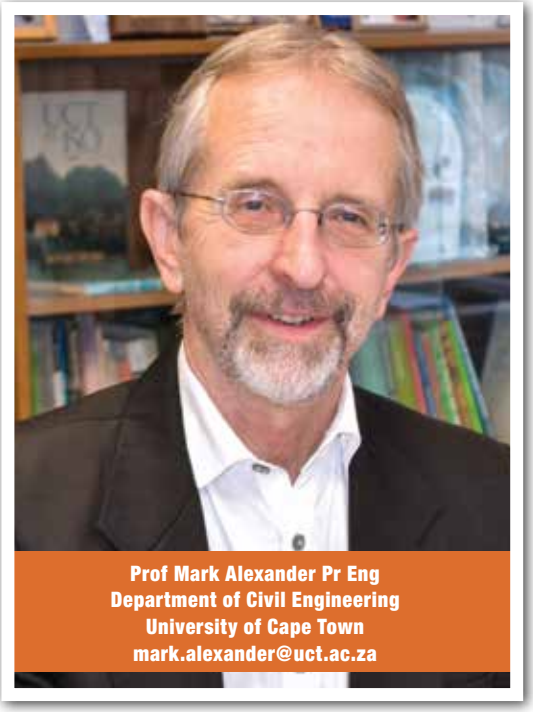

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Musings of a professor

Towards the end of 2015 Prof Mark Alexander of UCT delivered an unusual Snape Memorial Lecture, in which he shared personal anecdotes, paid generous tribute to his mentors, and offered some reflections on the industry. We herewith bring you the shortened 'musings' of this kind and highly respected engineer.

INTRODUCTION

It is a great pleasure and honour for me to deliver the 62nd Snape Memorial Lecture. This will be a Snape Lecture with a difference, though, as I'm going to take a more personal and reflective line, sketching some of my own road as a civil engineer over the last four and a half decades, and drawing some lessons from that for the profession and the industry going forward. I am doing this, firstly, because I am close to retirement and have a lot to share, and secondly, because personal reflections are often very useful lenses in which to see reality and convey it to others. I hope you will not find the personal focus self-laudatory – there is absolutely no intention of that.

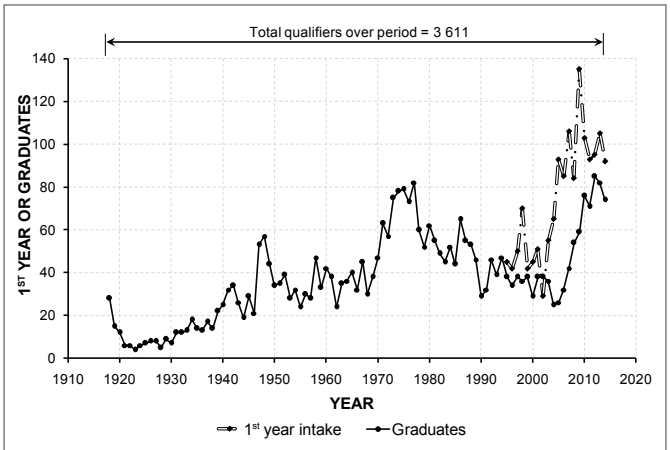


Figure 1: Total number of UCT civil engineering graduates between 1918 and 2015

Firstly, I would like to pay tribute to Professor Snape. Looking at his life I find similarities with mine in that he began his career as a municipal engineer, he worked on tunnels, and he was involved in outfall sewers. These are all activities in which I have been involved.

Prof Snape furthermore believed that a university teacher of engineering gained vicarious satisfaction through the achievements of his students in practice, and with that he was content. To which I say, "Indeed!"

Snape moulded and formed the University of Cape Town's (UCT) civil engineering department, leaving an amazing legacy – from 1918 to 2015 UCT produced 3 611 civil engineering graduates (see Figure 1), and it continues to be one of the foremost suppliers of quality engineering graduates. The peaks and dips shown in Figure 1 are understandably linked to the history of the time.

