INTRODUCTION TO PAPERS ON GROUND ENGINEERING

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Do we need to be able to maintain the UK's transport infrastructure?

Do we want to be able to adapt the UK's flood defences and other infrastructure to meet the climate change challenge?

Do we need to be able to dispose of our nuclear waste safely underground?

Do we want to improve the energy efficiency of the foundation systems for offshore wind farms?

The answer to all these questions is, of course, yes. Skilled ground engineering professionals are essential for all these activities, and for many others which the nation relies on to construct and maintain our built environment and infrastructure. However ground engineering professionals need post graduate degrees that neither they nor the industry can afford.

At the meeting of the Parliamentary and Scientific Committee (P&SC) on 28th February 2012 four presentations were given concerning the substantial contribution of ground engineering to the UK's infrastructure and the significant shortage of locally-based ground engineers in the UK which, despite the recent downturn in construction, is likely to get worse.

These papers include the presentations from that meeting. The concluding paper considers in more detail the nature and causes of the skills shortage in ground engineering, describes a recent initiative by the Ground Forum[1] to improve coordination between industry and academia and presents possible solutions to the current skills shortage.

WHAT IS GROUND ENGINEERING?

Ground engineering is defined by the Ground Forum as "An understanding of geological structures, materials and processes, combined with the systematic application of investigative, scientific and mathematical techniques to produce practical solutions to ground-related problems for the benefit of society".

All buildings and civil engineering structures are supported by the ground or are constructed underground so it follows that ground engineering is essential to the built environment, including all forms of infrastructure. Ground engineers provide advice, undertake design and supervise construction in a range of activities that involve the ground.

These include foundations (for buildings, bridges, wind farms, power stations, etc); retaining walls; tunnels and pipejacks; earthworks, including embankments and cuttings for roads and railways; port and harbour developments; and underground storage facilities for gas and nuclear waste. Ground engineers also undertake design and maintenance of reservoirs and landfill sites.

Even when no buildings or rigid structures are involved ground engineering plays an important role: coastal defences, flood control embankments, remediation of contaminated land, landslide mitigation, renewable energy (ground source heat pumps and geothermal), and recycling of materials to protect natural resources – all require people with an understanding of both geology and engineering.

WHAT IS A GROUND ENGINEER?

A ground engineer typically has a first degree (usually civil engineering or geology/applied geology), followed by a second degree (MSc or PhD) in soil mechanics, geotechnical engineering, engineering geology or a similar ground-related subject. (Civil engineers require knowledge of the ground; and geologists require knowledge of engineering. This is usually acquired in a one year MSc).

However ground engineers are in short supply. Job titles in the sector have been on the official Shortage Occupation List since 2004, and remain on it despite the increased rigour which the Government now applies to the regular reviews of the list, most recently in 2011. This enables the UK to rely on migrant professionals from outside the EU to meet the nation's needs for ground engineers and was described by one major employer as "our life saver". The Shortage Occupation List provides a short to medium term solution to the skills shortage but does not provide a sustainable long-term solution; 'home grown' ground engineers are essential.

1 The Ground Forum brings together Learned Societies and Trade Associations representing construction-related ground engineering disciplines; see www.ground-forum.org.uk for list of member organisations. The Learned Societies undertake the dissemination of information and oversee professional qualifications; while Trade Associations represent the commercial interests of consultants, contractors, and manufacturers in the sector. The Ground Forum is therefore a single voice which draws together construction-related ground engineering interests of both companies and individuals.

GROUND ENGINEERING – WHY IT MATTERS

VALUE OF GROUND ENGINEERING

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We know more about the solar system than we do about the ground beneath our feet. This was the view of Leonardo da Vinci in the 15th Century and remains valid today. Our knowledge of the ground has increased significantly, especially on the macro scale, but at a scale relevant to the construction industry we still struggle to understand what is there and how it will affect the structures we build. This can lead to contract delays, increased construction costs, damage to property and potentially failure during and post construction. To minimise the risks we need engineers and geologists who have appropriate skills and the tools to be able to investigate the ground and to work with nature to design, construct and maintain the built environment.

