theGeotechnica

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contaminated land analysis

Alcontrol Laboratories introduce @mis

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- an examination of OHSAS18001 accreditation
- effective stress series: part two

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an introduction

Welcome to the June edition of **theGeotechnica**. This issue contains details of Equipe's annual Trade Show and Exhibition - most notably, the completed speaker list. In terms of articles, this month's edition has some excellent geotechnical case histories which highlight some of the more advanced techniques available to engineers.

Firstly in the Training section we are publishing the second part of the effective stress series, written by Chris Wallace from Geolabs. This month, Chris explains the nuances of the various test forms and explains what to expect from each of the test variants. The two articles form a really useful guide to getting this test right and will help to give a much better understanding of the test, the type of sample needed, the results and the cost for the various elements of the test.

In the Geotechnical section we have a really interesting article which could equally have been included in the Innovations section, such is the nature of the content. The article from Monitor Optics Systems describes a case history in whichoptical fibre transducers were used to sense movements in a highway constructed over mine workings. The system provides an early warning device that alerts workers to unplanned movements, and as such enables highway repairs to be made before they become serious. This innovative system could revolutionise the way we consider long term settlement monitoring.

In this month's Environmental section we have an article from Alcontrol which demonstrates how their data handling system can cope with an impressively large amount of data, and enables the engineer to analyse the data and make decisions in an informed way - the numbers are really mind blowing.

In the Drilling section, Julian Lovell of Equipe writes for us on the subject of driller competency. This is a key element of Eurocodes however with the economic downturn we are seeing many of our best drillers retiring from the industry; this can only result in an acute lack of knowledge retained in the industry. Taking a closer look, Julian also highlights the fact that even many of those who we consider to be expert are often too important to the production figures to send on training courses, yet much innovation and legislation change has taken place in the last decade. Julian asks: is it not important to ensure that, even those who we consider to be skilled operators, carry out continued professional development.

It is just a month to go to Geotechnica 2012 so don't forget to book your free place to attend via the web site. Next month's issue of **theGeotechnica** will be published before the end of June and will be the pre-show edition. There are still a small number of exhibition spaces available, with the number falling every day. To ensure your exhibition space - book online now at www.geotechnica.co.uk.

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Contents: What's in this issue?

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Writing for **theGeotechnica** for the first time is James Preston of Monitor Optics Systems Ltd. In this article, James introduces MOS' method of monitoring the mining induced strain in road pavement.

Continuous monitoring of mining induced strain in a road pavement using Fibre Bragg Grating sensors: Hume Highway, Australia

BACKGROUND

Monitor Optics Systems (MOS) Ltd. design, manufacture and install fibre optic sensors and complete sensing solutions. Established in 2004 with offices in Dublin, Liverpool, Milan and Sydney (Australia), MOS has successfully installed and continues to maintain a number of unique sensing systems in Europe and Australia. The flagship project described here concerns the use of MOS sensing cables based on optical Fibre Bragg Grating (FBG) transducers to monitor the surface strain in the pavement of

"This major highway is subject to mining induced subsidence due to the extraction of underground coal."

Hume Highway in southern Australia. This major highway is subject to mining induced subsidence due to the extraction of underground coal. The longwall mining method being employed results in the ground immediately above the coal seam being allowed to

collapse into the void that is created as extraction proceeds, resulting in subsidence of the ground surface. The highway was constructed in the 1970's with a composite pavement structure comprising asphaltic surfacing, slag road base and stabilised (bound) sandstone

"Experience from mining beneath pavements of similar stiffness found that subsidence can induce damage..."

sub-base. Experience from mining beneath pavements of similar stiffness found that subsidence can induce damage typically consisting of cracking of the pavement and the formation of humps and steps.

Initially installed by MOS in 2008, and expanded on three occasions since then, the pavement monitoring system has become an essential component of a comprehensive management system developed and implemented by the highway authority and the mining company to manage the effects of mining subsidence and ensure the on-going safety and serviceable operation of the highway. This is one of the busiest highways in southern Australia and as such any monitoring system used for the safe operation and control of the highway must be proven to be extremely reliable.

"The sensing cable network deployed by MOS comprises over 800 multiplexed individual strain and temperature sensors providing continuous monitoring..."

The sensing cable network deployed by MOS comprises over 800 multiplexed individual strain and temperature sensors providing continuous monitoring over several kilometres of both carriageways of the highway.

DIRECT CONTINUOUS MONITORING OF PAVEMENT STRAINS USING FIBRE OPTICS SENSORS

As the accumulation of compressive strains in the pavement is the most important parameter to monitor in case of subsidence, the monitoring system was designed around the measurement of strain data using sensors embedded in the highway pavement.

"Optical fibre sensing systems are ideal for accurate, autonomous, long-term monitoring in the field..."

Optical fibre sensing systems are ideal for accurate, autonomous, long-term monitoring in the field, they do not require electrical power for signal transduction or transmission and are immune to electro- magnetic interference while not generating electromagnetic signals or sparks themselves. Fibre sensors based on FBG transducers add other advantages as they do not suffer from drift and can be multiplexed in series and in parallel to build very large and complicated sensor networks. FBG sensors are point sensors located within a standard size optical fibre. Their operating principle is based on the variation of a reflected wavelength as a function of the strain applied to the fibre. This wavelength variation can be measured very accurately so much that FBG strain sensors are used to measure strain variations of 1-2 micro strain (με).

FBGs are ideal strain transducers and show a linear relation between the strain applied and the optical output. However they are also sensitive to temperature variations: temperature fluctuations in the vicinity of a strain sensing fibre can indicate an apparent strain,

"The most common approach to avoid cross-sensitivity problems is to measure strain and temperature in parallel, using two separate sensing fibres..."

and vice versa. The most common approach to avoid cross-sensitivity problems is to measure strain and temperature in parallel, using two separate sensing fibres where one of these fibres is packaged in order to decouple it mechanically from its environment so that it senses only temperature, while the other fibre is deployed to measure both temperature and strain. A simple algorithm can then be used to process the measurement data in order to actively compensate for temperature effects and arrive at pure strain data.

The MOS temperature sensing cable is based on an FBG array encapsulated in a composite Glass Fibre Reinforced Polymer (GFRP) pultruded cable which is loosely enclosed in a polymer tube. The polymer tube allows the unrestrained thermal expansion of the GFRP cable and isolates the sensing cable from the

"These sensors can also be employed independently as temperature sensors if desired."

strain field of the host structure. These sensors can also be employed independently as temperature sensors if desired.

FBG technology was selected based on its affordability, proven performance for structural health monitoring and the relatively short lead-time required to

develop and deploy a complete monitoring solution including data management. The challenge remained however to develop a practicable method for deploying hundreds of FBG strain and temperature sensors over kilometres of highway pavement.

Monitor Optics Systems has developed its own proprietary method of embedding one or more optical fibres into a Glass Fibre Reinforced Composite (GFRC) sensing cable, of up to kilometres in length.

"The mechanical properties of the sensing cable can be tuned to optimise strain transfer from the structure to the sensing fibre..."

The mechanical properties of the sensing cable can be tuned to optimise strain transfer from the structure to the sensing fibre, while maintaining a very high level of protection for the optical fibre. This sensing cable design and construction is suitable for a number of different optical sensing techniques, including FBG and Stimulated Brillouin Scattering (SBS). The GFRC cable is compatible with most epoxy resin based adhesives. This enables the effective surface bonding and embedment of the sensing cables. The material properties ensure the survival of the cables when installed in environments such as concrete, asphalt, salt water and composite materials. The strain sensing cables can also be cast into concrete or asphalt matrices thanks to their durability and good temperature resistance (up to 200°C). If required, the cables can be surface treated or coated with polymers for added

"The sensing cables can be stored on reels for storage and transport..."

protection. The sensing cables can be stored on reels for storage and transport, and are readily deployed and installed in the field with the assistance of unskilled personnel, realising considerable savings in time and cost.

