate the geometric properties of objects using photographic images. Projects focus on both mobile mapping and indoor mapping, and aerial and satellite image mapping, providing important support to environmental management initiatives. In the field of land tenure and cadastral systems, the team explores the theoretical elements of cadastral systems, and the juridical and integrated cadastral systems in South Africa. The group is also doing research on computer-assisted mass appraisals of land values. Under the umbrella of visualisation, one of the Division’s major initiatives is the Zamani Project. This involves the recording, with state-of-the-art data acquisition and presentation technology, of the physical and architectural dimensions of numerous African heritage sites, and recreating detailed, data-rich 3D visualisation of these locations. Sites covered so far include the famed rock-carved Churches of Lalibela in Ethiopia, the historic Jenné settlements in Mali, and the Cederberg Mountains of South Africa.
African Centre for Cities

Affiliated with the School of Architecture, Planning and Geomatics, the African Centre for Cities (ACC) was established in 2007 to serve as a platform for interdisciplinary research on urban issues, both theoretical and applied, across UCT.

The primary focus is on applied research to address complex, intractable urban problems and challenges. The aim is to advance novel ways of thinking about and understanding urbanism across the global South, rooted in the realities of African urban spaces.

Highlights from 2012 include the Centre’s part in hosting a research workshop on African Urban Planning Law in Bellagio, Italy, and the launch of a major three-year programme of PhD student exchanges with Cape Town City officials.

Over 2012, the ACC-linked researchers published Climate Change at the CityScale, a book that emerged out of its Climate Change Think Tank; and a book on Climate Change, Assets and Food Security in Southern African Cities, a spinoff from the work of the African Food Security Urban Network hosted by the ACC. The research network hosted a conference on Migration Urbanisation and Food Security in Cities of the Global South.

During 2012, the ACC continued its active Brown Bag and Seminar series programme, and its involvement with three innovative participatory public art projects in Johannesburg. ACC staff members and associates participated in meetings in Bamako, Berlin, Boston, Dakar, Gothenburg, London, Nairobi, New York, Paris, Sao Paulo, Stockholm and Tokyo, among other cities.

In 2013 the ACC will continue its dynamic CityLab programme that supports much of its research and publishing. It is expected that the findings of two more labs will be published over 2013 – one on Philippi, the other on Central City Densification.

The ACC will also host the annual meeting of the Mistra Urban Foundation, a principal funder of the initiative, and will convene a major workshop to explore links with other key urban research centres in Africa.
About

As the custodian of the largest national research programme, the department is recognised as one of the leading academic departments of its kind in Africa. Two National Research Foundation research chairs, in minerals beneficiation and in bioprocess engineering, are already established in the department under the umbrella of the South African Research Chairs Initiative (SARChI) and two further such chairs, in catalytic nano-materials and reaction engineering, respectively, are in the process of being established. Work commissioned by leading chemical, petrochemical, mining and metallurgical companies gives depth and breadth to the department’s postgraduate programme, preparing students for employment and supplying industry with well-qualified employees. Academics remain in close contact with industry, undertaking challenging work at the forefront of their fields.

Research Areas

The department’s research activities are at present centred on:

- Minerals processing research focused on the flotation of ores using various cell technologies
- Catalysis research aimed at the synthesis and characterisation of heterogeneous catalysts and their evaluation for a wide variety of reactions and reactor types, including fuel cells
- Biological leaching of mineral ores, with work concentrated on the fundamental processes involved
- Bioprocess engineering focused on catalytic bioreactor design, process kinetics and the recovery of biological products
- Environmental process engineering, both at a conceptual and practical level
- Process synthesis featuring the application of pinch technology to heat and mass-transfer systems, as well as the control of process systems
- Crystallisation and precipitation research focusing on metal recovery in mineral processing and metal removal for environmental protection
- Educational research aimed at improving the quality of undergraduate teaching and learning
- Process modelling and optimisation
Research Groups

The Centre for Catalysis Research concerns itself with fundamental and applied research and development in the general field of heterogeneous catalysis – catalyst synthesis, physico-chemical characterisation and performance evaluation for industrially interesting chemical conversions. The principal fields of investigation include Fisher-Tropsch synthesis, zeolite/acid catalysis (especially as applied to hydrocracking and the transformation of phenols and derivatives) and catalysis by platinum group metals and gold.

The Centre for Bioprocess Engineering Research (CeBER) conducts research in modern bioprocess engineering and biotechnology principles and practice. The centre takes a cross-disciplinary approach to developing technologies for the process and biotech industries. Research areas include green biotechnology, hydrometallurgy, algae, white/red biotechnology and biominerals.