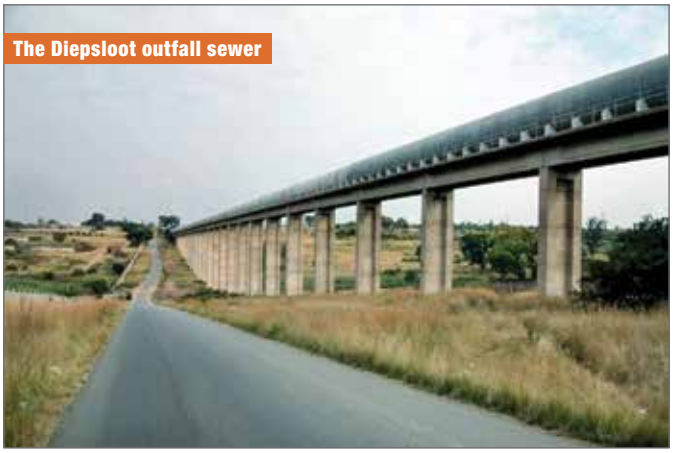
MY JOURNEY INTO CIVIL ENGINEERING

Johannesburg

My own journey in civil engineering started in Johannesburg – that great city of gold where I was born and brought up. It's still a city that excites me, and that has a very important role to play in the future of our country and of our continent.

It was while I was at school (King Edward VII School) that I began to have contact with the civil engineering industry. This was largely through my father who worked for The Roberts Construction Co. Roberts Construction merged with Murray and Stewart in the 1970s to become Murray and Roberts, which is very much a force in civil engineering today.

Civil construction was at a peak all over the country during those years, and we were doing exciting things. We were building Africa's tallest building at only R45 million (the Carlton Centre and the Carlton Hotel). We were building our urban freeways. We were building the majestic Gariep Dam, which is an amazing structure. This was an exciting time for civil engineers and for civil engineering students.



The Diepsloot outfall sewer

My father used to do the pay run (by ordinary car!) on Friday afternoons, and would often take me with him to the mines on the West Rand. Because of that I began to see construction sites, and became interested in how civil engineering and construction worked.

University of the Witwatersrand

I actually decided to switch from electrical engineering – it was my first choice at the time – to civil engineering just before the beginning of my first year, because I had been working in the 'exciting' structural steel detailing office of Roberts Construction!

I enrolled at the University of the Witwatersrand (Wits) in 1969 under the Johannesburg City Council student bursary scheme. Five hundred rand per annum was paid in ten instalments of R50 each, plus fees, and that's all I needed. This great bursary scheme ensured a constant stream of bright, young engineers to the public sphere.

We had wonderful professors at Wits – Profs Ockleston (structures), Jere Jennings (geotechnical), Des Midgley (water) and Geoff Blight (materials and geotechnical) – and we were very privileged to study and work under them.

Those were also turbulent times. We've had a turbulent history in our country and it looks like we're still going to have such for a while to come. Back then, we as students were also engaged in protests. We also marched against the authorities. We also brought up the injustices of our time and were counted among the group of people who sometimes had to face the riot police on the university campus. Today we have other issues, but these things happened then as well.

Mark's graduating civil engineering class of 1972 – Mark is in the second row, fourth from the right (there were 65 graduates from a starting class of 120); SAICE's current president, Dr Chris Herold, can be seen in the third row, fifth from the right

Civil construction was at a peak all over the country during those years, and we were doing exciting things. We were building Africa's tallest building at only R45 million (the Carlton Centre and the Carlton Hotel). We were building our urban freeways. We were building the majestic Gariep Dam, which is an amazing structure. This was an exciting time for civil engineers and for civil engineering students.

So at the end of all that came graduation in 1972. I graduated and was awarded the Roberts Construction prize as the top student, which was a bit of an irony, since I had applied for the Roberts Construction bursary in my first year, but was turned down!

EARLY ENGINEERING EXPERIENCE AND TRAINING

I moved into 'real' engineering in 1973 when I started working at the Civic Centre in Braamfontein, Johannesburg, in the then City Engineer's Department.

In that first job I mainly designed major outfall sewers and the associated hydraulic structures, which gave me a first taste of real engineering.

We as young engineers all had to undergo the 'baptism' in the Klipspruit Outfall Sewer (KOS), organised for us by the Design Branch. The KOS runs through the middle of Soweto, right next to the Klip River. We were taken out there at four o'clock in the morning and sent down the manholes to see what the sewer looked like in the low-flow periods. That was the way they reckoned we would learn about it the best. What they didn't tell us was that the night-spoil trucks were discharging in the manholes slightly further up the sewer at the same time. So you can imagine that, as we went down different manholes, heads popped up again at those manholes as this load went past. That was the baptism of the Klipspruit Outfall.