EMBEDDMENT METHODOLOGY

The flexible asphaltic concrete (AC) surface layer is approximately 100mm thick. The sensing cables were embedded in this surface layer at a depth of 30-40mm. A commercially available 2-component epoxy resin adhesive was selected to bond the sensing cables to the pavement. A number of alternative epoxy resins were considered for this purpose and the final selection was based on ease of installation, curing time, stiffness, creep and adhesion properties both to the GFRP sensing cable and the AC pavement layer. Test installations were conducted to assist in epoxy resin selection. The selected epoxy resin is used by the highway authority for other in-pavement sensor applications and in the airline industry for runway lighting. The epoxy resin is resistant to physical damage and is black in colour. Sensing cable embedment is illustrated in Figure 1.

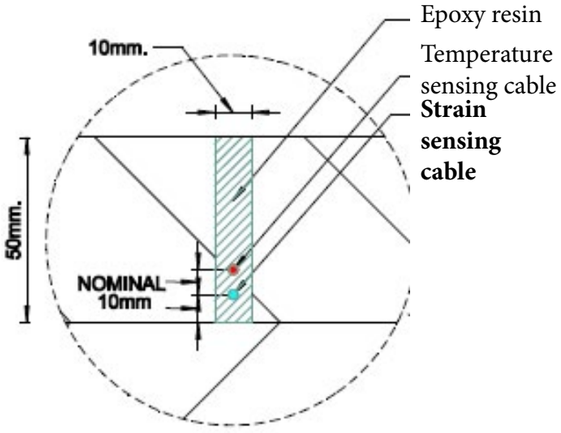

Figure 1. Strain and temperature sensing cables embedded in the asphaltic top layer of the pavement

THE MONITORING SYSTEM

Maximum tensile and compressive strains due to systematic mining subsidence were predicted to be in the order of +/- 1000με equating to approximately +/- 1nm of FBG central wavelength shift. Maximum temperature range was expected to be approximately 60°C equating to approximately 0.8nm of FBG central wavelength shift. To ensure that an adequate separation between FBG central wavelengths was maintained at all times, central wavelength spacing of 4nm was specified for the strain sensors.

"Variations in topography and shading result in variations in pavement temperature along the highway."

Variations in topography and shading result in variations in pavement temperature along the highway. For this reason it was determined that an FBG temperature sensor should be collocated with each FBG strain sensor to ensure accurate temperature compensation of the FBG strain sensor, and accurate determination of the pavement's diurnal behaviour.

From an assessment of the predicted strain profile a minimum resolution and accuracy of the monitoring system of at least 10με was required. The maximum rate of increase of strain due to systematic subsidence was predicted to be in the order of 10με/day, while that due to non-systematic ground movement was predicted to be up to 100με/day. On this basis an FBG interrogator with a resolution and accuracy of 1-2με and an acquisition rate of 1-4Hz was selected. The interrogator has a bandwidth of 80nm, allowing for up to 20 FBGs per channel at 4nm spacing. With the capacity to switch over 16 channels, a total of 320 FBGs can be supported by one interrogation unit.

SENSING NETWORK

The monitoring system network has been installed in stages in line with the progression of the long wall mining panels. The system has been fully operational since February 2009. Since that time it has been expanded twice, from an initial network of 120 FBG sensors to the present network comprising 840 FBG sensors (420 strain and 420 temperature sensors) distributed over a 2.5km stretch of both northbound and southbound carriageways. This has been made possible by the modular nature of FBG based sensors and interrogation units that allow the easy addition of sensors and quick modifications of the sensing network.

The FBG sensing cables vary in length and hence number of FBGs per cable, depending on the spacing between transverse pavement slots. To efficiently interrogate the FBG sensors, the sensing cables were serially multiplexed into strings of up to 20 FBGs inside in-ground pits located between each sensor cable.

"Signal transmission cables connected the ends of each sensor string to an onsite demountable building with demodulation equipment."

Signal transmission cables connected the ends of each sensor string to an onsite demountable building with demodulation equipment. A diagram of this is illustrated in figure 2. One end of each sensing string was connected to the demodulation system, and the other was available for redundancy in the event a new transverse pavement slot was introduced, which would split the sensor string in two.

Signal transmission cables connect the FBG sensor strings to a dedicated demodulation system located

"The modular demodulation system is progressively expanded as the sensor network expands..."

in an onsite demountable building. The modular demodulation system is progressively expanded as the

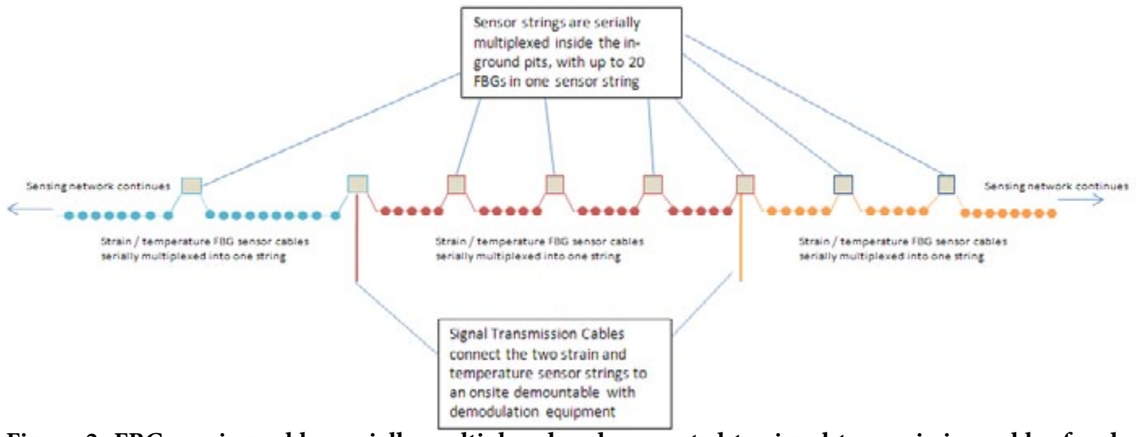

Figure 2. FBG sensing cables serially multiplexed and connected to signal transmission cables for demodulation

sensor network expands, with a total of four modules installed to date. The modules are controlled by a single central control unit and this manages the data acquisition and the transmission of data to an

"Data acquisition and transmission parameters can be modified easily and quickly..."

on-line database. Data acquisition and transmission parameters can be modified easily and quickly and this feature has been exploited in occasion of works on the road to determine in real time any change of the strain state on the pavement during the works.

General System Performance

The system has operated continuously over a period of 3 years and has proven to be extremely reliable and robust. Triggering of alarms and initiation of response actions is predicated on the FBG strain sensor data. The most recent mining phase (active subsidence) spanned a period of 11 months, from July 2010 to June 2011. Over this period five transverse pavement slots were cut at locations of high compressive strain as measured by the FBG sensors. The ability to interrogate a sensing cable from either end was exploited to good effect, allowing the slot to be cut through the signal cable without loss of signal from any of the FBG sensors. In effect the cutting of a slot converted a single sensing cable into two shorter

"This same feature was exploited to overcome loss of sensor signal..."

sensing cables. This same feature was exploited to overcome loss of sensor signal on the one occasion where a sensor cable broke within the pavement due to subsidence induced cracking. Another significant advantage of optical networks was highlighted when a lightning strike damaged a number of the electrical slot displacement transducers but did not detrimentally affect the MOS monitoring system.

