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issue no. 6
november 2011

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an introduction

Welcome to the sixth edition of **theGeotechnica**. This month's edition includes another in the Geotechnica speaker series. In this issue John Reynolds' article provides a real insight into how geophysics has changed explaining when used properly and in the right combinations, it can now produce high quality data which can really enhance our site characterisation models. John uses case histories to illustrate his discussion and demonstrate how effective geophysics can be.

In the Drilling section we have the first in a series of articles on borehole stabilisation and the use of drilling fluids and muds. This complex and fascinating subject can mean the success or failure of a borehole. In this issue, James Mansell imparts his knowledge on this very important subject. Future issues will carry further articles on the subject in order to build a real knowledge bank on the subject of drilling fluids and muds.

One of the aims of the Editorial Board is to improve awareness of hazards, and this month is no exception. Asbestos is a subject which is very emotive and where present on a site requires careful handling and appropriate PPE. In the Safety Issues section, Tom Phillips discusses the perils of asbestos from the employers angle, as well as the duty of care he bears – with respect to protecting his employees. Tom gives some really useful advice to consider when risk assessing the hazards faced for this potentially dangerous substance.

In our Eurocode section Len Threadgold of Geotechnics enlightens us on how it is possible to carryout Eurocode compliant site investigation without costing a fortune or throwing away all of our traditional methods. Len shows that the success of a project comes from good planning and an informed desk study to enable the investigation to focus on the design issues. Even so, flexibility is key, using a combination of different methods to obtain good quality samples and appropriate design data.

You might well ask what quantitative easing has got to do with training; our Training article this month shows the positive effects of these measures! It also provides an overview of the first three symposia part a series being run by Equipe. These have been very successful and extremely informative as well as entertaining – what more could you ask for from a symposium? There are still more in the diary so book early to avoid disappointment.

Our final article this month is from Roger Chandler and looks at how the use of Microsoft Excel spreadsheets can provide flexibility when used alongside larger database programmes, and thus avoids the complexity encountered if individual spreadsheets are used particularly for laboratory data.

Other things to look out for in this month's issue are some great job opportunities, both at home and overseas – so if you fancy a change or wish to progress your career take a look in the jobs section. If on the other hand, you are looking for staff then why not place your advert here with us in our jobs section, our rates are very competitive and we circulate to a large cross section of the Geotechnical community.

We are always on the lookout for interesting articles so if you want to tell the world about something you have done or are passionate about why not write an article, we will publish provided it is current of interest to the geotechnical world and is not defamatory. We now send to in excess of 6500 email addresses and we are read in many countries around the world. Our readership is growing issue on issue, so it makes **theGeotechnica** great place to showcase your work or advertise your products and services to a most receptive audience. Send your contribution or queries to magazine@geotechnica.co.uk or call 01295670990 for more information.

Contents: What's in this issue?

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Dr John M. Reynolds is Managing Director at geophysical consultant Reynolds International Ltd and was appointed to an Honorary Professorship at Aberystwyth University in 2005. Here, John writes for **theGeotechnica**, discussing how to maximise the benefits from using near-surface geophysical methods in ground investigations. This article is based upon a talk presented at Geotechnica in July 2011.

Mention site investigation and most engineers will think of boreholes and trial pit testing as being all that are required to identify what is present on a client's site and therefore what the next development stages

"...many projects are delayed with significant add-on costs because of 'unforeseen ground conditions'."

should be. Yet many projects are delayed with significant add-on costs because of 'unforeseen ground conditions'. The bigger the project, the greater will be the costs of any delays. Indeed, Tim Chapman (Arups) has recently stated in Ground Engineering (Nov. 2011, pp.12 & 14) that many clients regard significant delays and their attendant costs as being far more of concern than the price of the original site investigation. There are many, many, examples of where boreholes and trial pits, even though well executed and logged, have failed to pick up features within the ground that go on to prove expensive and time consuming to resolve.

Site investigation is all about risk management – to identify aspects of a site that risk affecting the subsequent development physically, through delays and

"When faced with especially a brownfield site there may be all manner of hidden features that may not even manifest themselves through a detailed desk study."

financially. When faced with especially a brownfield site there may be all manner of hidden features that may not even manifest themselves through a detailed desk study. Finding and identifying them with intrusive testing may be as effective as pinning the tail on a

"Even using statistical methods to optimise spatial sampling is but a game of probabilities."

donkey or relying on serendipity. Even using statistical methods to optimise spatial sampling is but a game of probabilities. You are trying to minimise the probability of there being a hidden nasty surprise on your site.

The problem

Complex sites with a lengthy history of industrial activity may have features that are spatially limited (e.g. underground cellars, steel drum graves) where the chances of finding them using intrusive techniques are very low by virtue of the large distances separating the boreholes and trial pits and the much smaller target dimensions. Intrusive testing samples a tiny proportion of any site, typically less than 1%. Yet entire remediation or development strategies are then based on this limited sampling regime so is it any wonder that unforeseen ground conditions arise? This is where geophysics can provide a valuable toolbox of techniques to help fill in the gaps and link between the intrusive testing locations.

Geophysical techniques provide the means of taking measurements over the majority of a site (typically >85% by area) and respond to contrasts in physical and chemical properties of materials present; the greater the contrast, the higher will be the detectability of the feature. Similarly, the larger the feature, the easier it will be to find it.

A site may contain features such as mineshafts, cavities, solution features, buried tanks and steel drums (Figure 1), utilities (dead or live?), foundations, cellars, contamination (solid or liquid), and UneXploded Ordnance (UXO; bombs, shells, etc.). In the case of UXO it is especially not desirable to find them with a drilling rig or mechanical excavator! There are clearly significant Health and Safety issues here too.

Figure 1: A site declared ready for construction actually contained a large number of discrete buried dumps of steel drums containing waste oil; these were located successfully using magnetometry, excavated safely and cleaned up efficiently.

Benefits of geophysical surveys

Most geophysical techniques have been used commercially and with great effect for more than two decades. There is no longer an argument to prove that the prin-

"The literature is full of many examples of what works and under what conditions and what the limitations are."

ciple of a method works. The literature is full of many examples of what works and under what conditions and what the limitations are. Many of the geophysical techniques available today have incorporated the latest computer and electronic engineering technology that makes some methods almost unrecognisable from their historical antecedents (Reynolds, 2011b). When it comes to data acquisition, geophysical methods have the following benefits:

- Rapid coverage of large areas
- High spatial resolution
- High spatial sampling
- Sample large volumes of material
- Generally non-invasive and environmentally benign
- Can be used for repeat surveys over time for monitoring
- Different techniques sample different physical/chemical characteristics of the subsurface
- Produce both qualitative and quantitative results
- Data can be further processed and modelled as part of the interpretation process

Geophysical methods can be deployed on land, over water, by air and down boreholes. Instruments can be carried by an individual operator or deployed on platforms that permit several techniques to be used simultaneously. Data acquisition can be linked directly with dGPS positioning to ensure that each data location is geo-referenced.

"Data acquisition is best undertaken by specialist geophysical contractors..."

Data acquisition is best undertaken by specialist geophysical contractors with experience in the methods to be used. There are about 25 such organisations in the UK, ranging from one-man bands through to large organisations; however, experience and quality can be highly variable.