Everything built is either on, in or with ground. Buildings and bridges are supported by the ground using foundations. The amount of the ground needed to support a structure depends on the characteristics and use of the structure and the properties of the ground. Ground engineers design systems that transfer the weight of a structure and all that it contains, and the external forces acting on the structure, such as wind and snow loading, to the ground. Most structures are built of manufactured materials such as bricks, concrete and steel which are much stronger than the ground on which they are built. This means the load of the structure has to be spread onto or into the ground using foundations. Therefore the volume of ground affected by the structure can be considerable. The spreading of the load can be compared to the concept of using snowshoes to stand on snow; and the volume affected is similar to the concept of the iceberg in that much of the support to a structure is hidden beneath the surface. The support of the ground not only has to ensure that the structure remains stable it also has to limit the movement or settlement of the building. All buildings settle. The classic case of differential settlement is the Leaning Tower of Pisa but with most structures this would be unacceptable. The foundation has to control that settlement so that the building functions as designed.

Ground engineers also build structures, such as tunnels, pipelines, basements and retaining walls, in the ground. Most of the services, including water, gas, electricity, communication and sewers, are installed in the ground. The difference between these structures and foundations is that the ground imposes the load on these structures; foundations impose the load on the ground. However, many of the principles that apply to foundations also apply to these embedded structures. In both cases the ground engineer has to work with the ground that exists which requires understanding the formation of the ground through extensive studies of the literature, how it impacts on the behaviour of structures and an interpretation of maps, plans and in situ investigations to establish what is actually there.

Ground can be natural, formed by geological processes, or manmade. In the latter case this includes archaeological deposits especially in towns and cities as well as the soil and rock used to build structures such as embankments, landscaping and earth dams. These manmade structures involve considerable quantities of ground being excavated, transported and placed in an engineering manner. The largest structures in the world, earth dams, are built of soil and rock; they have been used for centuries as a construction material. Embankments and excavations form part of the surface transport networks including roads, rail and canals; are used to develop level sites; and to build flood embankments and water retaining structures.

The design of all of these structures depends on detailed knowledge of the ground conditions established from investigations undertaken by competent professionals skilled in assessing the spatial variability of the ground and how it will perform during and post construction. These are supplemented and informed by geological and topographical maps, borehole records, utility plans, mining and quarrying records, surface and sub surface surveys.

Thus understanding the ground is critical to the success of the construction industry and ground is a key component of the built environment. The built environment is broadly split into domestic property; social infrastructure such as schools, hospitals, retail outlets, leisure facilities and other community structures; and economic infrastructure such as utility, communication and transport networks.

Infrastructure UK, created in 2009, focuses on the economic infrastructure, which allows society to function as it facilitates the movement of materials, products, energy, knowledge and people. These infrastructure networks are complex interdependent systems. For example, according to the Treasury, the road network comprises forty types of roads and includes a variety of structures such as bridges, culverts, walls and overhead gantries; communications equipment; and land. The highway network, a subset of the road network, has a replacement value of £77.5B, and there are some 11250 km of highways with 17,000 structures including 8,800 bridges. Transport and utility networks extend to about 1.41m kilometres and include hubs such as railway stations (2,770), ports (60) and airports (120) and major assets such as power stations, treatment plants (11,500) and reservoirs (1,090). In addition to these infrastructure networks that connect and service communities there is also the infrastructure that supports agriculture which includes some 400,000 ponds a source of water for irrigation.

The Treasury splits assets into residential buildings, (valued at £211B), commercial, industrial and other buildings (£245B) and civil engineering works (£780B). Civil engineering works are primarily the economic infrastructure. The infrastructure is continually being adapted to meet the needs of society and make use of emerging technology. Modern infrastructure can be traced back over 2000 years. The road network can be traced back over 2000 years; the rail network was started over 150 years ago; modern utilities were first laid down over 100 years ago. The UK has a mature infrastructure that has to be continually maintained, repaired, adapted and replaced.