Working across a range of groups, Prof Sue Harrison (left), here with researcher Melanie Griffiths, has been conducting studies on the use of bioprocesses for economic, environmental and social benefit.

Dr Adeniyi Isafiade, who studies the use of mathematical programming methods in the design and multi-objective optimisation of bio-refinery plants and the use of a systemic approach to the investigation of mining accidents, received a Y-rating from the National Research Foundation in 2012/2013. This marks him as a young scholar with the potential to establish himself as a researcher within the next five years.

The chief focus of research at the Centre for Minerals Research (CMR) is on the processes of flotation and comminution, arguably two of the most important operations in mineral extraction. The CMR enjoys extensive support from mining companies, suppliers, and statutory funding agencies.

With its main aim to advance existing fundamental knowledge in the fields of crystallisation and precipitation, the Crystalization and Precipitation Research Unit (CPRU) focuses mainly on two research areas: optimising precipitation in hydrometallurgical processes, and the development of innovative technologies for mining wastewater treatment. The Unit has been heralded internationally for its work in eutectic freeze crystallisation, in which clean drinking water and useful salts can be separated from frozen acidic water or brine.

The Centre for Research in Engineering Education (CREE) was established in 1996 to promote engineering education as a research field both at UCT and in the broader academic community. This focus has since been extended to include science and related disciplines, and CREE is now regarded as a key player in the promotion of engineering-education research and development in South Africa.

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The Environmental and Process Systems Engineering (E&PSE) research group works on environmental issues of the resource-based process industries, and explores the use of process and systems engineering skills to solve environmental problems in development contexts. The group’s work is strongly incorporated into the Minerals to Metals and Cities in Africa signature research themes.

The Process Modelling and Optimisation research group aims to provide graduate students with the numerical and computational tools to develop practical numerical solutions to industrially relevant processes. Applications of these methods cover a diverse spectrum of projects including bio-processing, catalytic processing, environmental processing & separation engineering.

Research in the Reactor Modelling Group concerns novel methods of mathematically representing and analysing complex fluid flow and unsteady state behaviour in chemical reactors. The two main branches are population balance modelling and computational fluid dynamics. Projects typically involve a mixture of fundamental advancement in one or both of these major areas, with industrial applications in catalysed polymerisation of α-olefins, the bioleaching of sulphide minerals, hydrogen fuel cells and bubble column reactors.
About

Research in the Department of Civil Engineering is conducted within the framework of well-established research groups in the areas of structural engineering and mechanics, geotechnical engineering, concrete materials and technology, hydraulic engineering, water quality and water engineering, urban engineering and management, transport studies and GIS. Members of staff also interact with research groups in other departments, such as the Centre for Research in Computational and Applied Mechanics (CERECAM). The Department has fruitful collaborative links with several local and overseas universities, and with local industry. Much of the work done by members of staff finds application in industry. The high quality of the research undertaken by the Department is evidenced by the considerable number of peer-reviewed publications in ISI-accredited international journals produced by members of staff annually, and the international recognition that members of staff enjoy in their areas of research. Members participate on the committees of numerous local professional bodies, provide expert advice to industry, and serve on the editorial and advisory boards of various international journals and conferences.
Research Groups

The Structural Engineering and Mechanics Research Group has built expertise in a range of fundamental, applied and computational research, from structural engineering and mechanics to biomechanics. Projects include research on the mechanics of shell structures, novel applications of shells, mathematical studies of symmetry in structural systems, the development of group-theoretic formulations for problems in structural mechanics, fatigue crack growth, the dynamic modelling and vibration control of high-voltage overhead power transmission lines under South African conditions, and the use of computational mechanics and electro-elasticity to better understand the biomechanics of myocardial infarction (or heart attacks).

In the Information for Community Oriented Municipal Services (iCOMMS) research group, the focus is on improving service delivery in developing countries through appropriate tools. Using a variety of technologies, such as cellphones, systems are developed to support basic service delivery in rural and under-resourced environments. iCOMMS has applied its expertise to an international water-quality monitoring project known as Aquastest, and, in an initiative known as Cell-Life, the monitoring of ARV treatment among HIV+ patients living in rural communities.

The Concrete Materials and Structural Integrity Research Unit, (CoMSIRU) is focused on the use and application of cement-based materials in the South African environment. It has developed a programme of basic concrete materials studies, and has conducted extensive research on technologies and procedures for the design and assessment of concrete structures. Within the unit there has been a marked focus on research into infrastructure performance over the last decade, largely in response to industry needs, with a growing interest in deterioration science, assessment technologies and renewal engineering.