We had a legend of a City Engineer at the time – Eric Hall. When asked once, "What would you have been if you hadn't had been a civil engineer?" he replied, "I would have been ashamed!" A great man, and he had great deputies – Val Bolitho, Ralph Reynolds, Tony Dollery, Alec Hay (who was my boss in the Design Branch), and the like.

These engineers were of a high calibre and of high integrity. They needed to be the very best in view of the enormous amounts of public money they handled and the huge decisions they had to take. The City Engineer was held in very high esteem.

I went back to Wits in 1974 to do a Master's, returning to the City Council to work on major tunnel and bridge contracts for some years, and finally ended up in the Water Branch as a water planning engineer.

The Diepsloot outfall sewer was carried in sections above ground on bridges, each about 1 km long. They were designed by Alec Hay and constructed by Murray and Roberts, and comprised 30-ton pipes with a 2.9 m internal diameter. After a few years, cracks developed in the pipe inverts and they began to leak. The City then approached Prof Geoff Blight for assistance in solving this problem. He said, "Sure, can I use some of your engineers?" So he put me and other young engineers on that pipe bridge for sometimes whole days and nights. We would get out there at two in the morning – freezing in winter walking across the top of those pipes (health and safety was not deemed much of an issue!) – and we would take strain and temperature readings through a whole cycle (there was no such thing as automatic recording in those days, you did it all manually). Eventually we

decided that the reason for the leak was that the thick walls of these pipes were restraining the stresses and strains due to the thermal gradients in such a way that they were building up significant tensile stresses – this was low-cycle thermal fatigue. This was unusual, because normally pipes come in fairly thin walls and the temperature is equalised throughout the pipe wall. In this case, there was a maximum temperature differential of about 20 degrees across the pipe wall, this differential varying throughout the day.

What we did was to cover the pipes with aluminium cladding and a thermal blanket. I spent many days and nights on that project and it led to my first paper as a municipal engineer – *Cracking on the exposed concrete pipeline of the Diepsloot outfall sewer, Johannesburg: Field investigations and interpretations*.

I also worked on the Bushkoppies outfall sewer. This ran right under Soweto and Pimville. While we were working on that tunnel, June 1976 happened. We were instructed to pack up the site, secure our explosives, and not return until we were told to do so, which was a couple of weeks later. Hector Pieterson and June 1976 changed our way of thinking. It changed everything about the world we live in.

TWO MAJOR EVENTS

In 1978 and 1979 respectively two seminal events occurred in my life – I got married to Lyn, my beautiful wife, and I went back to Wits as a lecturer, at the encouragement of Prof Blight.

ACADEMIA AS A CAREER

I have never regretted moving to academia as a career. I worked at Wits until 1992 as a lecturer in construction materials, alongside the next generation of outstanding professors – Alan Kemp, David Stevenson, and of course Geoff Blight.

Prof Geoff Blight was such a good mentor. He was my head of department and supervisor, he took me through my Master's and Doctoral degrees (I obtained the latter in 1986), and gave me a great legacy to live with.

I published my first international paper in the RILEM journal, *Materials and Structures*, during this time. This was the consequence of a spell of work at the Technion – Israel Institute of Technology – and the National Building Research Institute in Israel.

I also had the opportunity to get involved in some consulting in my own right. One such project was the Jupiter cement silos in Johannesburg – you can see them off the N3 if you are driving through the Geldenhuys Interchange. At the time, Ground Engineering (GEL) were putting in the piles for this, and Ross Parry-Davies came to me as a young, completely greenhorn engineer and academic, and said: "There are some problems with the concrete, can you help us?" Well, I should have said no, but I said yes. So he threw me into this problem. What was happening was that they had drilled into these piles, and after going down about 30 m, found that at the bottom there were large honeycombed sections.

We eventually came to the conclusion that this was because of the infiltration of groundwater during concreting – they

From left: Pilate Moyo, Mark Alexander and Hans Beushausen of CoMSIRU

hadn't controlled it properly. We thus decided to grout them up, but not after a severe grilling about my conclusions by Ken Witthaus of WLPU. This experience was an absolute baptism of fire, but in the end we came through and it was fixed. That was a great learning experience for me.

University of Cape Town

I moved to UCT's lovely campus in 1992. My inaugural lecture was titled *From nanometres to gigapascals – cementing the future*. By this stage I had firmly established concrete and cement as my research area. At UCT, I worked with academic heavyweights such as Tony Kilner and Mike de Kock. Anything that I ever learned that was of any value about teaching or education, I learned from Mike.