An optical fibre sensing system comprising many hundreds of FBG sensors distributed over many kilometres is being used to monitor the condition of the pavement of a major highway subject to mining induced subsidence effects. Following a lengthy testing and validation process, the system was installed and is currently in its fourth year of continuous operation. It is a critical component of the comprehensive management system developed and implemented by the highway authority and the mining company to control the effects of mining subsidence on the highway and ensure its on-going safety and serviceability. The system uses robust, easy-to-handle distributed FBG sensing cables developed by Monitor Optics Systems (www.monitoroptics.com) which are embedded in the top asphaltic layer of the pavement. The system has proven to be extremely robust and reliable and is highly effective for both the detection of mining induced compressive strains in the pavement and the verification of the effectiveness of mitigation

"The transmission of alarms and initiation of response actions is predicated on the system data."

measures. The transmission of alarms and initiation of response actions is predicated on the system data. It is intended that the monitoring system will continue to be expanded over time to facilitate the continued exploitation of high-value coal resources under the highway.

The success of this application points to the suitability of the MOS distributed FBG sensing cables for other ground movement monitoring applications, such as monitoring of landslide-prone regions, railway embankments, excavations and foundations; and the potential for these sensing cables to overcome some limitations of conventional vertical and horizontal inclinometers. ■

Lankelma delivering CPT services in Christchurch, New Zealand

geotechnical

Ground investigation specialist Lankelma launched its cone penetration testing service in New Zealand in early May.

Engineering Director, Carlton Hall, spent several weeks in the vicinity to set up the business operation and engage with the local geotechnical community. He recalls "I was constantly being questioned about our ability to penetrate the regional shallow gravels and, after many years of working through the river terrace deposits within the London Basin, I felt Lankelma could manage the gravel layers here – but of course it's our field staff, not me, that have to operate the rig!".

Following good performance using a conventional piezocone, Lankelma were challenged with a site within the Central Business District, where very dense shallow gravels have previously been encountered. Rejecting the opportunity to terminate at 6.5m deep on very dense gravels, Lankelma advanced "pre-push" casing to 9.9m. This was then extracted, the piezocone was re-inserted, which then progressed to 23m into the underlying sands.

"Lankelma were challenged with a site within the Central Business District, where very dense shallow gravels have previously been encountered."

Supervising Engineering geologist, Richard Phillips of Tonkin and Taylor Limited states "The data is great and the rig being able to puncture through the gravels (with or without the use of the casing / dummy probe) is something we had been really hoping for – excellent result".

"Lankelma have also managed to demonstrate their field skills by pushing through dense materials underlying Peat."

Lankelma have also managed to demonstrate their field skills by pushing through dense materials underlying Peat [which offers negligible rod support]. Again, first indications are that clients are delighted with the progress.

Carlton Hall believes the service offered by Lankelma will be well received: "I'm delighted to see our operators proving their abilities. Whilst in New Zealand I was really encouraged by the enthusiasm I encountered when addressing practicing companies and the learned societies. The Lankelma offer of highly skilled field operators and diligent logging geologists interpreting data will, I believe, prove popular". ■

Lankelma's Managing Agent in Christchurch is KGA Geotechnical Investigations Limited. They can be contacted as follows:

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contents

Alcontrol's Geraint Williams writes once again for **theGeotechnica**. This month, Geraint looks to the future of contaminated land, and how it is likely to be analysed in the coming years.

Online Lab Results Accelerate Remediation Processes – Avenue Coking Works Case Study

Fast analytical data is critical to the efficiency of remediation processes. However, analysis times are rarely

"...too often there are delays between sampling and analysis or between analysis and the delivery of results..."

the limiting factor; too often there are delays between sampling and analysis or between analysis and the delivery of results or worse still samples are deviating. Alcontrol Laboratories has therefore developed an online tool known as '@mis' to resolve these issues and the following article will explain how the new tool is helping remediation contractors at one of the UK's largest and most heavily contaminated sites to exploit the benefits of fast analytical data.

In addition to the online delivery of test data, the remediation contractor, VSD Avenue, is also utilising @mis to schedule analytical work so that the availability of results does not delay any of the remediation work. The £172.3m clean-up operation at the Avenue Coking Works near Chesterfield in Derbyshire has been underway for over two years and project director, Marcus Foweather says: "Over the lifespan of this project Alcontrol will have tested in excess of 10,000 samples

"This data is critical to the ongoing management of the remediation activities..."

for between 5 and 18 analytes. This data is critical to the ongoing management of the remediation activities, enabling us to identify soils for treatment and to check that cleaning operations comply with the required specifications. Almost all process management decisions are therefore affected by test data, so the ability to access results through Alcontrol's @mis system has been a fundamentally important part of the projects success".

Background

Historically, the land at the Avenue has hosted a variety of industries; primarily the coking works but also a large chemical plant, a liquor by-products works, a large rail head, a hazardous waste tip and two large contaminated silt lagoons. Covering 80 hectares (almost the size of 200 football pitches), the site presented a substantial challenge to VSD Avenue which is a joint venture consisting of civil engineering contractor Volker Stevin Ltd, DEME environmental contractors (DEC) and SITA Remediation.

The reclamation and remediation is being funded by the Homes and Communities Agency (HCA) through the National Coalfields Program. This redevelopment process started as early as 1999 with the emptying of above ground storage tanks and the dismantling of the above ground infrastructure

"The site was subject to significant demolition and clearance work but was left with a host of contamination problems..."

and buildings. The site was subject to significant demolition and clearance work but was left with a host of contamination problems below ground including the remaining sub surface infrastructure and contaminated soil and groundwater.

The completed project will create a substantial development platform for residential plots and employment

"The remaining three quarters of the site, once remediated, will be returned to the community for various uses..."

space for light industry. The remaining three quarters of the site, once remediated, will be returned to the community for various uses, including open spaces, sports pitches and a nature reserve, creating high quality habitats for a wide range of local flora and fauna including water voles, bats, butterflies, great crested newts and many other species.

Complex remediation challenge

The volumes associated with the project are unprecedented in the UK remediation sector: over 2 million cubic metres of material are being excavated with a significant volume of this having to be processed. Within this over 100,000m3 of contaminated sedi-

ments from the site's silt lagoons are also being processed.

The lagoons were originally built either side of the River Rother which passes through the site and there

"The range of contaminants and the breadth of physical variation of the material have called for a number of different remediation techniques."

is a waste tip above one of the lagoons. The range of contaminants and the breadth of physical variation of the material have called for a number of different remediation techniques. The site's thermal desorption plant is the largest in the UK and utilises advanced 'off gas' treatment and filtration systems. The thermal desorption plant has been designed and fabricated by VSD to be exceptionally efficient whilst delivering the requirements of the project and the state of the art plant meets all the agreed UK regulations on emissions.

Two large aerated bio beds treat a further 75,000m3 of hydrocarbon contaminated material and an innovative onsite water treatment facility employing a combination of chemical oxidation and biological degradation treat the cocktail of phenols, thiocyanates, benzene and ammonia in the waters. Other operations include the manual sorting of 237,000m3 of tip materials. This reuse in conjunction with the reuse on site of material from the thermal description plant and the bioremediation treatments allows a very high percentage of all the excavated materials to be reused on site with only a very small fraction of material leaving the site for landfill. This reuse of material on site removes the need for imported materials and saves many thousands of lorry movements, thereby reducing emissions and traffic congestion.

Further information on the Avenue is available at www.theavenueproject.co.uk.

The role of analytical chemistry

Soil and water analysis at the Avenue performs two key functions. Firstly, to inform the management of the treatment processes and secondly to provide verification that either treated soils meet with the required specification or that treated water complies with the sites discharge permit.

"The turnaround time for analysis is critical... results for most of the analyses are required within 5 days..."

"The turnaround time for analysis is critical" says earthwork planning engineer Steve Dobson, "results for most of the analyses are required within 5 days, so that we can plan remediation activities accordingly. It has been necessary, therefore, to work in close partnership with the technical staff at Alcontrol to ensure the delivery of timely analytical data".

"The online @mis system has helped enormously to provide us with fast results from what we call 'sentencing testing' - tests that help determine the appropriate method and level of remediation. In addition, the facility to schedule analytical work means that we get the data we need to maximise the efficiency of the remediation work, which helps to minimise cost."