The concern of the Urban Management Research Group is the delivery of municipal engineering services such as the supply of potable water, the removal and disposal of sewage, the protection of life and property from stormwater, the disposal of solid waste, and the provision of road-based transport systems. The delivery of each of these services involves the long-term planning of the infrastructure or network, the detail design of the elements of the network, the construction of each of these elements, the ongoing operation and maintenance, and regular rehabilitation of the infrastructure, as well as the planning, design and expansion of the system.

The Centre for Transport Studies serves as a home for cross-departmental teaching and research within the field of transport. It draws on the expertise of staff from UCT departments and other centres, most notably the Department of Civil Engineering, the School of Architecture, Planning and Geomatics, and the African Centre for Cities, as well as from nationally and internationally based academics and professionals.

Projects have covered everything from integrated transport planning and the development of intelligent transport systems to non-motorised travel and infrastructure in Cape Town.

The Urban Water Management Research Group is focused on the use and application of cement-based materials in the South African environment. It has developed a programme of basic concrete materials studies, and has conducted extensive research on technologies and procedures for the design and assessment of concrete structures. Within the unit there has been a marked focus on research into infrastructure performance over the last decade, largely in response to industry needs, with a growing interest in deterioration science, assessment technologies and renewal engineering.

In turn, the main thrust of the Urban Water Management Research Group is environmental systems engineering, which seeks to develop an understanding of the fundamental chemical, physical and biological processes operative in various water related systems such as water storage (impoundments), transport (rivers, pipes, sewers) and treatment plants (potable and wastewater). The principal aim is the conservation of both water quality and quantity for domestic, industrial, agricultural, recreational and ecological uses in South Africa.
Not so much focused on the design aspects of engineering, the Department of Construction Economics and Management concerns itself with business and managerial side of the discipline. That’s illustrated both by the composition of the department’s undergraduate and postgraduate programmes, and its research thrusts. Aiming to produce high-quality research, the department seeks to strike a balance between theoretical studies and applied problem solving, allowing it to upgrade the knowledge and skills of its students as well as construction managers, property consultants and quantity surveyors in industry.

Research Areas
Scholars and research areas have an array of interests, which include:

- Teaching and learning spaces
- Community-based facilities management
- Urban facilities management
- HIV/AIDS interventions and management
- Workplace stress of built environment professionals
- Corruption in the construction industry
- Student experience of an experiential learning approach to entrepreneurship
- Teaching methodologies in construction studies
- Pathways to contracting
- Building contractors’ compliance with building regulations
Assoc Prof Kathy Michell explored the place of facilities management at the levels of both individual buildings and urban precincts.

Construction industry development
Small and medium-sized building and civil engineering (grade 2-6) contractors make up over 92% of the South African construction industry. However, between them (over 6,300 firms) they secure only 13% to 17% of civil engineering and general building contracts offered by the public sector (measured by value). In an ongoing study, Dr Abimbola Windapo and Prof Keith Cattell examined what it would take these grade 2-6 firms to grow into ‘large’ contractors (grades 7-9). They also analysed the barriers that stand in the way of such growth. In one of their most recent reports for the Construction Industry Development Board, Windapo and Cattell identified factors such as management capabilities, the owners’ aspirations, and the role played by the personality and strategic decisions of the owners as being instrumental to the success and growth of construction companies. It emerged from the study also that movement up the ranks is slow, but steady, gradual and organic.

Wellness in construction
Prof Paul Bowen and Prof Keith Cattell, with Prof Peter Edwards of RMIT University in Australia, ran a study of the impact that HIV/AIDS has on the South African construction industry, where one in every four to five workers is said to be infected with the disease. That project included a look at how well staff members are trained in HIV/AIDS education, prevention and treatment; the extent to which employees know their HIV/AIDS status and, should they be HIV+, disclose it to their sexual partners; and stigma in the construction industry, among other issues. The three scholars also joined together for a project on workplace stress of construction professionals in South Africa. They set out to investigate, for example, organisational stressors, the degree of that occupational stress, how that effects professionals’ work and home environments, and how they cope with such stress. In a third study, the three looked into corruption in the construction industry, specifically the experiences of corruption among clients, architects, quantity surveyors, engineers and contractors. They also reviewed the nature of corrupt and fraudulent practices, whether among clients, built environment professionals, government officials, building inspectors or suppliers.
About

Research in the Department of Electrical Engineering covers a range of topics, including neural networks, control and instrumentation, acoustics, design of computer communication protocols, the simulation of electricity markets, image processing and vision systems, power engineering, power electronics, the use of computer control and instrumentation to optimise process performance, the design of wind generators, and broadband communication and wireless networks, among others. The department prides itself on its close working relationship with industry, a partnership that allows the department to remain at the cutting edge of electrical engineering trends and developments worldwide.