Over the years at UCT, I served as Head of Department, Deputy Dean, Acting Dean, Assistant Dean, and then finally moved back to a research-intensive mode in 2008.

This was also the time of democratic transition, which is still of course in progress. We were thrown into all the challenges of engineering education associated with rapid changes in the demographics of classes. And we marvelled at how under-privileged students coped with the difficulties posed by both the civil engineering course and a multicultural campus. The many success stories from these students help to keep us going as academics.

Intensified research trajectory

I went into an intensified research trajectory from about 2008, with the support of the National Research Foundation, the Cement & Concrete Institute (now The Concrete Institute), PPC, Lafarge, AfriSam, Natal Portland Cement, Aveng Grinaker-LTA, Haw & Inglis, Sika, Eskom, THRIP and the Water Research Commission, who have all contributed towards funding the research over the years.

Early supporters

One of those who supported me in my early research work towards my PhD was Dr Derek Davis, the Director of the Portland Cement Institute (PCI, now The Concrete Institute) from 1970 to 1984. It was through his financial assistance that I got to my first international conference. Afterwards, when I had my PhD, we worked together for some years on concrete aggregates. Together we published a series of monographs that are still in use today in the industry around the country.

There have been others who have taken an interest in me. One is Sid Mindess from the University of British Columbia. He has been a great colleague and mentor over the years (he was also the external examiner for my PhD!).

Then there was Arnon Bentur from the Technion in Israel, who got me to work at their lab. We've had many fruitful collaborations and he was really my introduction to RILEM.

I have been very privileged to work with people like these (more recently also with Yunus Ballim), but the list is just too long to include everyone here. Without these mentors and colleagues I'm certain I wouldn't have made the progress that I have.

CoMSIRU

That brings me to the unit called CoMSIRU (Concrete Materials and Structural Integrity Research Unit) at the University of Cape Town. I work with two great colleagues – Pilate Moyo and Hans

Beushausen. I was trundling along through the 1990s and early 2000s when these two guys joined, and they just transformed everything. With their energy and youthful enthusiasm, they have hugely contributed to CoMSIRU's growth in so many ways, and I owe them a debt of gratitude.

Involvement with RILEM

RILEM (Réunion Internationale des Laboratoires et Experts des Matériaux, systèmes de construction et ouvrages, or the International Union of Laboratories and Experts in Construction Materials, Systems and Structures) is an international organisation that exists to promote scientific cooperation, stimulate new directions of research, and promote sustainable and safe construction.

RILEM grew out of the ruins of the Second World War – Europe lay shattered, its cities were destroyed – when a group of forward-thinking laboratory directors decided they needed to do something about this. In 1947 they met in Paris under the chairmanship of Robert L'Hermite, the French National Laboratory Director. Sixteen countries, including Argentina and the USA, were present. They decided to put together this organisation to improve the technology of construction materials and structural engineering to help rebuild the cities of Europe, and in fact the whole world. From that humble beginning of sixteen directors and sixteen countries, RILEM has now expanded to 63 countries and 102 institutes, with its headquarters in Paris. RILEM has more than 1 200 expert members (at least 15 from South Africa).

RILEM played a seminal role in the development of my research and international career. It allowed me to rub shoulders with people who were writing the books and papers of which you read in journals; I could sit around tables with them and debate with them. I chaired two of RILEM's technical committees, served on the Bureau and Coordinating Committee, and much to my surprise, was elected International President for the period 2012–2015, which was a huge honour for me, being the first president from Africa.

SOME REFLECTIONS

I would like to briefly share some of my reflections on the profession and the challenges that we face today.

Civil engineering and the challenges we face

The ICE's definition of a civil engineer says, "Civil engineering is the practice of improving and maintaining the built environment to enhance the quality of life for present and future generations". If we pick out the key words *built environment*, *quality of life* and *generations*, we see they are about people and the earth we live on – civil engineering is primarily about what we do with and for people.

When we talk about the challenges we face in our profession, we have to go back to the socio-politico-economic context in which engineering is played out in the modern world.

What is our social, political and economic context? In large measure it is a neo-capitalist, market-driven economy – that's what we chose in 1994 and that's what we live with today. The drivers of this system are primarily the shareholders, the different companies (who wish to generate maximum profit) and the markets. In many ways, it is exploitation of our resources. It is not really focused primarily on communities and people, even though we think it is sometimes. It's not even focused on the profession itself. Of course this has many ramifications; not least are legal ramifications, as today we find ourselves enmeshed, in many cases, in a mass of litigation because of this route.