Replacement cost is more useful than historic value because much of the UK Infrastructure is either nearing the end of its life and will have to be replaced or it has to be adapted to meet the needs of society, cope with emerging technology, deal with climate change or conform to new regulations. The economic life of components within the infrastructure network varies from less than seven years to more than one hundred years but replacement of any one component can result in replacement of components that have not reached the end of their economic life. This is routine. Climate change and the move to a low carbon economy are introducing new concerns. Climate change is a particular issue for ground engineers since the impact of rising ground water levels below certain cities, rising sea levels and the increase in extreme events will impact on the stability of foundations, slopes, embankments and other ground related structures. Some 40% of the built environment will have to be adapted for climate change over the next forty years.

The value of the ground works is unknown but given the amount of excavation for tunnels, cuttings and embankments, and the scale of the network the ground work contributes between 30% and 40% of the total value of the economic infrastructure; that is between £234B and £312B. This excludes the cost of the materials such as concrete and steel that are used to build the structures such as foundations within the ground.

While the focus is on the importance of ground engineering in construction, ground engineers are also engaged in the extraction of minerals. The average American needs some 1,500 tonnes of minerals during their life. This is made up of about 42% of energy (gas, oil and coal), 9% of various economic minerals (eg iron, limestone for cement and bauxite for aluminium) and 49% stone, sand and gravel. Over 50% of the minerals extracted from the ground are used in the construction industry with the majority of those used either to make concrete (25%) or as fill (75%) to form structures such as road, rail and flood embankments and landscaping. Water, ground and fossil fuels in that order comprise the majority of materials society uses to function.

Understanding what is beneath our feet and how it behaves is challenging but is fundamentally important because of the value of the ground in providing energy, construction and manufacturing resources and underpinning the built environment. The most important technical risk in construction is the uncertainty of the ground. The most important risk in ground engineering is the current shortage of qualified ground engineers.

WHAT ARE THE BENEFITS OF GROUND ENGINEERING TO SOCIETY AND GOVERNMENT?

Rodney Chartres
Past Chair, Ground Forum

HISTORICAL BACKGROUND

Let us take as an example, travel and communication. Our early ancestors would follow animal trails which developed into tracks, then turnpikes with the advent of horse transport. These were then metalled in the early part of the last century to take motorised traffic. Historically, if there was an event such as a landslide or other geohazard encountered, the track would be re-routed. This would have been at negligible cost with little effect on the surroundings.

The development of canals and railways led to these linear routes following the best alignment through a valley. This has led to modern roads having little choice logistically other than following a more difficult and complex route from the ground engineering perspective. As the pressure on land has increased, economic and social factors mostly dictate linear infrastructure routes.

It was in 1959 that the first section of the M1 motorway was opened between London and Birmingham. The ground engineers had to deal with the geological conditions along this alignment with little deviation being possible.

The same applies to almost all other ground engineered projects today. A topical example in the UK is the route of the High Speed Railway 2 through the Chiltern Hills. The Secretary of State has announced the preferred alignment recently that will entail the design and construction of increased lengths in tunnel rather than cutting a swathe through this environmentally sensitive landscape. This poses some interesting ground engineering problems that will need to be resolved.

PLACE IN TODAY'S SOCIETY

Risk and failure are becoming more and more unacceptable to modern society. These concepts come at a price.

Perhaps the turning point and the awakening of such an approach in the United Kingdom to geohazards was the tragic consequences of the failure of the coal spoil tips above Aberfan, South Wales, in October 1966 with the deaths of 144 people, including 119 children at the local school.

Following this tragedy, Government made available the necessary funding for all spoil tips throughout the UK to be investigated by ground engineers. The tips that were found to be unstable were either removed or made safe with continuing monitoring.

FINANCIAL BENEFIT AND COST TO UK PLC

Ground engineering is to be found everywhere beneath our feet and is for the most part taken for granted.

However, the prospect of a new development or infrastructure project in recent years has often created a public outcry from mostly "Nimby" protestors.

The social and economic benefits to society brought by an improved infrastructure and built environment are often overlooked.