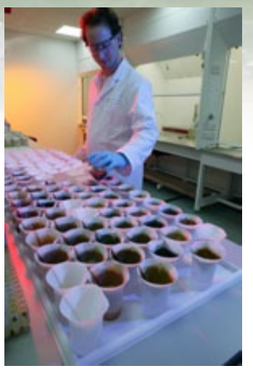
"We worked very closely with Alcontrol to develop a bespoke testing strategy to ensure compliance with the projects requirements and the ability of the @mis system to export in AGS format has helped us to manage the enormous volume of data that is being produced."

The analytical process

Staff at the Avenue utilise @mis to schedule analytical work by pre-ordering sample containers that are bar-coded before delivery. Using the online system,

"...each samples details are associated with the individual barcode so that once the sample is collected it can be transported straight into the laboratory..."

each samples details are associated with the individual barcode so that once the sample is collected it can be transported straight into the laboratory without any logging in or acceptance delays - this saves around one day on average. The samples are simply scanned on arrival into the Alcontrol LIMS (laboratory Information Management System), which manages the analytical process and the samples are then immediately passed to the preparation area.



Samples are transported in chilled cool boxes to the laboratory and the temperature is checked by a remote infra-red thermometer on arrival. Sample delivery normally takes place at 6am on the day following sampling. Samples from the Avenue are analysed at Alcontrol's Chester site utilising a range of technologies including GCFID, GCMS, ICP and HPLC and data is downloaded automatically into the LIMS. Following analysis, online results are immediately available via @mis, from which it is also possible to print test certificates.

The Avenue presents an interesting analytical challenge both in terms of the volume of samples and the range of contaminants to be tested. However, two of the main advantages to be gained from an organisation the size of Alcontrol are an ability to manage an extremely high volume of samples and the analytical resources to be able to measure almost anything - Alcontrol laboratories are ISO 17025 and MCERTS accredited for a broad range of analyses and provide over 3,000 different tests.

Looking Forward

The utilisation of the internet to provide analytical data has been given a high priority at Alcontrol and as a result, eight full-time IT staff are employed to continuously improve the @mis system in line with requirements that are driver by customers and end-users. For example, the team has recently developed a capability for @mis to automatically issue notification to mobile phones when results exceed assessment criteria or pre-set alarm levels. Fast results are clearly essential to effective site investigation and efficient remediation, and for this reason the number of consultants and contractors benefiting from the @mis online system is growing rapidly. ■

drilling specialists - can you walk the walk?

drilling

contents

Writing for **theGeotechnica** once again is Equipe Training's Julian Lovell. In this issue, Julian discusses the apparent decline in drilling standards as an entire generation of drillers begin to retire.

There is a lot of talk about the declining quality of drilling and loss of skills as the 'old boys' retire but do we really understand how we can measure this and if proven improve it?

So the first question has to be - do we have a problem? Let's share a few anecdotes: There was the one about the cable percussion driller who still after 30 years on the handle back taps his U100 hammer after every blow to ensure that it never gets stuck – unsurprisingly he always recovered 'laminated' clays; there is the one about the driller who left all his samples outside in the frost because it was the Engineer's job to collect them;

"...there was the one where the Terrier rig was carrying out SPTs but the rig was actually set up to carry out a DPH.."

there was the one where the Terrier rig was carrying out SPTs but the rig was actually set up to carry out a DPH (50kg dropping through 500mm) and always had been set up that way; there was the one where the driller always used the same core barrel and type of bit on every single job, and there was…

Those of us, who have been around a while, will recognise the good drillers who still take pride in their work and try to always do a good job. They diligently complete their logs, carry out all of the tests to the Standards, take care of their samples and always let the right people know when there are queries or problems. The best ones even tell you what they can do to solve the problems. These drillers should be cherished by their employers and encouraged to pass on their knowledge and experience to the drillers of the future but in reality these are often the drillers who make the money. In the current climate, their time is precious and when work is scarce or keenly priced these are the key people to generate some revenue out

"... how many of these good drillers have a complete understanding of current technical and health and safety requirements?"

of the jobs. However, how many of these good drillers have a complete understanding of current technical and health and safety requirements?

We have the drillers who 'talk the talk' but how many of these have truly served their 'apprenticeship'? Many have been put on the handles when they are still learning the basics and how many of these have picked up the bad habits passed on by others. Without a formal training programme this is very difficult to pick up and sort out. The Land Drilling NVQ is a good start but it really only brushes the surface and could do with a review and some tightening of the assessment criteria. The competency level set by the drilling industry could be heightened and a structured training programme could be encouraged. This should be led and supported by industry but is there any desire? It all comes at a price but is it a price which the industry can afford?

"We then have a plethora of drillers and drilling companies who own and operate drilling plant with a very varied but typically poor understanding of drilling..."

We then have a plethora of drillers and drilling companies who own and operate drilling plant with a very varied but typically poor understanding of drilling and all that comes with it. These are the individuals and companies who continually obtain poor quality samples, lose core, part casing, get tools stuck down the hole, take ages to complete the work, panic when artesian water is encountered, leave boreholes uncapped and don't understand installation or grouting principals amongst other things.

So how can we measure the true quality of the drilling – production / core recovery / technique / safety standards / complete and compliant logs / efficiency / reliability / flexibility. Well surely it should be all of the above. If a driller is having problems who is best placed to provide advice on these aspects or to know

"Who is best placed to technically assess the job against all of these aspects from a drilling perspective prior to starting the project?"

if the driller really understands the issues. Who is best placed to technically assess the job against all of these aspects from a drilling perspective prior to starting the project? Is it the Supervising Engineer / Geologist, is it the Managers or is it an experienced Driller / Drilling Specialist? These individuals all play a part in the team but which one can 'walk the walk'?

"Equipe provide Drilling Supervisors and Drilling Specialists to clients both in the UK and overseas."

Equipe provide Drilling Supervisors and Drilling Specialists to clients both in the UK and overseas. The requests have often come from clients and consultants who have recognised that the quality of the drilling aspect of the project is paramount. The trend has also been for assistance on specialist and overseas projects rather than for 'run of the mill' UK projects but can we really over look whether the basics are being covered let alone the more complicated aspects of the work.

So what did the Drilling Supervisor / Specialist bring to the table which the Site Engineers / Geologists couldn't. The answer is simple – they have been there and done it before and they speak the same language as the drillers on the ground? The two case studies below explain this in a bit more detail.

Case Study 1

Background: The drilling contractor was appointed on the basis of perceived capability which was based upon previous contracts, availability of plant and location. The Consultant was unsure of the contractor's true capability and requested some assistance at the commencement of the project.

Problems encountered: The drilling contractor was principally a mineral exploration company and although he had good plant and equipment he did not fully understand geotechnical work. Advice was provided by the Drilling Specialist on:

- Measuring the depth of the boreholes using tapes
- Using a dip meter to record water levels
- Using stepped surface set bits instead of impregnated bits
- Extracting the core horizontally
- Placing the core in the box in the right order
- COSHH statements for polymer being added
- Pre-ordering equipment
- Carrying out in situ tests and packer tests

1. Hands on advice from Drilling Specialist on the ground

2. Advice on suitability of rigs and their capability is essential.

3. Proof that core can be recovered in poor ground conditions with expert advice.

Case Study 2

Background: The drilling contractor was appointed by the client to complete a ground investigation for

"The Consultant insisted that some rotary coring was added to the project as well as the wash bored boreholes."

an extremely large airport extension. The Consultant insisted that some rotary coring was added to the project as well as the wash bored boreholes. He was allowed a total of three cored holes and therefore recovery was imperative.