Taken as a whole from data acquisition through to comprehensive interpretation, geophysical surveys can reduce the following:

- Health and Safety risks
- Professional Indemnity risks
- Project delays
- Project on-costs from unforeseen ground conditions
- Need for over-engineering structures to cover uncertainty in ground conditions,

contents

And increase the following:

- Reliability of information
- Cost effectiveness of ground investigations
- Technical robustness of ground models.

Using geophysical techniques may in some cases reduce the need for so many boreholes and trial pits but they will never, ever, replace them. Indeed they should be considered as complementary techniques, where the geophysical survey helps the engineer to locate the best locations for intrusive testing so maximising the benefit of those tests. The boreholes and trial pits provide essential ground truth for the geophysical interpretation. All of this helps to reduce ambiguity and uncertainty and increase the quality of knowledge about a site.

Key aspects of geophysical investigations

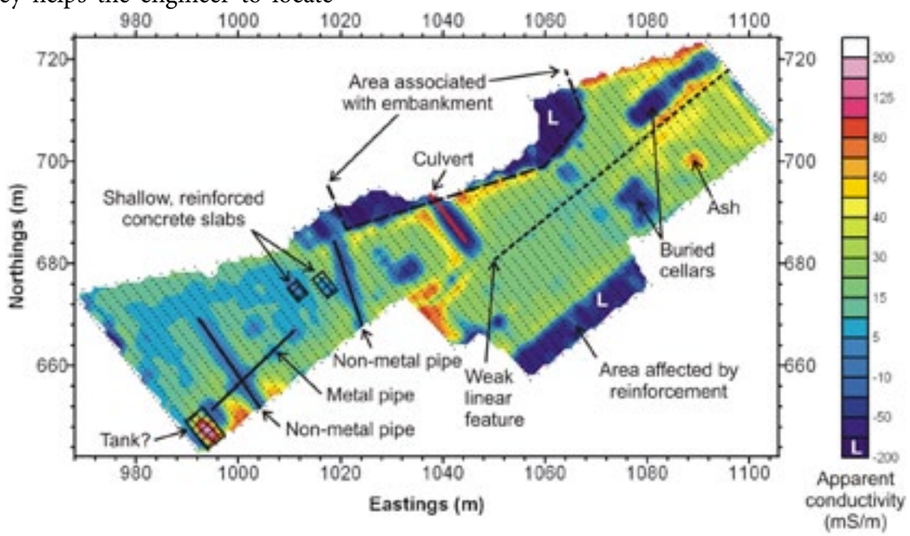

Figure 2: Apparent conductivity data across a housing development site in north-west London, with features identified.

Perhaps the best way to illustrate the benefits arising from geophysical surveys is to use a case history (Reynolds, 2004). The client was a housing developer. There had been three successive sets of intrusive investigations undertaken on the former industrial site comprising shell and auger boreholes and trial pits. Furthermore, the top 300 mm of ground was stripped off the site prior to construction. Just before building was due to start, the Environment Agency halted work on the site as they feared that pollution from the excavation of foundations might enter a canal that bordered the northern side of the area through a series of drains that crossed the site. No further intrusive investigations were permitted and the only way that the client could progress matters was to survey the area non-intrusively. A geophysical survey was commissioned comprising ground conductivity and magnetic gradiometry methods. A survey grid was established across the area with a line separation of 2 m and station intervals of 1 m (for the conductivity survey) and nominally 0.2 m for the magnetic gradiometry. The results of the apparent conductivity survey are shown in Figure 2.

The high apparent conductivity area along the north-west border was associated with an embankment along the canal edge made up of building rubble, including asbestos. Several areas of very low apparent conductivity were identified that were later correlated with buried underground basements and cellars. Two of these anomalies were orthogonal to each other and correlated when juxtaposed with the footprint of a former building. A small apparent conductivity anomaly was identified and was found to be due to buried ash, an undesirable commodity in an area designated for residential gardens.

"Several areas of very low apparent conductivity were identified that were later correlated with buried underground basements and cellars."

Before the geophysical investigation had been undertaken, the client was sceptical about the value of using geophysics – it was seen as just another cost eating into his profits. However, the benefit was quickly recognised once the geophysical investigation had been completed and a subsequent intrusive investigation undertaken, with the approval of the Environment Agency. Using the geophysical results it was possible to locate trial pits where geophysical anomalies indicated problem ground and where there were no culverts (these could be identified on the ground conductivity and magnetic data) to provide a pathway for any pollution towards the canal. The ground model compiled integrating the initial intrusive investigation with that targeted by the geophysical survey showed a significantly greater amount of detail than that from prior to the geophysical investigation (Figure 3). Using the trial pit information, the lateral extent of different specific material types could be mapped. Former building foundations and associated pipes and drains were identified and removed and the basements and cellars clearly identified and remediated. Had it not been for the geophysical survey, mechanical excavators could have driven over the tops of these cellars and would have undoubtedly gone through what were extremely weak ceilings. Furthermore, within the cellars foul water contaminated with hydrocarbons from discarded oil drums was found and would have caused ongoing pollution and could have represented a continuing health hazard to later residents on the site. Once the client realised what had been found from the geophysical investigation, he stated that the cost of the geophysical survey had been easily justified by the discovery of just the underground cellars, let alone all the other features located and subsequently dealt with. In addition, the Environment Agency was satisfied that the investigation and subsequent development could be undertaken with minimal risk of further pollution to the adjacent canal or to later residents on the new housing development.

"Using the geophysical results it was possible to locate trial pits where geophysical anomalies indicated problem ground..."

"Using the trial pit information, the lateral extent of different specific material types could be mapped."