The impression of complete desecration of the countryside by large construction machinery and occasional deposition of mud on surrounding roads is a fashionable image.

How many of us today complain about the M25 or that the Channel Tunnel and its high speed railway link to London were constructed? The role of the ground engineer is to minimise the impact of such projects on the environment whilst delivering a safe and cost effective solution.

The Treasury and other financial models indicate that the construction sector makes up around ten per cent of the United Kingdom's Gross Domestic Product.

It is also recognised that between a quarter and a third of a project's construction costs are to be found beneath the ground. This equates to about 2-3% of GDP. This figure excludes open cast mining, sand and gravel abstraction and the winning of other minerals together with the challenges of the waste disposal and recycling sectors that are heavily dependent on good ground engineering advice. The true value of ground engineering to the UK economy has not been assessed accurately.

In addition, it should be noted that the halting of a major construction project has an immediate effect on the local and national economies.

The UK has a tradition of offering an innovative and quality engineering service worldwide. The positive contribution made to our overseas trade balance has been significant in the last thirty years. However, the competition from the Chinese ground engineering community is increasing, particularly in the field of minerals extraction and its associated infrastructure in sub-Saharan Africa and South America.

Can UK plc afford to sit by and watch as our international competitors invest in educating ground engineers to the highest standards at their universities and train professional staff to be in direct competition?

THE PRESENT AND THE FUTURE

The challenges being met today by ground engineers are increasingly more complex.

Good ground engineering is dependent on the need for accurate geological data that will form the basis of any ground model. We should not forget the vital role of the British Geological Survey (BGS). It is not only custodian of our various rock and soil collected material but also responsible for the preparation of themed maps and the dissemination of geological information.

The advance of the use of 3D and other technologies at BGS has been exceptional. This work is the cornerstone of current and future ground engineering and it is important that sufficient funding is found in order for this work to continue and flourish.

Following the offshore earthquake in Japan in March 2011 and the effect of the tsunami on two nuclear power plants, scrutiny has never been more stringent. Ground engineers have always played a key part in the design of the substructure and foundations of nuclear power facilities and the repositories that are required to store waste for long periods generated by this industry. We are at the dawn of a massive construction programme within the nuclear power sector.

As a green alternative to nuclear power, the use of wind and tidal/wave energy has expanded rapidly in the last few years. This is set to continue with the challenges that need to be overcome in the designs for both offshore structural foundations on the seabed and on the peat that covers most of our remote upland moorland locations in west Wales and Scotland.

Tokyo and San Francisco lie in seismically active zones. Such locations around the world lead ground engineers to design more and more complex structures in a quest to build in greater resilience against earthquake damage.

Hydrogen is recognised as a likely replacement for oil to power road transport in the future. Following electrolysis from the night time power capacity, the hydrogen will need to be distributed in liquid form by pipelines to the consumers. This very low temperature transportation will open up new challenges to be overcome beneath the ground.

The entire utilities buried infrastructure requires constant repair and modernisation. So much dates from the Victorian era and is now in urgent need of replacement.

This summer will see severe water shortages in the south and east of England at a level not experienced since 1976. The role of the ground engineer to come up with innovative solutions such as the previously proposed Craig Goch transfer from Wales to the Thames catchment or other micro reservoir schemes is clear. In the meantime, the agricultural and industrial sectors will suffer.

LEGISLATION

There is a number of anomalies within the legislative process that need addressing to ensure the continued improvement and delivery of ground engineered projects.

As a Borough Councillor, I have seen at first hand the constraining effects of our planning system. This is being examined as a part of the Government review.

An anomaly that needs addressing is that structural engineer's reports are asked for as a matter of course for minor residential extensions. Interestingly, detailed ground engineering reports are rarely sought. The cumulative costs of resulting foundation failures to UK plc is significant, albeit through insurance and other claims.