Problems encountered: The drilling contractor was not sufficiently experienced in rotary coring but on paper had the capability. The Drilling Specialist provided advice on all aspects of rotary coring including:

- Type of rotary rig, core barrels and bits
- Type of flush and suitability of existing pumps
- How to strip a core barrel down and maintain
- When to reject a damaged core bits
- When to reject bent or damaged drill equipment
- How to spot when the core barrel needs adjusting

1. Initial rig and site set up - have you ever had that gut feeling that it's not going to work!

2. Rig and set up after consultation with Drilling Specialist (rig changed to a Casagrande C6)

3. Good quality core recovered after Drilling Specialist made the Contractor unseize the core barrel

For both projects, the Consultant believed that the Drilling Specialists had achieved what their Supervisor's could never have achieved. The ability to have an experienced person who could not only 'talk the talk' but 'walk the walk' made the real difference. Not only could they talk drilling but, if needed, they could jump on the handles and show them and they could pick up a set of chain dogs or a cuff wrench and split a core barrel down. They could set up a flush system and explain why damaged equipment had to be discarded. The hands on is not the important bit it's the total understanding of the drilling process which Engineer's and Geologists will not have. The experiences of these projects are not limited to overseas and can unfortunately be seen on many UK drill sites today. Also what some of us would consider to be 'run of the mill' UK projects are no longer the case as inexperienced drillers can still make a hell of a mess of these.

"The message is clear that there is no substitute for real experience..."

The message is clear that there is no substitute for real experience and the drilling industry needs to take stock of where it is right now. Who are the drillers of the future? How are they obtaining their experience? Should we be trying harder to instigate structured training and move the industry forward? In order to achieve this we must utilise the experience we already have in the industry and create a robust training platform which will breed the future Drilling Supervisors and Specialists.

In the meantime, isn't it nice to know that we still have a few drillers who can 'walk the walk'. ■

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Conference Programme

Wednesday 4th July

Session 1: Standards and Codes (Chair - Dr John Powell)

10:00 - 10:30 **Dr John Powell** - *Eurocode Update*
Technical Director, Geolabs

10:30 - 11:00 **Derek Smith** - *The New Yellow Book - What's the difference?*
Coffey Geotechnical

11:00 - 11:30 **Dr Kieran Dineen** - *Which form of conract now?*
Terra Firma Ground Investigation

Session 2: Geology in Geotechnics (Chair - Prof Rory Mortimore)

11:30 - 12:00 **Prof. Rory Mortimore** - *What next for The Chalk?*
ChalkRock Ltd

12:00 - 12:30 **Keith Banton** - *Ground Gases and the Coal Measures*
The Coal Authority

12:30 - 13:00 **Dr Jackie Skipper** - *The Geology of the London Basin*
Geotechnical Consulting Group

Session 3: Improving efficiencies and data handling for Site Investigation (Chair - Peter Reading)

14:00 - 14:30 **Digby Harman** - *Digital data - From rig to report: benefits and opportunities*
Soil Engineering

14:30 - 15:00 **Dr Roger Chandler** - *The 5 biggest problems you must avoid when working with geotechnical data.*
Keynetix Ltd

15:00 - 15:30 **Peter Reading** - *Sampling Integrity and Laboratory Testing*
Equipe Training Ltd

Thursday 5th July

Session 4: Geo-Environmental Engineering (Chair - Prof Paul Nathanail)

10:00 - 10:30 **Prof. Paul Nathanail** - *Sustainable Remediation*
LQM Ltd

10:30 - 11:00 **Jamie Cutting** - *Shaking Up Contaminated Land: The role of Applied Geochemistry*
Chemtest

11:00 - 11:30 **Seamus Lefroy-Brooks** - *Asbestos: A time bomb waiting to happen*
LBH Wembley

Session 5: Geotechnical Engineering (Chair - Peter Reading)

11:30 - 12:00 **Neil Smith** - *Piling Platforms and Temporary Works*
AGE

12:00 - 12:30 **Dr Mohsen Vaziri** - *The Geotechnical Engineering Challenges of Off-shore Wind Farms*
Ramboll

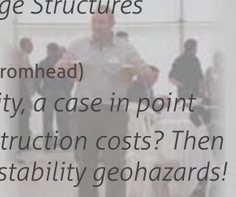
12:30 - 13:00 **Dinesh Patel** - The *Geotechnical Challenges of Large Structures*
Arup Consulting

Session 6: Geohazards and Risk Management (Chair - Prof Eddie Bromhead)

14:00 - 14:30 **Prof. Eddie Bromhead** - *Geohazards- Slope stability, a case in point*

14:30 - 15:00 **Dr Clive Edmonds** - *Want to avoid extra over construction costs? Then don't forget about ground instability geohazards!*
Peter Brett Associates

15:00 - 15:30 **Paul Maliphant** - *Risk Management: Can you afford not to?*
Halcrow



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OHSAS18001 - look closely, it may not be all it seems!

safety issues

contents

Writing for **theGeotechnica** once more, Tom Phillips, an independant chartered occupational safety professional from RPA Safety Services, discusses the increase in false accreditation of OHSAS 18001.

Having looked at a wide variety of management systems over the years and being continually asked if OHSAS18001 is 'something we should go for' it's worth examining the relevance of this and other management systems. In this competitive environment, where costs are under pressure, can they pay for themselves and what reliance can be placed on those companies claiming to be compliant? This article doesn't just apply to 18001, but equally applies to other standards such as 14001 and 9001.

The first thing to say, to get it out of the way if you will, is that OHSAS18001 has little to do with keeping people

"...18001 is nothing more than a management system... aimed at continual improvement."

safe! A controversial statement possibly, but 18001 is nothing more than a management system, aimed at continual improvement. It is up to the organisation to make it work for them and if done right, it should have a dramatic improvement on the 'management' of the safety within the company. Over the years I've audited many companies with 18001 who have glaringly obvious safety issues, but the point is once these issues have been identified, a good 18001 management system makes it more likely they will be resolved and managed.

"In essence, 18001 puts pressure on the organisation to act on the findings of audits, risk assessments and recommendations from competent advice."

In essence, 18001 puts pressure on the organisation to act on the findings of audits, risk assessments and recommendations from competent advice. Failure to act on these findings or to changes in legislation may result in loss of accreditation or at the least, significant non-conformance – hence the success of management systems. They compel companies to act and demonstrate leadership commitment and for this reason HSG65 (HSE guidance on management systems)

"A good management system might just ensure you spot shortcomings in your safety management systems..."

is currently being updated to incorporate 18001. A good management system might just ensure you spot shortcomings in your safety management systems and address them before they result in accidents. Having a good management system in place, is also a good indication that you may be able to defend any prosecution of corporate manslaughter, should the unthinkable happen.

So what value the certificate on the wall? Well, it depends

"Did you know anyone can look at your management system and issue you a certificate saying it complies with 18001?"

on what it actually states! Did you know anyone can look at your management system and issue you a certificate saying it complies with 18001? It's a little bit like asking a friend to diagnose an illness on the basis they once spent time in hospital! There are many companies selling safety compliance and offering management systems advice, along with 'compliance certification' which looks good and ticks a box. But be aware, many of these companies have no background in health and safety and are often expanding their certification options on the back of their ISO quality systems work. It isn't illegal, but is it morally justifiable? The Government doesn't think so. The Lord Young review of safety, completed in 2010, established a register to which competent safety advisers should belong. Although not legally binding, the review indicated that companies who take advice on safety systems from well intentioned amateurs, may not be doing themselves any favours.

Similarly, 18001 'accreditation', under the terms of UK Regulation, can only be obtained (in the UK) from a company underwritten by the United Kingdom Accreditation Service (UKAS) by virtue of regulation. Claiming false accreditation may be in breach of the Business Protection from Misleading Marketing Regulations 2008 (Statutory Instrument 2008/1276) and result in fines and prosecution. The same applies to other management systems such as 14001 and 9001.

"If it says 'in compliance with' or 'certificated to' 18001 then you may find it has been carried by non accredited auditors."