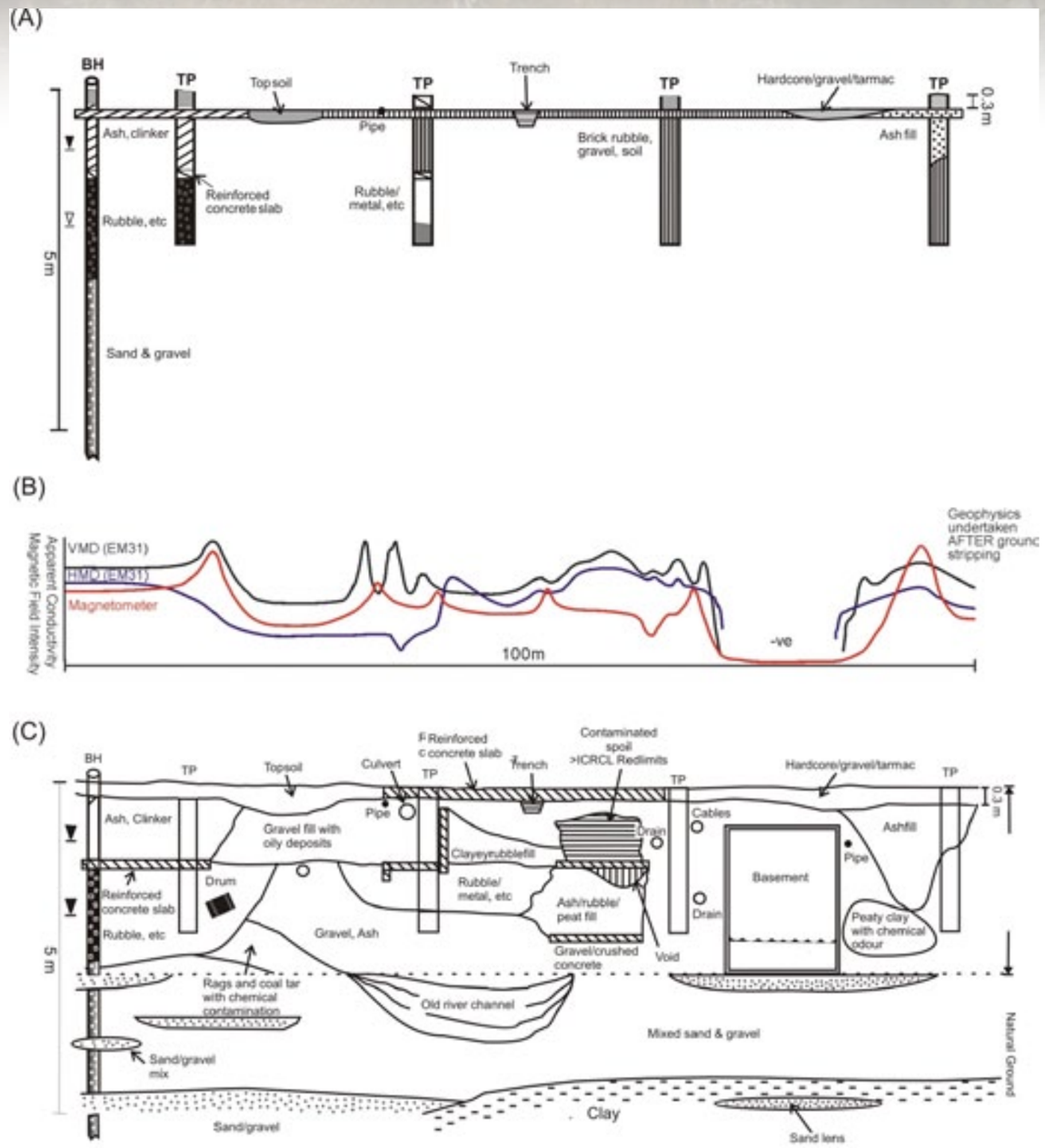

Figure 3: (a) Results of one borehole, three trial pits and a 300 mm ground strip along a 100 m transect; (b) Magnetic and apparent ground conductivity data (vertical and horizontal dipoles) across the same ground; and (c) the ground model resulting from subsequent intrusive investigation of geophysical models combined with the initial ground investigation results (Reynolds, 2004).

"The use of multiple geophysical methods over the same site has the advantage that each one responds to the physical characteristics relevant to it."

The use of multiple geophysical methods over the same site has the advantage that each one responds to the physical characteristics relevant to it. For instance, magnetometry is used to identify ferrous metal and other magnetically susceptible material, while the conductivity data indicate materials that are electrically conductive, whether metallic or not. This permits a qualitative interpretation as to likely composition of materials causing types of anomalies

"This means that asbestos-cement culverts can be differentiated from metal water pipes..."

in accordance with the matrix below. This means that asbestos-cement culverts can be differentiated from metal water pipes; ash, which is both conductive and magnetic, can also be identified, for instance.

Property	Conductive	Non-conductive
Magnetic	Ferrous metal pipes, ash, Pulverised Fuel Ash, iron foundry slag, cables	Brickwork, fired earth, crushed dolerite fill
Non-magnetic	Leachate, clay, saline groundwater, non-ferrous metal	Stone rubble, asbestos-cement pipes, hydrocarbon contaminated clays, glass

The data journey

The vast majority of geophysical surveys are designed and specified with respect to the data acquisition as being the primary consideration with ~80% or more of the cost being associated with the field work and only <20% with the reporting, much of which tends to be factual rather than interpretative. Consequently, much of the information obtained is never used. The focus on field data acquisition is a result of most of surveys commissioned being designed by the geophysical contractors who undertake them. The norm has been for the ground investigation to comprise a series of discrete, separate and largely unrelated phases comprising predominantly boreholes and trial pits and sometimes geophysical investigations. The results of each are usually reported separately and provided as hard copy documents, which may be presented as PDFs. While the documents and maps can be read on a computer, the interpretation results cannot be used directly by a client's engineer. The results have to be transposed, if they are used at all.

"The norm has been for the ground investigation to comprise a series of discrete, separate and largely unrelated phases..."

"The focus should be on what information the client needs for his/her purposes."

I have argued for many years that this is the wrong approach. The focus should be on what information the client needs for his/her purposes. The survey design and specification should be focused on the interpretation and the associated deliverables and then what quantity and style of data should be collected with which techniques to deliver the required outputs. This places the focus very much on the interpretation rather than the data acquisition. It also allows the survey design to incorporate other information, such as environmental and geological results from desk studies or other sources, plus borehole data perhaps in one of the increasingly accepted digital formats, and digital aerial photography, so that the results can be managed in a single 3D volume (ground model) such as

through a 3D GIS, from which interpretation outputs can be transferred into 3D CAD files. This approach maximises all the data collected.

"The difficulty for many clients, especially if they have had little or no previous experience of geophysics is where to go for information..."

The difficulty for many clients, especially if they have had little or no previous experience of geophysics is where to go for information about how to procure an appropriate geophysical survey that will produce the required deliverables. One source of guidance is 'Geophysics in engineering geophysics' (McDowell et al., 2002), which advocates clients appointing an Engineering Geophysics Adviser (EGA) who can manage the whole process from designing and specifying the survey, supervising the geophysical contractor(s) on site, and undertaking the detailed integrated interpretation and reporting. The EGA can identify suitable geophysical contractors and advice on the procurement through the tendering process as necessary. It also means that the overall survey design is not influenced by the amount of site work or the type of equipment a given contractor has available, which is a tendency if the survey design is undertaken by a contractor, who benefits the longer a survey takes on site.

"The EGA can identify suitable geophysical contractors and advice on the procurement through the tendering process as necessary."

"The use of an EGA is all the more important for larger and more complicated projects."

The use of an EGA is all the more important for larger and more complicated projects. A briefing note for civil engineers has been produced by the Institution of Civil Engineers (Schoer, 1999). The most recent and comprehensive overview of environmental geophysics has been provided by Reynolds (2011a).

Conclusions

It can be concluded from the above that:

- Near-surface geophysical techniques form a powerful toolbox to complement traditional invasive techniques in ground investigations
- Most geophysical techniques have been well proven over decades of use and are being developed continually in terms of data acquisition technology, and methods of data processing, modelling and interpretation
- Interpretation incorporating borehole data can now be undertaken in a single 3D volume and the outputs provided directly into a client's own software environment
- With enhanced data acquisition techniques comes the need for better data management
- Larger data volumes and more varied data types, including borehole data in AGS format, should be integrated into a 3D ground model.

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Len Threadgold is the Chairman industry main-stay, Geotechnics. Writing for **theGeotechnica** for the first time, here Len enlightens us on how it is possible to carryout Eurocode compliant site investigation without costing a fortune or throwing away all of our traditional methods.

The impact of European legislation and directives are being felt in the site investigation industry, and the recent introduction of Eurocode 7 and the associated European and International testing standards has had significant implications for technical reports, in-situ testing, and sampling techniques.