There is an abundant and free source of geothermal heat beneath our feet. This is harvested in urban areas by the installation of energy piles as part of the foundation system for new and refurbished buildings and structures. The problem lies in the question of the ownership of this heat source and the contention that heat is being harvested from beneath adjacent properties. Let us hope that the lawyers can resolve this potential conflict and that appropriate legislation can be introduced as a matter of urgency. The ground engineering profession certainly can meet the technical challenge.

In my time as Head of Geotechnics of the Property Services Agency it took more than two years for the Treasury Solicitor to deliberate prior to permitting publication of a map to show potential geohazards throughout the UK. It was feared that it might have blighted those properties and areas identified. Quite the opposite has been the case. Let us hope that the ownership of ground source heat can be resolved more quickly!

CONCLUSION

What a feeling of wonder one gets on rising from the Jubilee Line at Westminster Station on the journey to the surface via the various escalators. The scale and enormity of the massive struts supporting this bold excavation adjacent to the Thames is there for all to see and appreciate. Portcullis House sits atop this sophisticated infrastructure, supported on its six massive piles. This is a fine example of what good ground engineering has to offer modern society.

TRAINING OF GROUND ENGINEERING PROFESSIONALS – How can UK provide skills required to maintain infrastructure?

John Burland
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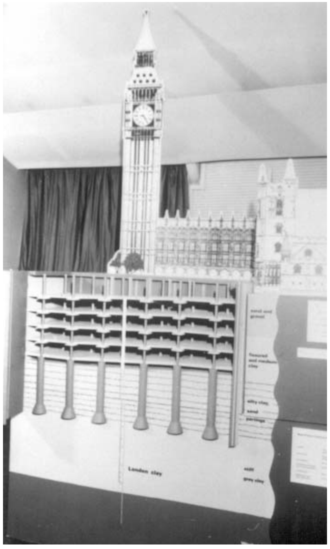
Richard Jardine
Professor of Geomechanics, Imperial College London

The Palace of Westminster has been impacted by two major civil engineering projects, the underground car park in New Palace Yard in the 1970s and the new Westminster Station for the Jubilee Line Extension in the 1990s. These can be used to illustrate the types of skills required of a ground engineering professional.

The underground car park is nearly 20m deep and its retaining walls come to within 2.5m from the north edge of Westminster Hall and 10m of St Stephens Tower. The retaining walls were initially designed on the basis that the clay was homogeneous and continuous – standard practice at that time. However Professor Burland examined the samples in detail and made the significant discovery that between a depth of 20m and 30m the London Clay contains thin layers of sand and silt. This transformed the design of the project. Because the ground water is in hydraulic continuity with the River Thames there was a significant risk that, as excavation took place, water would seep in horizontally through the sand layers and burst upwards into the excavation, which would have been catastrophic. The design was changed to eliminate this risk.

A key requirement of the design of the underground car park was to ensure that there was no risk to the stability of the surrounding historic buildings and that any damage was at most superficial. This necessitated the use of advanced computer modelling of the excavation process – the first time it had been used in the UK. Such an analysis is useless unless the appropriate



strength and stiffness parameters of the ground are known. At that time laboratory methods of determining such parameters were crude. We analysed the movements that had been observed around other excavations in London. The stiffness values derived in this way were generally very much higher than those obtained from routine laboratory tests. Accurate measurements of ground movement were made during construction. The predictions were broadly in agreement with the measurements but there were some subtle and important differences.

An intense programme of research work was then carried out at Imperial College aimed at (1) improving our ability to measure accurately the stress-strain properties of soils (led by Professor Jardine) and (2) the development of advanced computer modelling techniques (led at Imperial College by Professor David Potts). The outcome was a significant improvement in our ability to predict ground movements and their impacts on nearby structures.

This account of the work carried out on the New Palace Yard car park illustrates a number of skills that are required of a competent ground engineer:

1. The knowledge and experience to investigate the ground and ground water conditions at a site so as to identify risks and uncertainties and to develop cost effective designs that minimise the risks.

2. Knowledge of the applied mechanics principles governing the stiffness and strength of soils and rocks that is far in advance of what can possibly be taught at undergraduate level.

3. Knowledge of the advanced experimental techniques required for investigating the mechanical properties of soils and rocks.