Research Areas

- Working with collaborators in the Departments of Electrical Engineering and Computer Science, the UCT Centre of Excellence (CoE) in Broadband Networks and Applications is concerned with the development of the powerful broadband networks that are shared across billions of devices across the globe. Research emphasises industry relevance, and areas of interest include the support for emerging languages in search engines, knowledge management systems, digital libraries and, of local concern, wireless meshed networks for use in rural areas.
- The Control and Instrumentation research group explores the digital control systems that drive everything from car engines and aircraft to robots and washing machines. Staff and students work in areas like time-invariant continuous and digital input-output systems, and the advanced control laws for large interconnected industrial plants.
- The Digital Image Processing laboratory at UCT does research into computer vision, which involves using and developing computer algorithms for extracting information from images and video sequences. Much of the current work is in multi-view 3D reconstructions and subsequent use of these for classification and optical sensing. The group also has interest and capacity in medical imaging and computer tomography, with a strong emphasis on industrial applications.
- Studies in the Networks Systems Research group are related to data communications, telecommunication and data network architectures, wireless networks and satellite communications, essential for innovation in any country. This work is conducted under four main themes – cognitive-radios design for intelligent next-generation wireless networking; monitoring, cooperation and resource coordination in next-generation networks; service protection and availability enhancement in MPLS.
networks; and mobile networking technologies for e-learning.

The Power Engineering group looks at generation transmission and the distribution of electricity, and ways to improve the efficiency of such systems. Research is conducted on three-phase electric power systems – the most common means for the world’s electric grids to transfer power – and the conversion between AC and DC power, as well as the development of specialised power systems.

The Power Networks research group is dedicated to answering some of the fundamental questions in how power networks or power supply systems function. Those are questions related to the stability and reliability of such systems, the costs of interruptions, the size of networks, and planning and design approaches.

The Radar Remote Sensing Group is involved in projects related to radar systems, as well as some that are within the broader area of monitoring and sensing systems. Projects include work on a passive radar system for monitoring air traffic using FM radio broadcast signals; the design of a network of radar sensors that could provide very sensitive monitoring along coastlines; input into the development of the Karoo Array Telescope (KAT) large radio telescope in the Northern Cape; and involvement in the SASAR II (South African SAR II) project, a short wavelength synthetic aperture radar system used to produce high-resolution images of land features.

The Radio Frequency and Microwave Engineering group deals with devices that operate in the radio frequency spectrum, including mobile phones, radios, Wi-Fi and walkie-talkies, and digital satellite television. Among other areas, researchers in the group work in radar and sonar as well as defence electronics, and are beginning to explore the role of software in communications.

Assoc Prof Azeem Khan, Dr Paul Barendse and Dr Moin Hanif, with Part-Time Professor Pragasen Pillay (based at Concordia University, Canada), driven research in the Advanced Machines Energy Systems group.

The Signal Processing and Inverse Problems group, which studies the operations or analysis of signals in either detached or continuous time, works on a range of topics, including communications signal processing, sonar signal processing and digital image processing. Their work can be applied, for example, to the creation of digital maps of the earth’s surface, as well as in X-ray and ultra-sound imaging, and in industrial tomography.

The Soft Computing group works in a discipline associated with in exact solutions for computationally-difficult tasks, a departure from traditional ‘hard computing’ where data and results are assumed to be precise. Projects are concentrated in three areas – fuzzy logic, neural computing and evolutionary computation.

The Software Defined Radio Group focuses on the use of high-speed analogue-to-digital converter chips for the development of radio and radar systems that rely on software rather than hardware. In keeping with this interest, group members have explored the field of reconfigurable computing as applied to, very specifically, its in-house Reconfigurable Hardware Interface for computing and radio platform, aka RHINO.

The Mechatronics and Robotics research group at UCT focuses on research in robotics and mechatronics, working closely with the Control and Instrumentation research group, as well as with researchers in mechanical and biomedical engineering. The group’s efforts are largely concentrated on bio-inspired robotics computational intelligence and neuromorphic engineering, looking at biological systems and the way they work physically functionally and neurologically, with a view to improve conventional design techniques to engineer multi-functional robots.

The Advanced Machines Energy Systems (AMES) group has developed significant expertise in the management of energy systems, grid integration of renewables, and asset management. Their previous research on motor efficiency involved the US Department of Energy, Eskom and the South African National Energy Research Institute (SANERI). The current research areas include: monitoring and fault diagnosis of machines, PM machine design, induction motor efficiency estimation, fuel cell emulators and converters, wind turbine emulation and control, and resonance damping.