There has been considerable debate in the geotechnical press about the benefits and drawbacks of Eurocode compliance, but one thing is clear- the Eurocodes

"...the major players in the geotechnical industry are learning to live with the requirements..."

are here to stay. Consequently the major players in the geotechnical industry are learning to live with the requirements, and developing working methods to suit. A recent project, undertaken by Geotechnics Limited from its Coventry head office, illustrates the nature of the Eurocode compliant working methods now being adopted in the engineering reporting carried out by the company.

Highway upgrade project

In July 2010, Geotechnics was awarded a site investigation contract in Stourport on Severn, UK for a highway upgrade project related to a proposed development of an approximate 8ha site by Tesco. It was important from both the client and the designer's perspectives that the investigation and the subsequent design work were seen to be Eurocode compliant.

In accordance with the requirements of the Highways Agency, a Preliminary Sources Study Report (PSSR) was undertaken prior to the main ground investigation works. This is the equivalent of the desk study of existing information and site reconnaissance which has been the corner stone of high quality site investigation practice in the UK for a number of years. It forms part of most projects and is considered to be critical for a successful and efficient investigation design.

"This is the equivalent of the desk study of existing information and site reconnaissance..."

The proposed highway works are to include the upgrade and resurfacing of an existing road and the construction of a new link road running on embankments up to 2m in height, in accordance with the highway design scheme devised by the client's design engineer,

Arup. The proposed link road will cross a former factory site and a flood plain, and will involve the construction of a new road bridge and a footbridge over the River Stour.

"The PSSR showed that the site is underlain by soil comprising Recent alluvial deposits and Pleistocene River Terrace sediments."

The PSSR showed that the site is underlain by soil comprising Recent alluvial deposits and Pleistocene River Terrace sediments. These superficial strata are underlain by rocks of the Wildmoor Sandstone Formation of Triassic age.

"The investigation was designed to comply with Eurocode 7 and the new European and International testing standards..."

The investigation was designed to comply with Eurocode 7 and the new European and International testing standards, and employed a wide range of techniques. These included both cable-tool and rotary drilled boreholes, window sample boreholes, trial pits, static cone penetration testing (CPT), pressure meter testing, dynamic cone penetration (DCP) testing and CBRs. Selection of the most appropriate techniques to suit the expected ground conditions was critical to optimising sample quality.

Inspection pits were used to investigate the foundations and sub-grade of an existing retaining wall and bridge foundations. Cored samples were taken of the existing pavement structure, and the presence of a number of exposures of the sandstone allowed geological mapping. The ground investigation work was carried out under the supervision of experienced engineers.

In accordance with BS EN 1997-2: 2007 and BS EN ISO 22745-1: 2006, Class 1 undisturbed samples were required for compressibility and shear strength testing. These were made possible by utilising a piston sampler in the soft alluvium and thin-walled, 100mm diameter open-tube samplers in firmer clays. Laboratory testing was undertaken at Geotechnics' UKAS accredited testing laboratory in Coventry.

"The results of the investigation were drawn together as a ground investigation report (GIR) to include the field work data and laboratory results together..."

The results of the investigation were drawn together as a ground investigation report (GIR) to include the field work data and laboratory results together with a summary of the ground and groundwater conditions encountered. Engineering and geotechnical Parameters for each material type were also presented for use in detailed design.

Equipment

On a wider front, Geotechnics Limited has also recognised the need for the development and availability of Eurocode-compliant sampling equipment and has liaised with a number of industry-leading manufacturers to ensure that high standards are maintained.

Eurocode 7 has particular implications relating to Class 1 sampling and the calibration of Standard Penetration Tests (SPTs) and Dynamic Probe equipment. UT100 thin-wall steel sampling tubes, catcher boxes and cutting shoes are now being more commonly

"Recent experiences with the new UT100 tubes have been mixed..."

used. Recent experiences with the new UT100 tubes have been mixed; they are now being more commonly used to sample soft to firm clays reliably, but the cutting shoes and tubes can buckle when driven into stiff gravelly clays such as glacial till.

Geotechnics has also recognised the need to comply with SPT hammer calibration re-

"Geotechnics has also recognised the need to comply with SPT hammer calibration requirements..."

quirements under the Eurocode. All hammers used by the company are fully calibrated and certificates are included in reports where required. The company also has mandatory arrangements in place to make sure that approved subcontractors in its supply chain use calibrated hammers. Other factors which affect the potential variability inherent within the test, such as operator skill and equipment condition are also monitored by site audits. Interpretation of the results, not in isolation, but as one part of the assessment of the ground model is crucial.

"It is through well designed and planned investigations that high quality data will be obtained..."

It is through well designed and planned investigations that high quality data will be obtained to allow Eurocode compliant design. A phased approach to the investigation including a desk study and if possible, a preliminary investigation is one way of achieving this aim. The information obtained from the desk study and preliminary investigation stages can be used to determine the best techniques to obtain high qual-

"The information obtained from the desk study and preliminary investigation stages can be used to determine the best techniques to obtain high quality data..."

ity data for the particular site conditions, whether through in-situ testing or by obtaining Class 1 samples for laboratory strength and compressibility testing. Preliminary information on the ground conditions will also allow a considered view to be taken on which method is most appropriate for the obtaining of the Class 1 samples.

Geotechnics Ltd is one of the largest geotechnical and geoenviromental specialists in the UK with offices in Coventry, Exeter and Chester. Please contact Pam Knight pknight@geotechnics.co.uk or call 01244 671117 if you require more information about this article or any other matter; she will be delighted to help.

drilling

contents

This is the first in a series of articles on borehole stabilisation and the use of drilling fluids and muds. In this issue of **theGeotechnica**, James Mansell of Clear Solutions International Ltd. imparts his knowledge on this very important subject.

In all drilling applications we are continually striving to improve productivity whilst effectively controlling both risk and cost – to do this we must control the formations being drilled.

"The ground being drilled not only affects the type of drill bit which is used but also impacts on our drilling fluid selection..."

The ground being drilled not only affects the type of drill bit which is used but also impacts on our drilling fluid selection, the mud mixing, pumping and recycling equipment used. Throughout the following series of drilling fluid related articles we will demonstrate how the proper use and management of drilling fluid not only significantly improves the efficiency of the drilling operation but also reduces costs and wear and minimises our impact on the environment.

Minimising risk - is something we all want to do, but in order to manage risk we must first understand it. When it comes to drilling and cutting the ground, there are 4 essential components to be considered when evaluating operational risk:

1. The formation itself
2. Our method of cutting the formation
3. The fluid used whilst cutting the formation
4. The pumping, mixing and recycling equipment used to process and handle the drilling fluid

To these we add the final and most important component, which is:

5. Health & safety and the environment.

The fluid - The three principle reasons for using a drilling fluid are:

1. To support the ground during the drilling process, to stop the surrounding ground collapsing into the borehole and to control subsurface pressures (i.e. artesian water pressure) until the constructed item is installed and sealed.
2. To efficiently remove the drilled cuttings from the borehole and to cool and lubricate the cutting head and drilling assembly.
3. To seal and protect the formations and aquifers being drilled and to minimise the drilling operations environmental impact.

Drilling fluid mixing and recycling plant for large directional drilling projects, significantly boosts production rates whilst effectively minimising the environmental impact of large scale drilling operations.

The fluid/formation interaction - The majority of fluids used in geo-drilling projects are water based – from a cost/environmental perspective this is great but it has a down side in that the water component of the drilling fluid will in itself adversely effect many of the formations through which we commonly drill.