4. An understanding of how to carry out and interpret advanced numerical modelling of ground engineering problems together with the limitations and

pit-falls associated with such modelling.

5. A knowledge of case histories and the lessons learned from them – an essential aspect of good ground engineering.

The construction of the 40m deep new Westminster Station beneath Portcullis House was a major civil engineering achievement. The sophisticated computer modelling that was carried out was informed by the measurements that had been made during the construction of the car park. Precise monitoring of movements of the clock tower and the surrounding buildings was carried out under the direction of Dr Jamie Standing of Imperial College.

This demonstrates the key role played by novel geotechnical construction processes. For example, to reduce ground movements the bottoms of the retaining walls of the station box were propped by struts constructed in tunnels before excavation commenced. Most importantly a novel method of controlling the settlement of the foundations of the clock tower was developed. The method, known as compensation grouting, consists in injecting cementitous grout into the ground at chosen locations beneath the foundations so as to jack them up in a controlled manner if any settlement takes place. The technique was used very successfully to control the changes of inclination of the clock tower during the works – a topic of considerable press speculation recently.

A geotechnical engineer requires knowledge of the various geotechnical processes that have been developed in recent years. Such processes require careful monitoring and control so that techniques of monitoring form another essential skill of good ground engineering.

Awareness of what the Romans could achieve, or of Brunel and Bazalgette's achievements can make it difficult for modern Civil Engineers to convince others of the rate of advance in our subject, its complexity and its importance to the economy. But there have been many big, innovative and important developments over the last few decades and these require a high ability, well trained cohort of specialised professionals to carry this progress forward.

For example, offshore Geotechnics has progressed from working in a few 10s of metres of water to astounding projects achieved at 2000m depth or more. Academic research and engagement has helped this significantly. The group at Imperial College has provided contributions to many of the major new deepwater developments. These include for example the Ormen Lange field, offshore Norway, that provides a large part of the UK's gas from the rear scarp of a huge landslide that developed a tsunami 8,000 years ago that would devastate much of coastal NW Europe if it were to be repeated in modern times. This clearly required very careful, advanced and specialist work. Our contributions have also been important in deepwater Gulf of Mexico projects (the events of 2010 make us all aware of the potential risks faced in that region), deepwater Angola and elsewhere – as well as contributing to the latest developments in the Atlantic Frontier sites West of Shetlands and new high capacity wind farm developments in Germany and other North sea sectors. The economic impact of this work is huge. Major infrastructure projects are taking place within urban areas world-wide involving tunnelling and excavations. The design methods of assessing and mitigating impacts on buildings are based largely on the research work carried out within the UK.

None of the above could have been done in the same way 30 years ago. There is a wealth of new knowledge being created by the universities and industry here and abroad. This has to be disseminated in a consistent and systematic way. The knowledge transfer mechanisms open to us include academic papers (great for Research Excellence Framework (REF), but not read or under-stood by many practitioners), short courses (important, but really only trailers and taster sessions), undergraduate teaching which is inappropriate for the specialisms involved and finally specialist Masters Courses.

In our experience MSc courses have been the most efficient means. They give us a chance to really teach advanced and specialised material in a broad context, and make sure that the material is understood by requiring testing examinations and coursework. The geotechnics MSc courses run at Imperial College contain all of the elements described above. Moreover they are kept up to date by the latest research findings, technical developments and notable engineering projects. It has been our experience at Imperial College that a full year of 'total immersion' is required for a student to gain most benefit.

These courses have become the backbone of UK geotechnics profession and about half the membership have an MSc, and of those about half took their degree at Imperial College. Around 40% of Arup's geotechnical staff have an Imperial MSc degree including all six of the geotechnical directors.

The history and the product is good, but what is happening now? The bad news is that student debt, four-year MEng courses, the cancellation of Research Councils' MSc support schemes and the coming fee hikes are wiping out the UK take-up of places at the top MSc schools. We are now down to 10% UK take up in the Imperial geotechnics courses, and this will probably reduce further as the fees bite. The courses are therefore principally training the UK's economic competitors. Without financial support it simply doesn't make sense for an able MEng graduate with a good degree and a good job, to quit, spend £30k and risk possible unemployment just to attain specialist skills that the Industry does not seem able to reward.