So check the wording of your certificate carefully. If it says 'in compliance with' or 'certificated to' 18001 then you may find it has been carried out by non accredited auditors. Although this does not mean your system is poor or not in compliance, it may mean it won't stand full scrutiny and may not satisfy the standards suggested in the forthcoming revision of HSG65. This could also be an issue for those companies selecting and recruiting contractors on the basis they have 18001, 14001 etc. In such cases, where the words 'accredited' are missing, it is worth checking their systems closely, as you may be putting your business at risk.

"The number of UK organisations offering such non-accredited certification has expanded tremendously over the last few years..."

The number of UK organisations offering such non-accredited certification has expanded tremendously over the last few years as the commercial importance of these schemes has come to the fore. But recent incidents where failings have been found at companies claiming conformance to standards, have lead government departments such as the Department for Business Innovation and Skills (BIS) and DEFRA, to advise care when selecting compliance schemes and when declaring 18001 compliance status. DEFRA have welcomed the progress that has been made by UKAS to strengthen the accreditation of certification bodies and the development of an international standard, ISO 17021, on conformity assessment. The 17021 standard sets out the requirements for bodies providing audit and certification of management systems and incorporates new guidance, produced by the European Cooperation for Accreditation.

In summary then, any management system can be claimed to be in compliance with a standard, but only those externally audited by a Certification Body accredited by the United Kingdom Accreditation Service (UKAS), can truly be thought to measure up without further scrutiny. We all like value for money, but is what you are paying for truly of value? ■

contents

Writing on behalf of GEOLABS Limited, Chris Wallace writes for **theGeotechnica** about effective stress testing. This second part looks at practical considerations when specifying and performing effective stress testing, and what the results mean.

Drained or Undrained Revisited

In Part 1 we looked at what happened during compression to the pore pressure for an undrained test (rise followed by fall), and volume change for a drained test

"The main reason for performing an effective stress test is to determine the effective stress parameters..."

(squeezed out then drawn in). The main reason for performing an effective stress test is to determine the effective stress parameters: cohesion and angle of friction. Whether you require undrained parameters:

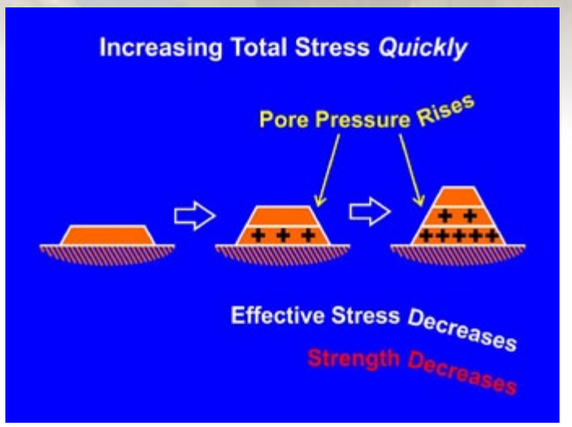
Undrained
cohesion: c'
angle of friction: φ' (phi')

…or whether you need drained parameters:

Drained
cohesion: cd
angle of friction: φd (phi)

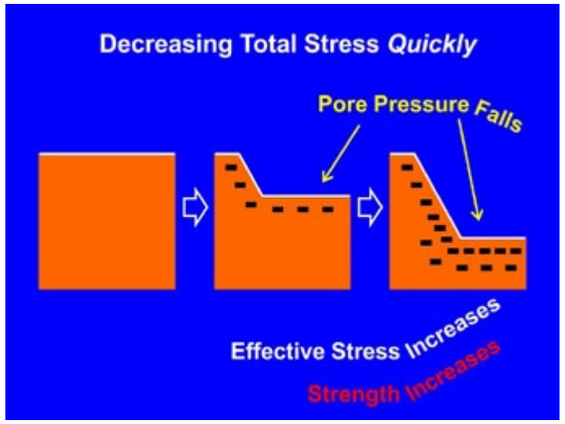
…depends on your specific project. This is not a course on soil mechanics, but the following should give the uninitiated an idea of why we need both test types.

Building an Embankment
Imagine we are building an earth embankment with cohesive material. During the relatively short period of construction the increase in pore pressure generated by the overburden can't be dissipated as quickly as it is formed:



Over a long period of time, however, the water can flow away and the excess pore pressures can dissipate, allowing a higher shear strength than during the construction phase. So we can see that in this scenario that the critical stage with the lowest strength is during construction. Here there is insufficient time for the excess pore pressures to drain away – so an **undrained test** is what we need to give us those undrained c' and φ' parameters.

Excavating a Slope
In this example we see that rapidly reducing the overburden causes the pore pressure to drop:



The increased effective stress caused by the dropping pore pressure helps to increase the strength. The problems come when water from the surrounding area is drawn in, allowing the pore pressures to equalise and

"...our concern this time is with the long term prospects, not the construction phase..."

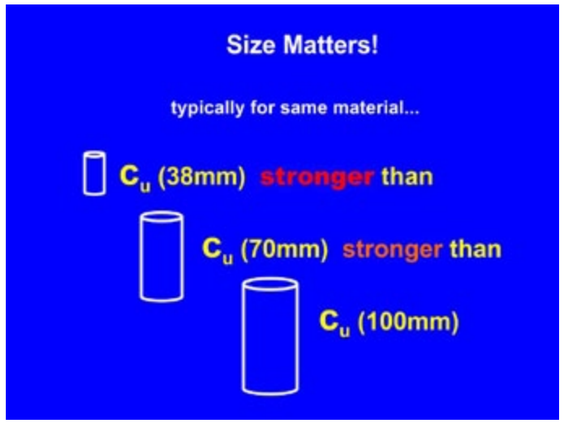
the strength to drop. So our concern this time is with the long term prospects, not the construction phase – a **drained test** gives us those long term drained cd and φd parameters.

Size Matters!
So we know the basic type of test to specify, but what size should we specify? There are several issues that are relevant to this. From a quality point of view, the bigger the better: the more insitu structure and features we can include in the specimen, the more representative the result will be. If we consider our 100mm diameter undisturbed Class 1 sample (sample disturbance and what constitutes a Class 1 sample is topic all on its own!) of stiff fissured clay, it is highly likely there would be fissures within a triaxial specimen taken from that sample.

Reducing the Diameter
If, however, we sub-sample it down to give 38mm diameter specimens then there is a good chance that we will have fewer or no fissures. It is easy to see why if we consider how it is prepared: even if you've picked a good laboratory that soil-lathes the specimens (the laboratory equivalent of cutting layers off a kebab!) rather than defiling your samples by pushing in 38mm tubes (with the horrendous disturbance that can cause), there is still the possibility that during trimming

"That fissure, which had been present insitu, would be excluded from the final specimen."

the material will come apart at a fissure. That fissure, which had been present insitu, would be excluded from the final specimen. I'm sure many of you have seen an apparently anomalous quick undrained triaxial test result where a very stiff clay has given a low shear strength. This could well be the case for a fissured material where the specimen has failed along a fissure, rather than giving the high result expected had the shear plane been formed in intact material.



So be aware that different size specimens could give different results for the same material.

Stick With 100mm Diameter?
This might make you think that 100mm samples are the way to go. In an ideal world, yes, but cost and test time might temper that decision. Let's have a recap on what an effective stress test involves:

1. Prepare specimen and set up in a triaxial cell
2. Saturate the specimen to ensure any air voids are filled with deaired water (water that has had dissolved air removed from it)
3. Consolidate the specimen (squeeze water out) to a known effective stress.
4. Shear the specimen at a speed slow enough that pore pressures are equalised throughout the specimen for an undrained test at the point of failure, or that excess pore pressures are not generated throughout the test for a drained test.

During saturation, raising the cell pressure alone may not give a saturated response. In this case we would

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need to introduce water into the specimen in a controlled manner to fill any air voids if. If we let water in at one end only (usually at the top since we measure the pore pressure at the bottom) then to saturate the base of the specimen water has to travel through the specimen's entire length. The larger the sample,

"We can reduce the time taken by fitting paper filter drains around the periphery of the specimen."