For this reason we must add drilling fluid additives to the water to control the following reactions:-

- Swelling of the formation whereby it hydrates, sloughs into the borehole and reduces the effective borehole diameter.

- Fluid losses into permeable formations – this can not only permanently damage the natural permeability of production zones (i.e. aquifers) but also destabilises poorly consolidated formations such as sands and gravels.

- Fluid losses into highly fractured formations.

- Washing out the formation to form voids, these washouts destabilise the ground above and can result in the hole collapsing and/or under-filling of the hole when cementing or grouting.

- Artesian or subsurface pressure forcing ground water or gas back to surface in an uncontrolled manner.

- The drilled cuttings also react with the water phase in the drilling fluid and if not controlled they can quickly destabilise the drilling fluid by dispersing into the drilling fluid and as a result rapidly build mud weight, viscosity and fluid loss, necessitating an expensive dump and dilute approach.

The ideal drilling fluid - will be cost effective, environmentally acceptable, safe to handle, will mix quickly, and be easily handled and maintained on surface.

"Once mixed the drilling fluid will then enable the driller to cut a smooth, stable gauge hole..."

Once mixed the drilling fluid will then enable the driller to cut a smooth, stable gauge hole through a range of formations with no indications of borehole instability whilst also balancing down hole pressures, optimising penetration rates and preventing formation damage. To achieve all of these things significant research and development has been put into developing drilling fluids such as Pure-Bore® which can exhibit the following characteristics:

Smaller more mobile drilling fluid mixing and recycling combined with high-pressure mud pump systems significantly improve production rates when used with the correct drilling fluid additives.

- A drilling fluid which loses viscosity under high flow rate/high shear conditions (i.e within the drill pipe and the jets) enabling more drilling fluid to pumped down the hole with a lower mud pump pressure. This drilling fluid then develops a higher viscosity whilst flowing more slowly within the larger annulus in low shear conditions, helping to effectively transport the drilled cuttings back to surface.

- Stable gel strength to suspend the cuttings and prevent them settling to the bottom of the hole whilst the fluid is static within the borehole.

- Low fluid loss and a thin tough wall cake to reduce the amount of water entering the formation – if the fluid can't escape from the borehole into the formation and a positive hydrostatic head is maintained then formation can't collapse into the borehole.

- Low solids and low sand content to reduce pressure losses and pump wear.

- An inhibitive/encapsulating fluid that helps prevent reactive formation wanting to hydrate and slough into the borehole and to prevent cuttings from these formations breaking up and dispersing into the

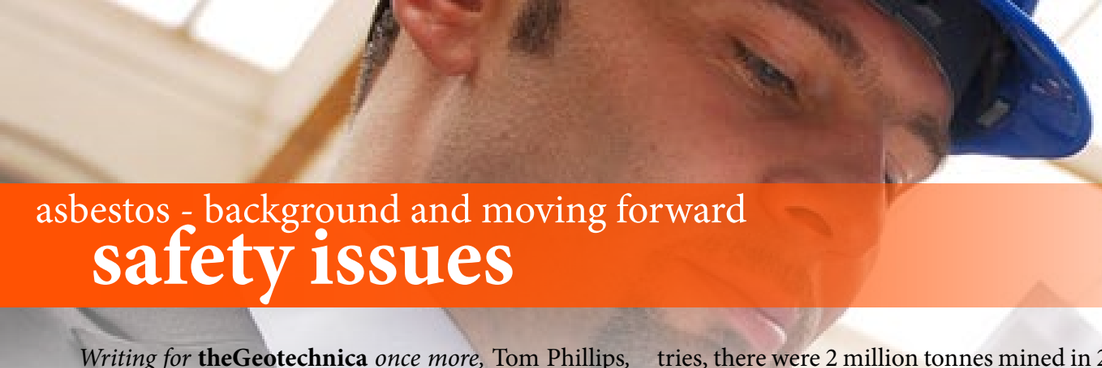
drilling fluid.

- A stabilised fluid system that is not upset by cement or high concentrations of chalk or limestone and provides a strong cement/grout bond on the borehole wall at the end of the drilled section

Throughout our series of (drilling fluid) articles we will expand on this introduction to drilling fluids by looking at the following aspects of drilling fluids in more detail:

- The specifics of various drilling fluid characteristics and how to adjust and modify them to optimise drilling performance in various formations
- The safe and effective mixing and use of different drilling fluid additives
- The importance of flow rate and annular velocity in the drilling fluid process
- The effective recycling, handling and disposal of used drilling fluids
- Minimising the risk of formation damage – optimising the productivity of production wells
- The effective sealing and grouting of boreholes for different applications

We would welcome any questions from drillers so that we can address any specific questions regarding drilling fluids or their use. ■



asbestos - background and moving forward

safety issues

contents

Writing for **theGeotechnica** *once more,* Tom Phillips, *an independant chartered occupational safety professional from* RPA Safety Services, *discusses the history of asbestos, its different forms and the continued threat that it still poses to the industry.*

For most of us, asbestos is a word we have grown up with. In schools it was used as the fire retardant filler for Bunsen burner mats and we used asbestos gloves to remove things from furnaces. It has even found its way into the everyday lexicon through reference to materials with brands named derived from asbestos such as Artex and Asbestolux. People who can pick up hot objects often refer to possessing 'asbestos hands'.

Derived from the Roman 'asbestinon', which translates literally as 'unquenchable', it has been used since ancient times. The Greeks used it for wicks in lamps as they never burnt away and the Romans used asbestos to make cloth napkins, which were cleaned by throwing them into the fire. As recently as 1929, scientists were predicting dresses woven from asbestos 'that will be as lustrous as silk and will give long wear, with ease in cleaning'.

In the late 1800s, when the people of eastern Quebec realised the money that could be made from what was known locally as "cotton rock", they decided to name their settlement after it. They never could have guessed what it might one day mean to come from a town called Asbestos.

A naturally occurring mineral, asbestos is found widely throughout the World. Although rare, there are small deposits in the UK but the largest producers

"Despite bans in more than 40 countries, there were 2 million tonnes mined in 2009 and it is still a major export for many countries..."

have historically been Russia, Canada, South Africa and Australia. Despite bans in more than 40 countries, there were 2 million tonnes mined in 2009 and it is still a major export for many countries, who export mainly to developing countries such as India and Indonesia.

From the 1950s to the 1980s, hundreds of building products contained asbestos and it was widely used until 1999 when the phased ban on the use of asbestos materials in the UK became complete and its general use is now banned. The use of asbestos products peaked in the Sixties and early Seventies.

"...it is abundant, cheap and can be easily mixed and moulded."

The popularity of Asbestos as a material is due to its versatility. It is hardwearing and has high tensile strength, is a good insulator of both electricity and heat and it is mostly resistant to acid. Above all, it is abundant, cheap and can be easily mixed and moulded.

There are 3 main types of asbestos which are regulated. Known generally as white, brown and blue these are more technically Chrysotile, Amosite and crocidolite respectively. There are also a number of other non regulated 'asbestiform' minerals such as Richterite which are still considered harmful but only generally encountered in low levels as contaminants with other materials.