Clearly, the UK industrial and educational governance system has missed a very important trick. Decisions made to meet the interest of our individual research councils, student funding bodies, industries and universities have all come together to produce a perfect storm in which our future ability to design, build and manage our expensive infrastructure is at risk. Our Civil Engineering work covers around 10% of the UK's GDP, with energy supply adding a further substantial segment of value. This is far too important an economic issue to ignore.

GROUND ENGINEERING IS EVERYWHERE – BUT GROUND ENGINEERS ARE IN SHORT SUPPLY

What are the issues: What can we do?

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There is an almost uniquely broad need for adequately trained ground engineers within the construction industry. No other construction sector is involved in such a breadth of project types as ground engineers. This skills shortage is recognised by the Migration Advisory Committee and has led to at least sixteen ground engineering disciplines being included on the Government's Shortage Occupation List ever since it was first established.

Provision of an adequate supply of locally-based 'home grown' ground engineers is essential if the United Kingdom is to stop relying on migrant professionals, but courses are under threat because of budget pressures in universities and the economic crisis in the construction industry. UK-based students for the crucial MSc degrees are also in short supply because of the increasing cost of courses, the recent withdrawal of funding by the Research Councils, the level of debt which most graduates now accumulate, and competition from other sectors. Against this background, representatives from academia and industry met recently to consider: What are the issues? What can we do?

WHAT IS THE PROBLEM?

There are currently 15 universities in the UK offering MSc courses in subjects that would qualify as ground engineering. These courses are continually under pressure and several have closed in the past few years – including courses in hydrogeology, even though this is an area of acute shortage. Some of the pressures come from factors that affect all university courses: the need to diversify university income; the Government-driven move towards research and research funding; and the need to ensure that courses, even in specialist areas, are financially self supporting.

Most taught MSc degree courses require a minimum of 16 students in order to break even. In the past student numbers were limited by a shortage of students completing first degrees in civil engineering and geology. This problem has been resolved to some extent in recent years, to be replaced by new difficulties. In response to other pressures a number of universities now offer four-year first degrees in civil engineering leading to an MEng or a four-year geology course leading to an MSci. Neither an MEng nor an MSci contains sufficient specialist content to produce a Ground Engineer of the calibre produced by a three-year first degree and a specialist MSc. However, there is little incentive for someone graduating from MEng/MSci courses to undertake a further year of study to obtain an MSc when they already hold a master's degree.

This reluctance is compounded by financial considerations for potential MSc students. A survey by Birmingham University of students who enrolled for a ground engineering MSc course but withdrew before the course began ('non-arrivals') revealed that finance was a significant factor. MSc course fees are currently £4,000 to £5,000 and, while not employed, the students must also cover their living costs. Many now graduate from their first degree with substantial student debts which they are reluctant to increase further. MSc courses are not eligible for government loans and must be paid for 'at the door' (ie: on arrival); unlike undergraduate courses there is no delayed payment option. This is the biggest problem as many graduates simply do not have the money available or cannot access bank loans (especially in the current economic climate) to pay for MSc course fees. These factors will intensify in the coming years. The increase in undergraduate tuition fees will result in even greater student debt after 2015. Additionally, undergraduate tuition fees as high as £9,000 a year will have a knock on effect on postgraduate course fees which are expected to reach £12,000 from 2012. An early warning about the effect that this might have was given by Leeds University who raised fees to £5,000 last year and experienced a 40% drop in enrolments.

Inclusion of at least sixteen ground engineering disciplines on the Government's Shortage Occupation List has been a huge help to the industry. Such reliance on migrant professionals is not a long term solution however and the industry has already found various shortcomings with migrant ground engineers such as an inability to write contractually sound technical reports in English, no familiarity with UK ground conditions, only staying in the UK long enough to be trained and get experience up to Senior level and then going back home leaving us with a shortage of experienced senior technical management.