Dr Simon Winberg is a lecturer and researcher in the Software Defined Radio Group, which has been working on the Reconfigurable Hardware Interface for computing and radio platform, or RHINO.

Dr Fred Nicolls of the Digital Image Processing group.
About

This dynamic department has grown over the past few years to incorporate not only the activities of the degree programmes in mechanical and electro-mechanical engineering, but also 14 world-class research groups that support a growing number of postgraduate students. Research interests in the department are varied. Groups and individual academics study everything from robotics to project management, performance improvement to structural impact, gas dynamics to fatigue and fracture mechanics. Many researchers have become leaders in their fields, their work and findings hailed – and applied – across the world.

SARChI chairs

The department hosts two chairs under the South African Research Chairs Initiative (SARChI) of the national Department of Science and Technology. The first is the chair in computational mechanics, held by Prof Daya Reddy, director of the Centre for Research in Computational and Applied Mechanics, based in the department. The second chair, in industrial computation fluid dynamics, was awarded in 2012 and was, at the time of publication, yet to be filled.
Research Groups

1. The broad research focus of the Advanced Manufacturing Laboratory is on high-performance machining, polishing technologies, manufacturing process optimisation, intelligent manufacturing systems, laser processing technologies and complex system failure analysis.

2. With extensive experience in flight vehicle simulation and design, the Aeronautics Research group focuses mainly on aerodynamics, flight dynamics, modelling and field-testing. Its work covers everything from the mechanics of paraffins to, in a study conducted with aircraft manufacturer Airbus, the aerodynamics of aircraft flying in close proximity.

3. Medical expertise meets mechanical engineering in the Bioengineering research group, where work on maxillo-facial reconstruction and the development of implants for use in bone tumour surgery has been very successfully applied in surgery.

4. The Blast Impact and Survivability Research Unit (BISRU) aims to build a deeper understanding of blast and impact scenarios using experimental and computational techniques, including theoretical numerical simulation. Its main objectives are to develop techniques that would reduce the risk of injury and save lives, and to understand the mechanics and dynamics of blast and impact loads.

5. In addition to the main research thrust within the Centre for Materials Engineering, which focuses on metal alloy development, this group also looks at the physical, chemical, electrical, mechanical and processing properties of all engineering materials, including polymers, ceramics and composites. Its modern laboratory facilities enable advanced characterisation and mechanical property measurement of a broad range of engineering materials, and the group is so able to support local industrial development by providing assistance with a selection of materials.

6. A major research focus of the Centre for Research in Computational and Applied Mechanics (CERECAM) is on the computational simulation of flow, and deformation and failure in natural processes, engineering components or artefacts.

7. The Composite Materials Laboratory busies itself with research into all aspects of the manufacturing and processing of composite materials. Work here starts with commercially available raw materials and composite materials, which are then processed to generate test specimens for use in non-destructive testing research and blast impact evaluation.

8. The Industrial Computational Fluid Dynamics (CFD) research group looks to develop the next generation of industrial/computer simulation technology. A specific area of interest is multi-physics problems, which requires development of novel algorithms and the use of high-performance computing platforms.

9. The core focus of the Energy Research Centre is on energy and development needs, energy efficiency, modelling of energy systems and climate change mitigation.

10. The Education Research group looks to understand the student learning experience with the objective of increasing the number of engineers that graduate from the undergraduate and postgraduate programmes offered in the department.

11. The applied and scholarly study of management methodology and technique is the main research thread within the Engineering Management research group.

12. The group focuses its attention primarily on the manufacturing, engineering, petrochemical and consulting sectors.

13. The research taking place in the Non-Destructive Evaluation laboratory aims to augment the capability of industry to inspect structures non-destructively, while also enhancing its means to establish the structural integrity of components through sensor monitoring techniques.

14. Currently, the two main research areas of the Robotics Research Laboratory are the development of an urban search and rescue robot platform, and a remotely operated underwater robot.

15. Research into alternative fuels are the order of the day at the Sasol Advanced Fuels Research Laboratory. This group seeks to gain a fundamental understanding of the behaviour of fuels in fuel systems and internal combustion engines.

16. Dr George Vicatos (middle), of the bioengineering research group, worked with MSc student James Boonzaier (right) and maxillo-facial oral surgeon Dr Rushdi Hendricks (left) on a number of groundbreaking surgeries repairing entire cleft palates. The work earned the team Popular Mechanics’ award for South Africa’s Inventor of the Year in 2012.
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