The harm caused by asbestos has been known, or at least suspected, since the Greeks used slaves to mine and work it, noting a 'sickness in the lungs' of slaves who wove asbestos into cloth but the first documented death related to asbestos was not until 1906. The first diagnosis of asbestosis was made in the UK in 1924 and by the 1930s, the UK regulated ventilation and made asbestosis an excusable work related disease. The term mesothelioma was first used in medical literature in 1931 and its association with asbestos was first noted sometime in the 1940s.

The most serious condition caused by asbestos exposure is mesothelioma, a form of cancer that principally affects the external lining of the lungs (pleura) and lower digestive tract (peritoneum). It is always fatal and results in an extremely painful and slow death. Currently there are around 2000 deaths a year caused by mesothelioma and other asbestos related diseases, such as asbestosis and lung cancer, account for around the same number of fatalities.

"...employees working today are still at risk."

With such a large number of deaths and a predicted latency of not less than 15 years between exposure and discovery, employees working today are still at risk. For those in the geotechnical industry, it will be those working in laboratories or working on landfill sites who will be at the highest levels of risk. As a company, we regularly asked about samples returned for mechanical testing which contain obvious lumps of asbestos, which we recommend be quarantined for further consideration, but it is the ones which get through the initial visual screen which concern us most. Many materials look harmless and innocent but in fact are well known asbestos containing materials and therefore, unlikely to be spotted.

What can employers do to protect themselves and their staff? Initially the site needs to be assessed for risk, an inherent responsibility under the Health and Safety at Work Act 1974 and further outlined in the Control of Asbestos Regulations 2006. From this initial assessment, a level of comfort or not can be determined regarding the likely presence of asbestos. Where samples are considered to be more likely to contain asbestos, they need to sampled to confirm but this is often a laboratory test, to determine the presence of fibres. There is still no consensus yet relating to the acceptable number of allowable fibres in a soil sample but where they are detected, any further mechanical work should be considered carefully.

For general work however, where asbestos is not considered to be a high level of risk it is nonetheless 'reasonably foreseeable'. As such, there is a requirement under regulation 10 of the Control of Asbestos Regulations 2006 to ensure there is a need to train staff to understand the impact of the substance and how to work safely if it is suspected as being present. Training should also consider what to do in an emergency and how to ensure others are protected during works.

Generally, unless staff are going to be carrying out licensed work with asbestos, the level of training they need is fairly basic. A syllabus is outlined in regulation 10 and this can generally be covered in a few hours on a training course. The course should be focused on the effects of exposure, where asbestos containing materials may be present and the controls staff should expect to protect themselves and others. In our experience however, very few geotechnical staff have been provided with any training at all.

"...main contractors are now demanding this level of awareness training for all staff..."

With an increasing drive to re-use construction materials and develop brown-field sites, shouldn't we be making sure our staff are properly trained? Certainly main contractors are now demanding this level of awareness training for all staff working on construction sites. It is now considered mandatory and is an implied requirement of registration with many of the third party assessment bodies such as CHAS and Achilles. ■

training

contents

With over 35 years experience as a chartered geologist, Pete Reading now finds himself a technical director of Equipe Training. Here Pete writes once again for **theGeotechnica**, *this time discussing Equipe's latest round of symposia, courses and seminars, featuring Geophysics in Geotechnics and Geotechnical Laboratory Testing, amongst many others.*

Many geotechnical managers are despairing because they cannot provide suitable and adequate training for their staff due to company budget constraints and cost cuts. The problem has increased with the deepening of the market downturn and its sheer longevity yet, when projects are commissioned it is now even more critical they are completed efficiently. Therefore, it is also critical that the staff know what they are doing at all stages of the project.

In this time of austerity, Equipe has developed its own form of quantitative easing with respect to training for the geotechnical and drilling community. In addition, to the NVQ funding which Equipe has won (see 'The future is NVQ' article in Issue 5 of **theGeotechnica**) it has also developed a series of FREE TO ATTEND Geotechnical Training Symposia.

The series of symposia are an extension of the Equipe 3As Seminars which provide high quality training days on geotechnical topics presented by experts in

"These one day seminars were developed to improve awareness of the subjects, their applications in the real world and their advances."

the field. These one day seminars were developed to improve awareness of the subjects, their applications in the real world and their advances. The symposia also follow the same aims but were developed in conjunction with leading contributors to create one and two day training events.

This series has covered Geophysics in Geotechnics, Geotechnical Laboratory Testing, Cone Penetration Testing for Onshore and Offshore Geotechnics, Field Instrumentation, Ground Investigation Processes and Health and Safety in Geotechnics.

Colin Tickle demonstrates ground probing radar to delegates

Geophysics in Geotechnics

This single day was developed by Equipe, TerraDat and European Geophysical Services and covered both surface land geophysics, shallow marine and downhole geophysics. From the very outset, the use of geophysics was questioned by the operators themselves. However, the questioning was not from a point of view that it should be ignored because it doesn't work (a common misconception) but that it is an extremely useful additional investigation tool when specified by those who understand the advantages and limitations of the techniques.

An important aspect of each symposium is not only good case studies but also demonstrations and the geophysics symposium had both in abundance. Helen Scholes from GCG discussed the use of geophysics on the Crossrail project and Ryan Temple provided a case study of how geophysics when specified correctly greatly enhanced the Thames Tideway project. The demonstrations included a seismic test performed by Dr Simon Hughes, Operations Manager of TerraDat and interpreted by Prof. John Reynolds and a ground penetrating radar survey of the Equipe courtyard performed by Drilline Products.

"The quality and content of the talks and demonstrations was of the highest standard..."

The quality and content of the talks and demonstrations was of the highest standard and included talks from the suppliers, specialists, consultants and clients which provided a well rounded view of the topic. Many attendees left the day with a different attitude to the use of geophysics in their projects and many myths had successfully been dispelled.

Peter Reading discusses laboratory testing with an attentive audience.

Geotechnical Laboratory Testing

This two day symposium was held at Geolabs laboratory facility in Garston to allow delegates to experience the tests first hand as well as learn about the theory behind them.

The first day was a guide to conventional laboratory testing presented by Equipe's very own Technical Director, Peter Reading. The presentations covered classification testing, compaction testing, shear strength, settlement and permeability testing and were strongly enhanced with visits to the laboratories. Delegates were able to talk to the technical staff and see how the tests are regularly performed by the skilled technicians.

Time was spent giving advice on how to schedule tests and what results might be expected, including what to expect to be reported on the test summary sheets and what is critical to making informed decisions when choosing design parameters. The day also included advice on how much material is needed for each test and the influences of sampling method and size on the test results which is an area where most laboratory staff would criticize site staff.

Amongst the tests covered by Peter were the importance of moisture content and how it affects strength and density. Why the plasticity indices are so important being true constants for a particular soil. Real examples of the relationship between the plasticity index values and the natural moisture content were looked at and how this relationship enables an assessment of stiffness, and the susceptibility of the soil to shrinkage and swelling.

"Real examples of the relationship between the plasticity index values and the natural moisture content were looked at..."

"Day two was a world class series of presentations on advanced laboratory testing..."

Day two was a world class series of presentations on advanced laboratory testing made by some of the country's leading authorities on the subject. The day started with a marathon presentation from Mike Rattley of Fugro Geoconsulting Limited. Mike presented a whistle stop theory behind the Constant Rate of Strain (CRS) Oedometer Test and the Simple Shear Test.