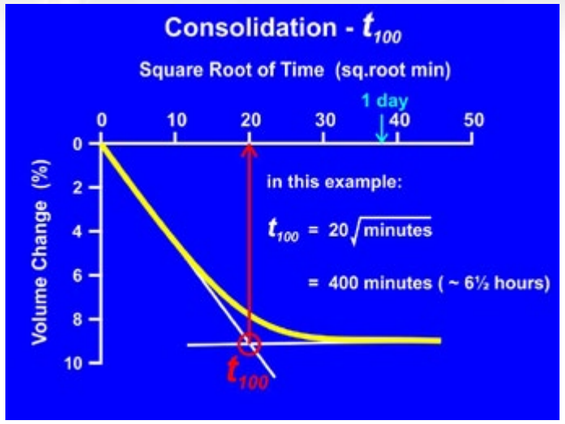
the longer this takes. We can reduce the time taken by fitting paper filter drains around the periphery of the specimen. These allow the water to get easier access all around the specimen. Now, instead of having to travel the whole length of the specimen, the water only needs to get from the periphery to the central vertical core: a quarter of its original journey. All well and good BUT a 100mm diameter specimen will still need water to flow 2½ times further than a 38mm diameter specimen. Consequently larger specimens can easily take longer to saturate than smaller ones.

"Exactly the same arguments apply as for saturation, except we now want to let the water out."

The next stage is consolidation. Exactly the same arguments apply as for saturation, except we now want to let the water out. With impermeable clay samples of low silt content this can make a big difference to the stage duration: 1 day for a 38mm specimen can become 3 days or more for a 100mm specimen.

Shearing Speed

The rate at which the specimen consolidates has a knock-on effect for the shearing stage. When we plot the volume change during consolidation against the square root of time we usually get a graph with a straight line portion at the beginning. Where this straight line intersects a horizontal line at the final volume change gives us our t100 value (the time at which, theoretically, excess pore pressure is 100% dissipated):



"This t100 value is used to calculate the shortest allowable time to failure..."

This t100 value is used to calculate the shortest allowable time to failure (at which point pore pressures will be equalised throughout the specimen for an undrained test, or almost no excess pore pressure generated for a drained test). It is multiplied by a factor which depends on the test type and the drainage conditions. For example, for a specimen fitted with filter drains and drained through the top cap the factor is 1.8 for an undrained test, and 14 for a drained test. By multiplying the t100 value by this factor you can see we get 400 minutes x 1.8 = 12 hours for an undrained test or 400 minutes x 14 = around 4 days for a drained test. If the example graph was for a 38mm diameter specimen, then going up to a 100mm diameter test

"...4 days becoming 12 days for a drained test could well push you over budget..."

could double or treble the time required: 4 days becoming 12 days for a drained test could well push you over budget and/or behind schedule if you have not anticipated these consequences.

Talk to Your Lab

A good laboratory will discuss the options with you and be able to give you an idea of the anticipated test durations and associated costs once you've described the material type and test(s) being considered.

Sets of 3 or Multistage Tests?

Unless you do not require the cohesion and angle of friction, you will want results from shearing stages performed at (usually) three different effective consolidation pressures. These will enable a set of Mohr's Circles to be constructed to give you your effective stress parameters (undrained: c' and φ', or drained: cd and φd). To have three effective consolidation pressures you can either:

- Test three specimens, each specimen at a different effective consolidation pressure

or

- Test one specimen, but perform three pairs of consolidation/shearing, starting at the lowest pressure and finishing at the highest.

Three Specimens

The three specimens option is given in BS1377 and, if performed on three 100mm diameter specimens, is technically the best option. However, you will not get three 100mm diameter x 200mm long specimens from a 450mm long U100 or UT100 sampling tube. Probably more off-putting, though, is the cost – more on that shortly.

Multistage
The multistage option is described in Ken Head's "Manual of Soil Laboratory Testing – Volume 3". This method essentially follows BS1377, but stops the first and second shearing stages before a shear plane has formed. After each of those early shearing stages the specimen is unloaded and reconsolidated to the next effective consolidation pressure before the next shearing

"This requires the least material, but takes the longest test time..."

stage. This requires the least material, but takes the longest test time since the consolidation and shearing stages are performed consecutively on a single specimen, rather than all three specimens being able to be tested simultaneously. The multistage test has the advantage that you only have one setup charge and one saturation stage, so that part is not duplicated (with its corresponding costs). The main downside of the multistage test comes when we want to test impermeable clay samples.

Ever Increasing Durations
The first consolidation stage will increase the packing of the particles comprising the material and so reduce

"This means the next consolidation stage will be slower since the water to be squeezed out will have a more difficult path to follow."

the specimen's permeability. This means the next consolidation stage will be slower since the water to be squeezed out will have a more difficult path to follow. The third stage will be slower still since the second consolidation will have squeezed the particles together even tighter. On a sand sample this will have little impact: the permeability is so high that the time to failure will probably have to be increased to meet the BS1377 recommended minimum shearing time of 2 hours. The minor reduction in permeability will very likely still result in shearing stages taking less than a day each, so no increased duration or cost. However, for a 'fatty' pure clay the durations can increase dramatically from, say, 2 days consolidation for stage one up to 8 days for stage three. The t100 values will get progressively larger also, so increasing the durations of the later shearing stages.

Sand Samples – Good for Multistage Tests
A 100mm sand specimen might take 7 days for a single stage test, or 11 days for a multistage test. The small difference of 4 days is due to the extra one day each for the additional consolidation and shearing stages. The extra days of the multistage test would cost considerably less than the cost of the other two specimens

"Consequently, multistage tests are a cost effective option..."

comprising a set of three. Consequently, multistage tests are a cost effective option for where the material is a sand or at least of comparatively high permeability. This is equally true for drained or undrained tests: the high permeability keeps the shearing stages short, regardless of drainage conditions.

Drained Multistages – Very Slow for Clay
The reduction in permeability mentioned previously can have a dramatic effect on a drained multistage test on clay. The lengthening consolidation stages and associated slower shearing stages can change the 12 day duration of a single stage test to a 30+ day multistage test. The cost benefit of the multistage test's single saturation stage can be wiped out by the significantly longer overall test duration. The only advantage of the

"In comparison, a set of three 38mm specimens is a good choice in terms of cost and turnaround..."

multistage test is that it uses less material. In comparison, a set of three 38mm specimens is a good choice in terms of cost and turnaround since the shorter drainage paths of the smaller specimens help every stage

"...you have to be aware that the potential lack of macro features (fissures etc.) could give different results..."

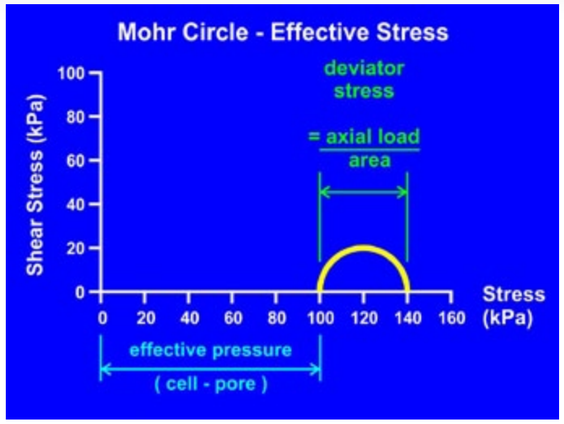
progress more quickly. However, you have to be aware that the potential lack of macro features (fissures etc.) could give different results to tests performed on larger specimens. It may be that 38mm specimens are not possible or suitable anyway: BS1377 puts a limit on the particle size allowable of a 1/5th of the specimen diameter. This limit means that 38mm specimens would not be suitable for samples having an appreciable amount of gravel larger than 8mm.