Furthermore, we've moved to democracy in South Africa. This has meant the need for consensus, transparency and accountability. That is a good thing. It does demand of us, however, that we spend inordinate amounts of time working through these issues, which can on occasions become very tedious and counterproductive.

The concerns that I am expressing here briefly will only really change when we have wider societal change. I think we will go through another societal shift when we maybe move to a more socially conscious model. There is a need for change in our society's ethics, and ultimately our profession's ethics.

The state of engineering expertise and engagement

I think this is still strong overall, but it is also severely lacking in some sectors, not least in the public sector, whether at national, provincial or local level. Of course there are notable exceptions.

You only have to witness the recent closure of some school buildings in the Western Cape because of structural inadequacies to realise that we do have a lack of capacity. Clearly there is a problem somewhere.

Because of our training, we as engineers are competent to solve these problems – we think logically and rationally, and we put solutions in place. It's dealing with people, dealing with communities, and dealing with committees (i.e. engaging with the public sector) that are the real challenges in engineering.

Manglin Pillay, SAICE's Chief Executive Officer, has this to say in his CEO piece in the August 2014 edition of *Civil Engineering*: "CESA … reported in 2010 that there was a migration of engineers from the public sector to the private sector, mainly into consulting engineering. From 1990 to 2010 the ratio of government technical professionals to population declined from 1:2 700 to 1:27 000, while the number of employees in consulting increased from 12 000 to 21 000. … As a result, the public sector has become an uninformed and incompetent client, and this is the main reason for inadequate service delivery and deterioration in public engineering infrastructure." Manglin also makes the point that, since 80% of civil engineering infrastructure spend inside the country comes from the government at different levels, politics and the public sector influence professional civil engineers at every local and district municipality, provincial department and national department associated with infrastructure. SAICE has of course done a lot towards better understanding of the role of engineers through initiatives such as Civilution.

As engineers we sometimes feel somewhat uncomfortable in the public sphere, as we are conservative by nature. Why? Because if something goes wrong with the things we do, the consequences are normally horrendous. There is often loss of life and always huge loss of capital. We are conservative by nature and our training also makes us so. To enter the public sphere, we in fact need a different mind-set altogether.

I've always thought it interesting to trace the differences between China and their National Economic Development Plan, and South Africa and India who, to a large degree, have followed a very different path – due to what I would call the democratic

imperative. The consequences have been quite severe, due to a lack of understanding of the role of engineers and technology in developing a country, a lack of investing in education of the right kind and at the right scale at primary, secondary and tertiary level, and the failure to invest in developing a generation of new academics. We somehow thought they would just appear from nowhere, but they didn't; now we're realising that we should have invested in a new generation of academics way back.

But let's not downplay the real brilliance of our engineers – just look at things like the Fulton Awards, the SAICE Awards for outstanding civil engineering achievements, and the Southern African Institute of Steel Construction's Awards, among others. These inspiring and impressive winning projects display what the profession is so good at. Let us acknowledge that.

A note of caution here from Robin Carlisle (as reported by the *Cape Times* in October 2014) who had this to say about engineers: "The enquiring mind of engineers – 'how can I do it better, faster, safer' – has enriched human life on so many levels. Cities cannot come about without them, as they create the necessary urban order … This speaks to me very profoundly about an industry … that I think has shrunk in on itself to some degree … that does not see itself as Brunel saw it, i.e. today's engineers by and large do the bidding of the visionaries, rather than being the visionaries themselves. Engineers might not be ideologically driven, but their work is influenced by the ideologies around them. If those forces push them in the wrong directions … [they need to] be held to account."

We could debate that issue, of course. We don't live in the age of Brunel. Brunel was not an academically-trained engineer, but he had an innate sense of design and knew how to do things – he succeeded by trial and error. Sometimes they got things very wrong, and then got them right again – which we no longer have the liberty or luxury of doing. In engineering today, we have to get it right first time. So there are differences, but we can still consider some of those contrasts.

Engineers and the engineering process

I think we're losing control of the process of engineering, particularly in consulting. We have this issue of bidding for engineering work, based usually on lowest cost. This is corrosive. Quoting John Glenn, the American astronaut, on being asked how he felt at the moment of lift-off, he said: "I feel exactly how you would feel if you are getting ready to launch and knew you were sitting on top of two million parts – all built by the lowest bidder on a government contract."