Dr Patrick Hooker, Director of GDS, gave an enlightening talk on the resonance column test which is starting to arrive in the commercial sector and the Hollow

training

contents

Symposium delegates watch a demonstration of the effective stress apparatus in the Geolabs laboratory

cylinder test which until recently has only been available in universities. Dr Chris Wallace of Geolabs gave an enthralling talk on small strain and bender element testing which have become commonplace in the larger commercial laboratories. Chris explained not only the physics behind the tests but also how they help to provide a much better understanding of the stress strain relationship of soils when subjected to changes in stress.

Dr Appolonia Gasparre of GCG and a Researcher at Imperial College, asked the question – 'why bother to do advanced testing?' Her talk drew together all the earlier talks and demonstrated that only with the significant advances in measurement and computing power are we able to measure the parameters which enable more exacting designs for structures and foundations.

The day was rounded up by Dr Andrew Ridley, Managing Director of Geotechnical Observations, who asked 'whilst it is all well and good to be able to measure these parameters such as stiffness but can we rely on the samples we use to test'. Whilst Eurocode de-

"Whilst Eurocode demands that we use a class one sample for high quality testing, how can we determine that we have actually got one?"

mands that we use a class one sample for high quality testing, how can we determine that we have actually got one? Andrew demonstrated that by measuring suction pressures it is possible to determine the degree of disturbance.

"It is clear that all of us practicing in the geotechnical industry... must have a very good understanding of the reason we are scheduling the tests..."

It is clear that all of us practicing in the geotechnical industry and involved with laboratory testing must have a very good understanding of the reason we are scheduling the tests, what results we should expect and what the limitations are. As our request for more accurate and precise results grows, tests, which have previously only been obtainable at universities, will become commonplace in commercial laboratories like Geolabs. These advanced tests will become more essential as they provide the parameters which are required by finite element and advanced computer modelling and enable us to use real parameters determined from the soils on our sites rather than adopting values from published text.

Chris Wallace of Geolabs demonstrates how bender elements work.

Cone Penetration Testing for Onshore and Offshore Geotechnics

Equipe again were able to organise this event using two of the world's leading experts on Cone Penetration Testing in Tom Lunne of NGI and Dr John Powell of Geolabs.

Tom and John provided a comprehensive journey through the use of CPT from its conception to its more recent use on sea bed ROVs. The symposium discussed data processing, corrections, soil profiling, soil identification and sampling methods available for the CPT equipment.

Darren Ward, Managing Director of In Situ Site Investigations brought a CPT truck which was used for live demonstrations through the days and also provided some very interesting views on other CPT sensors such as the video cone, environmental cones and soil moisture cone which are becoming more popular.

Brian Georgious, Geotechnical Manager for Gardline Geosciences, brought a sea bed CPT frame and discussed its use and why CPTs are used for marine investigations. Brian's talk was complemented by Dr Peter Allen, Managing Director of Geomarine, who provided a talk on the use of the application of CPTs for marine geotechnics.

The event was completed by Asger Eriksen, CEO of Zetica, who created a lively debate about the precision of UXO investigations specified for CPT. Asger questioned the distribution pattern of most investigations and the limitations of the techniques and appealed to specifiers to get the experts involved at a much earlier stage. This sentiment was heard at all of the symposia and will undoubtedly resound through future symposia.

What's New?

The 2011 symposia are far from over as there are still places available on t7th December 2011 for Ground Investigation Processes – British Standards v Eurocode – where does the UK want to go? This event will question the use of British Standards and Eurocode, where they fall down, the implications to UK practice and open out the debate to ask if new standards are required or wanted. It will have presentations from each stage of the Ground Investigation process where these aspects are discussed and debated.

Programme

- Contract Implementation - BS or Eurocode or does it really matter?
- NEC Conditions of Contract – Impact on Ground Investigations
- Ground Investigation Fieldwork – Does Eurocode compliance add costs?
- Laboratory Testing – BS1377 vs Eurocode update
- Implementation of Ground Investigation Practice under Eurocode
- Reporting – Compliant practice

This is followed by Health and Safety in Geotechnics on 8th December 2011 which will provide updates on legislation and regulations which directly affect the geotechnical and drilling industry.

Programme

- Where is H&S in a difficult market – HSE update
- CDM (2007) – Millstone or Life Ring?
- Buried Services
- Plant and Equipment Regulations Update
- NEW Trial Pitting Guidance
- Asbestos in the Ground and in the Laboratory

"The 2011 season will be completed by the recently postponed Field Instrumentation symposium..."

The 2011 season will be completed by the recently postponed Field Instrumentation symposium which is now to be held on 11th and 12th January 2012. This eagerly awaited symposium has been developed by Equipe and John Dunnicliff who is recognised by most in the field as the expert.

The two day symposium is supported by most of the UK's leading geotechnical instrumentation suppliers and contractors who will also be exhibiting and providing case studies and technical presentations to supplement John's considerable expertise. These two days will really be something to experience. ■

Equipe Geotechnical Symposia

Awareness - Applications - Advances

Field Instrumentation in Geotechnics

11th and 12th January 2012

at The Drilling Academy, nr. Banbury

FREE TO ATTEND

Programme

Day 1

08:45 – 09:15	Registration and Coffee
09:15 – 09:30	*Welcome and Introductions* – **Pete Reading *et al***
09:30 – 09:50	*Introduction of Participants* (audience participation)
09:50 – 10:05	*Engineering is a Risky Business* – **Pete Reading**
10:05 – 11:20	*Systematic Approach to Planning Monitoring Programmes*, **John Dunnicliff**
11:20 – 11:35	Morning Break
11:30 – 11:45	MOGE & *GIN*, **John Dunnicliff**
11:45 – 12:45	*Overview of Hardware – Part 1*, **John Dunnicliff**
12:45 – 13:15	*Monitoring the Performance of Infrastructure Embankments*, **Dr Andrew Ridley**
13:15 – 14:00	Lunch Break
14:00 – 14:45	*Use of InSAR as a Field Instrument*, **Kevin Banks**
14:45 – 15:15	*When, where and how to specify vibrating wires + Case Study*, **Rory O'Rourke**
15:15 – 15:30	Afternoon Break
15:30 – 16:00	*Ensuring appropriate monitoring specifications*
16:00 – 16:30	*Training and Competence*, **Nick Slater**
16:30 – 16:45	Summing Up and Close

Day 2

08:45 – 09:00	Coffee
09:00 – 10:00	*Overview of Hardware – Part 2*, **John Dunnicliff**
10:00 – 10:30	*Tottenham Court Road / The Shard*, **Aidan Laimbeer**
10:30 – 10:45	SAA Demonstration
10:45 – 11:00	Morning Break
11:00 – 12:00	*Workshop - Planning a Monitoring Programme for an Embankment on Soft Clay* **John Dunnicliff**
12:00 – 12:30	*Use of Robotic Total Stations in Geotechnical Applications*, **Nick Russill**
12:30 – 13:30	Lunch and Equipment demonstrations
13:30 – 14:35	*Load, strain and stress applied + Blackfriars Case Study*, **James Gale**
14:35 – 15:05	*Wireless technologies moving forward*, **Grant Taylor**
15:05 – 15:20	Afternoon Break
15:20 – 16:10	*Fibre Optics*
16:10 – 16:40	*Data handling, storage and web based monitoring Systems,* **Dr Roger Chandler**
16:40 – 17:00	Summing up and close