Should industry be taking a greater share of the financial burden being faced by both universities and individuals? The argument from university authorities is that vocational training is not their responsibility; and from elsewhere, including Government, that industry should pay for the skills it requires. Most of industry agrees in principle, provided Government recognises that everyone needs Ground Engineers and therefore public expenditure must also play its part. Two further factors are relevant:

1. Government agencies and local government have been estimated to be the client for up to 40% of all ground engineering work, and

2. Government supports knowledge transfer from academia to industry; taught MSc degrees are one of the fastest means of achieving that transfer of knowledge because the students are back in industry within one year.

PROBLEM SOLVED?

Profit margins in the ground engineering industry are typically less than 5%. This means that a bursary of £12,000 (enough for an MSc course fee from 2012) requires turnover of around £240,000. In some quarters, UK construction is considered unduly expensive in comparison with other European countries. There is little opportunity, even in normal economic conditions, to increase charge-out rates and hence profit margins; and in the current climate, with reduced rates to win work and keep staff employed, increases are unthinkable.

Since 2008 the turnover of many geotechnical consultants and contractors has fallen dramatically; margins have dropped (some are operating at a loss), several medium-sized piling contractors have closed down, and takeovers and mergers have increased. Expenditure is constantly scrutinised and cut (including, sadly, support for universities and training); and graduate recruitment has been reduced or stopped.

Many companies already supply 'in kind' support in the form of visiting lecturers, prizes, work experience, research projects (and supervision) for MSc dissertations; research facilities; and personnel for research steering groups. Additionally, even a well-qualified MSc graduate requires further training in order to develop in their career to chartered status and beyond. For most companies commitment to CPD represents a significant investment in terms of staff time, cost of courses and provision of training officers and mentors.

THE FUTURE

A recent meeting brought industry and academic representatives together and greatly enhanced understanding of the problems which each are experiencing.

But what can this achieve?

- Industry and academia can work together to ensure that courses meet the needs of industry.
- We can maximise the effectiveness of industry support 'in kind'.
- We can do our best to increase the visibility and attractiveness of the sector to potential students.

However, most companies cannot, at the moment, increase salaries or recruitment, nor can they provide additional cash for bursaries because no spare cash exists. Industry cannot alleviate the need for university courses to be self-sustaining, although all parties are very concerned that if student numbers fall any further then the continuity of these essential courses will be threatened.

Over the past years the UK has had to import Ground Engineers to plug a gap in skills and experience especially amongst experienced practitioners. The gap goes back to the beginning of the 1990s when recruitment dropped and candidates were snapped up by the City hungry for numerate and computer literate graduates. Unless a solution can be found, there will be an even greater skills shortage in 10 years time that will extend indefinitely into the future.

It is not only the construction industry that needs Ground Engineers – the country needs Ground Engineers. This is a problem that requires a sustainable solution, and this depends on industry, academia and government. The Ground Forum considers that the Government should reconsider its current policy towards funding of postgraduate training for Ground Engineering professionals and in particular the MSc courses. Funding support for MSc degrees in ground engineering subjects does not necessarily have to be provided by the Research Councils; it would seem reasonable that the Government departments which use ground engineering expertise should provide the required support. The total support required is modest, in the order of £3 million per year (100 UK-based students per year at an estimated fully funded cost of £30,000). This would guarantee that the UK has a sufficient Ground Engineering skills base for all normal circumstances.

If even such modest full funding of these essential courses is not feasible then Government support could be provided through tax concessions for employers who fund postgraduate training of their professional staff and provision of affordable loans to postgraduate students on the same basis as undergraduate loans. Such measures would help to alleviate the supply problem.

Current Government policy is to reduce or eliminate reliance on migrants from outside the EU so finding a new source of funding for locally-based students on taught MSc courses in ground engineering has the potential to resolve two problems simultaneously. The one certain conclusion is that doing nothing will result in a disastrous shortage of ground engineers in the UK and an even greater reliance on migrant professionals.