The tendering process applied to professional services, such as consulting engineering, is like asking a group of heart surgeons to give the lowest price for a cardiac by-pass, whereas experience and expertise should be the paramount criteria when engaging an engineer.

The growth in turnkey projects has also led to the 'commodification' of engineering expertise. Engineers are now seen as commodities – our expertise can just be bought off the shelf, and one of these days our expertise can be substituted by using

a computer program. That is another serious issue we need to grapple with.

I think that we've lost control of the companies and enterprises in which we work. Often the top jobs in engineering companies are being taken over by the finance people whose staff are not engineers themselves. I am not trying to make out they're not important – I value them – but their training does not fit the bigger questions and the long-term issues that concern engineers and their clients.

To illustrate the difference between engineers and financiers, I quote from *Time* magazine of 25 September 2014, from an article titled *Mary Barra's bumpy ride at the wheel of GM*. Mary was coming in as the new CEO of General Motors (GM) in America after the ignition switch disaster that caused many deaths from malfunctioning GM cars. The article was a commentary on the difference between engineers and financiers: that Mary was an engineer rather than a financier (financiers had been at the helm of that organisation for the last few generations). The article went on to say that such engineers are "way more grounded in the reality of what goes on as opposed to the financial folks who float at the top and delegate everything."

As engineers we are in this for the long haul, not for the kick-back – that's the big difference. I appreciate the complex nature of relationships between the different sectors involved in an engineering project – owners, designers, contractors, architects, quantity surveyors and ultimately the funders and decision-makers – but engineers have been reduced to mere service providers in this industry, to the ultimate detriment of not just the profession, but society itself. We need to realise that we are caretakers of the profession for the next generation. We don't own the profession. It's not the place to maximise the benefits for our own advantage. We need to understand our role in terms of the big picture and the long-term scenario, and not the short-term gains.

Education of engineers

The schools have let us down badly. Universities are expected to fix twelve years of poor schooling, and the reality is, we can't. Twelve years of deficient schooling cannot be made up in four years of engineering at university when everything is in the melting pot and pressure cooker at the same time – it just doesn't happen.

However, we have to work with these young people. We have to give them a chance. The poor schooling system is not their fault. The curriculum is always under pressure; the students are always under pressure; when they get out of university they are under pressure. The graduates produced today from an institution like UCT are only what they've always been – bright, capable young people. They have the ability to develop into competent and useful engineers, given the right environment in which to flourish. They're not fully-fledged engineers yet – they cannot be. Unfortunately the ability and commitment of the engineering companies to mentor and develop these young engineers have steadily eroded, often due to the issues I have dealt with above, and this is beginning to have severe consequences. In addition we have the requirements of ECSA, which we didn't have in the same way when I was at university.

Then there is also the move to a research environment at universities. Nowadays promotion at university depends largely on one's research profile, and this has not favoured the development of teaching-rich positions, which is what we really need. So we need to look more at appointments on a part-time basis or at retired professionals who can bring in the needed perspective and experience to fill out the teaching team.

Having in a way criticised the over-focus on research, I now make a punt for research. I think research has a critical role to play in our profession and industry. Let me go back to my UCT inaugural lecture of 22 years ago. What I said then is still strangely relevant 22 years later. First of all, the cost of research at university is a fraction of the cost in a commercial setting. Secondly, research students are trained for the industry at a high level. This provides stimulation for both students and staff, leads to an interdisciplinary approach between universities and industry, generates new knowledge, and promotes innovation for the industry. We are a chronically under-generated, non-innovative industry, and that is because we often neglect to sponsor the research community. As a dedicated researcher I want to appeal to our engineering companies for a change in attitude regarding the role and importance of research.

CONCLUSION

In closing, I quote from TS Eliot's *Little Gidding*: "We shall not cease from exploration. And the end of all our exploring will be to arrive where we started and know the place for the first time."

It's been a very enriching experience. □

Having in a way criticised the over-focus on research, I now make a punt for research. I think research has a critical role to play in our profession and industry. Let me go back to my UCT inaugural lecture of 22 years ago. What I said then is still strangely relevant 22 years later. First of all, the cost of research at university is a fraction of the cost in a commercial setting. Secondly, research students are trained for the industry at a high level. This provides stimulation for both students and staff, leads to an interdisciplinary approach between universities and industry, generates new knowledge, and promotes innovation for the industry. We are a chronically under-generated, non-innovative industry, and that is because we often neglect to sponsor the research community. As a dedicated researcher I want to appeal to our engineering companies for a change in attitude regarding the role and importance of research.