Speakers

John Dunnicliff, Independent Instrumentation Consultant
Dr Andrew Ridley, Managing Director, Geotechnical Observations
Tony Simmonds, International Projects Manager, Geokon Inc.
Rory O'Rourke, Managing Director, Datum Monitoring
Kevin Banks, IDS UK
Nick Slater, Business Development Manager, ITMSoil
Nick Russill, Managing Director, TerraDat
Aidan Laimbeer, Commercial Manager, Sol Data
James Gale, Strainstall
Grant Taylor, Geosense Division Manager, MGS
Dr Roger Chandler, Managing Director, Keynetix

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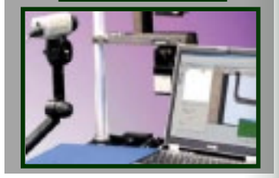

Equipe Geotechnical Symposia

Awareness - Applications - Advances

Geotechnical Laboratory Testing

24th November 2011

at Building 19, BRE Conference Facility, Bucknalls Lane, Garston, Watford, WD25 9NH

Delegate Fee - £100+VAT

Programme

08:45	Coffee and Registration
09:15 – 09:30	**Introduction - Why test?**
09:30 – 11:00	*Classification tests - Moisture Content, Plasticity, Density, Particle size*
11:00 - 11:15	Morning Break
11:15 - 12:00	*Compaction related tests - Compaction tests, CBR, MCV*
12:00 - 12:30	**Laboratory Tours** Group 1 – Building 26 - classification and sedimentation Group 2 – Building 15 - compactions, CBR and sieves lab
12:30 - 13:00	Group 2 – Building 26 - classification and sedimentation Group 1 – Building 15 - compactions, CBR and sieves lab
13:00 - 14:00	Lunch
14:00 - 15:00	*Strength testing – Vane, Triaxial, Shear box*
15:00 - 15:15	Afternoon Break
15:15 - 16:00	*Deformation and permeability - Permeability, Consolidation*
16:00 - 16:45	**Laboratory Tours** Group 1 - Building 26 - oedometer, Rowe cell Group 2 - Building 22 - shear box
16:45 - 17:00	Discussion and Close

Lecturers:
Pete Reading, Equipe
Dr John Powell, Geolabs
Chris Wallace, Geolabs

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should you use Microsoft Excel in your laboratory?

contents

Roger Chandler, Director of Keynetix, continues his seriesof articles for **theGeotechnica**. Here, Roger discusses the benefits of the use Microsoft Excel in your laboratory.

Almost without exception all geotechnical labs around the world use Microsoft Excel to some extent in processing or reporting their data. The prolific use of this program comes as a direct result of the complexity of geotechnical testing compared with other types of testing and the ease in which Excel reports can be set up and customized. Interestingly, laboratories visited during recent research in the UK and Australia that claimed to have made a significant investment in a management system for their geotechnical laboratory, all used Excel to some extent to produce their reports for their clients, often outside of their purchased central system.

"Relying only on Excel to produce your test certificates initially seems a good idea but can quickly lead to problems."

Relying only on Excel to produce your test certificates initially seems a good idea but can quickly lead to problems. Each sample will have a separate spreadsheet for each test, meaning that for a small job of four samples, each with five tests, your data is stored in 20 different files. When dealing with larger jobs the problem grows exponentially, especially when the client requests a change to the report that affects every page. Instead of making the change once in the data and automatically reprocessing the report the change needs to be made in potentially hundreds of different locations.

A bigger problem with using Excel is that the spreadsheets are usually set up without any consideration for the difference between data and reports and, as a result, are set up without any data spreadsheets. In his book "Excel Advanced Report Development" (2005) ISBN 978-0764588112, Zapawa (2005) presents an interesting, and many would agree vital, principle that

"... all data should be held in a separate spreadsheet to the report..."

all data should be held in a separate spreadsheet to the report as this allows the data to be presented in many different report formats. Without this principle he claims that there is no data in your spreadsheet.

To illustrate Zapawa's principle it is useful to look at Triaxial test certificates that are produced in Excel. As with many Excel based certificates the data will have been entered directly into the report template so when the client requests AGS data from the Excel reports, or requires a summary table of results, it will often involve many manual cut and paste stages for each test.

In a recent project I installed a HoleBASE system for a large land reclamation project in the Middle East. The

Excel: Familiar desktop icons.

contractor had over 5,500 spreadsheets for the laboratory testing work and the client required the data in AGS data format. The contractor had estimated that it would take around four man months of simple cutting and pasting to extract the data from the reports. If the data had been stored in a central system which automated the Excel report production the extraction of AGS data would have taken no more than four minutes. (For this one project I did write a small application specifically for them and the AGS data was extracted from all spreadsheets in around four days).

In summary, Excel is an excellent tool for the geotechnical laboratory to produce geotechnical reports but it should be used in conjunction with an external data storage system rather than storing the data inside each and every spreadsheet.

Excel Flexibility

KeyLAB uses Excel spreadsheets as the data entry and calculation engine for all the tests.

Following the rules suggested by Zapawa no data is saved in an Excel spreadsheet. The data is saved to a SQL database together with information on when it was saved and who by. This enables the data to be

"This enables the data to be reprocessed at any time into a report format or AGS file..."

reprocessed at any time into a report format or AGS file and allows laboratory managers to keep track of vital key performance indicators using the management reports features.

Most laboratories have created spreadsheets that are used as the paper worksheet for a test. KeyLAB allows these spreadsheets to be incorporated and used for the data entry. This reduces the learning curve for technicians to around 20 minutes for all tests. To put it simply - the data entry guidelines are "fill in the same boxes on the screen that are filled in on your worksheet".

So to answer the original question – "Should you use Microsoft Excel in your laboratory?" the answer is without doubt that you should in some shape or form but you must be careful to separate the data and the report parts of the work. This is quite difficult to do using standard Excel routines and functions but quick and easy to do using KeyLAB.

This article is an extract from a paper presented in Brisbane in October 2011. The paper entitled "Increasing Laboratory efficiency and value of laboratory data by maximising the use of common Data Formats" can be downloaded, together with supporting information from www.keynetix.com/agta2011. ■

directory

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K4 SOILS LABORATORY
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site investigation

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training and education

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Specific experience in the following is preferred:

- Engineered Fills – earthworks testing, design, specification and validation, assessment of embankment/fill settlements.
- Foundations – Extensive knowledge of foundation types, current specialist solutions and applicability. Assessments of bearing/load capacity, settlements. Familiarity with numerical modelling and software packages an advantage.
- Modified and stabilised soils using lime, cement, PFA, GGBS.
- Slope Stability – scheduling of testing, analysis, mitigation, reporting
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- The principles of Eurocode 7
- Knowledge of reinforced earth design and retaining walls preferred.

The successful candidates must be comfortable interfacing with clients, other professionals, contractors and regulators as the role will involve a mix of technical and project management skills as well as the preparation of proposals, overseeing reports and mentoring or more junior staff. The position can be based in either our Kenilworth or Newton-le-Willows and could also be offered as a part-time vacancy (subject to a minimum number of working hours to be agreed).

Please submit your CV and covering letter to John Cartwright, Applied Geology Limited, Unit 23 Abbey Park, Kenilworth, Warwickshire, CV8 2LY. Tel. 02476 511822. NO AGENCIES.
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