Practicalities
The previous two examples show the extremes in permeability. A sandy or silty clay would lie somewhere in between: this makes the choice much less clear cut on cost and may come down to practical considerations such as:

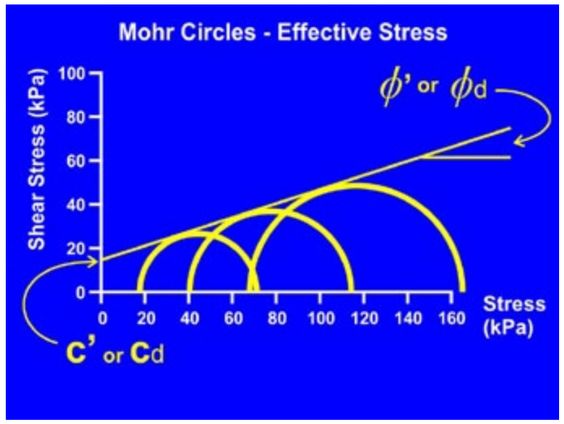
- How much material you have: limited material may force a set of three 38mm or a single 100mm multistage.
- Time constraints may require three specimens to be tested consecutively rather than going for a more cost effective multistage
- Gravel content may rule out smaller diameter specimens.
- Availability of different diameter triaxial cells at your chosen laboratory may favour a particular route.

Ask your friendly laboratory to guide you through this potential minefield and help you select the best option.

Mohr's Circles
You chose your tests and the lab has sent your results: what do they mean? One of the graphs presented is a set of Mohr's Circles. The diameter of a circle represents the axial stress (axial load, excluding cell pressure, divided by the cross sectional area), and its distance from the origin represents the effective stress:

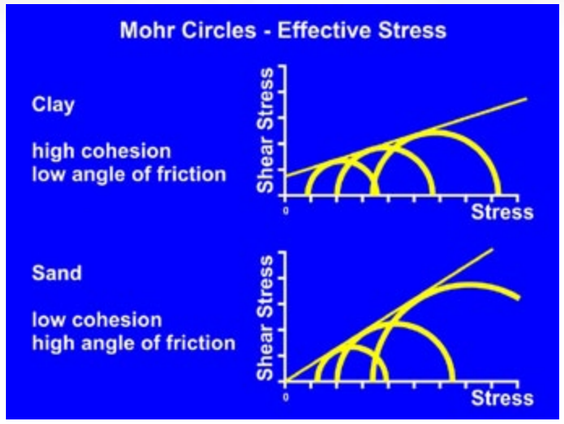


When we plot three circles representing the failure condition from each of three specimens or stages then we can fit a tangent to them. The angle of the tangent to the horizontal is the Angle of Friction, and the intercept of the tangent with the y-axis is the cohesion:



You may find it interesting to note that BS1377 refers to the effective stress parameters for both drained and undrained tests as c' and φ', whereas in other literature the drained parameters are often identified with a 'd' subscript (cd and φd). Even though the cd and φd parameters don't have the dash to signify that they are effective stress parameters, by their definition drained

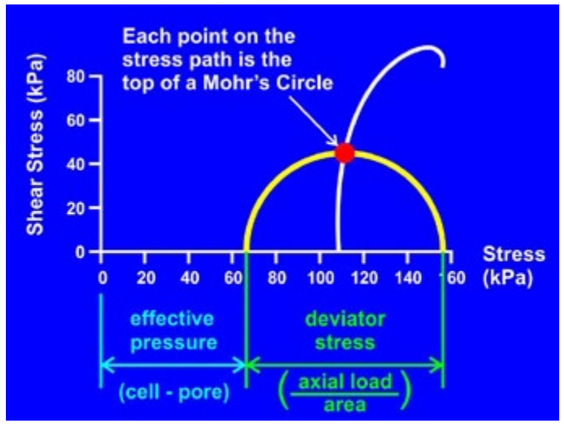
tests must give be effective since there is no excess pore pressure. The type of material tested determines the angle and position of the tangent:



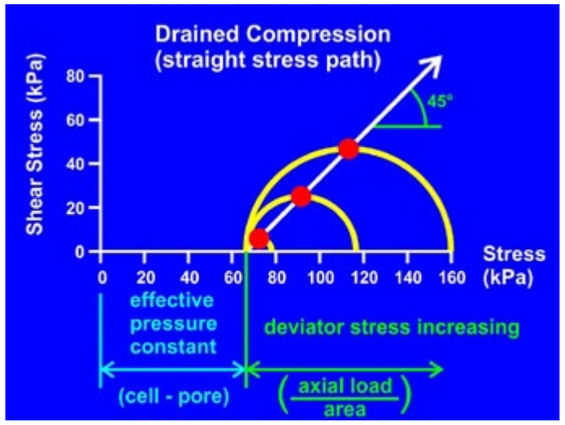
Now that you have been introduced to Mohr's Circles, we can progress to the stress path plot.

Stress Paths

The key to this plot is that it can be thought of as the tops of a whole series of Mohr's Circles covering the whole shearing stage from beginning to end (rather than having circles at just the failure condition):

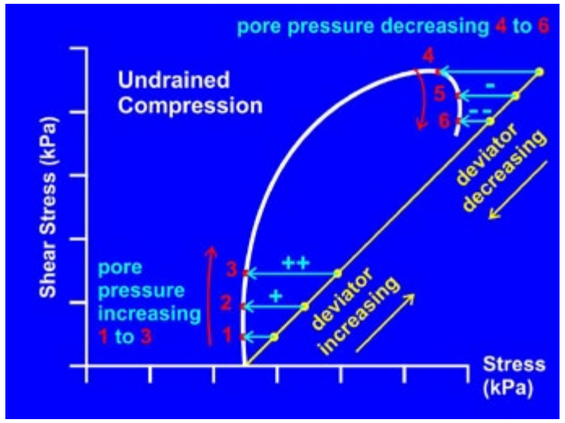


If we consider a drained test, the shearing stage starts with a positive effective pressure (created by the consolidation stage) but zero shear stress (we haven't started loading yet). As we apply the load the shear stress goes up (so the circles get bigger), but the pore pressure stays constant (because it is drained). If the pore pressure stays constant, then so does the effective stress: this fixes all the circles so they all have the same left-most starting point:



"For an undrained test any increase in pore pressure decreases the effective stress..."

For an undrained test any increase in pore pressure decreases the effective stress and so pulls the circle to the left (towards the origin). So we can think of an undrained stress path as the combination of the 45° line from the drained test, together with a displacement to the left from any pore pressure increase:



Failure Criteria

We usually take the calculated time from the consolidation stage (t100 x factor) as being to the failure condition.

"...if you are particularly interested in the shape of the stress path curve then you should let the laboratory know from what axial strain you are interested in."

However, if you are particularly interested in the shape of the stress path curve then you should let the laboratory know from what axial strain you are interested in. This is because it is only after that calculated time that we can we rely on the pore pressures being equalised throughout the specimen. Any sooner and there may be a difference between the pressure we measure at the base and the actual pore pressure where the shear plane would develop. This difference could cause the stress path to displace to the left or right of where it should be. If you are interested in the stress path from, say, 0.5% axial strain, then we would set the shearing speed so that 0.5% strain was reached in the calculated

"The downside of this is that if you have chosen 0.5% as your 'significant strain interval'... then taking it to failure at around 5% will take ten times longer."

time. The downside of this is that if you have chosen 0.5% as your 'significant strain interval' (as it is called in BS1377), then taking it to failure at around 5% will take ten times longer.

Do's and Don'ts

Don't specify CU on a triaxial test schedule (which the laboratory may interpret as "Consolidated Undrained") if you actually want c_u (undrained shear strength) from a quick undrained (UU) triaxial test. This can be a costly mistake if you get a £500 effective stress test when you only wanted a £20 to £30 total stress test!

Do use a laboratory UKAS accredited for effective stress tests. If the laboratory has accreditation, check it covers the tests you require (some laboratories get

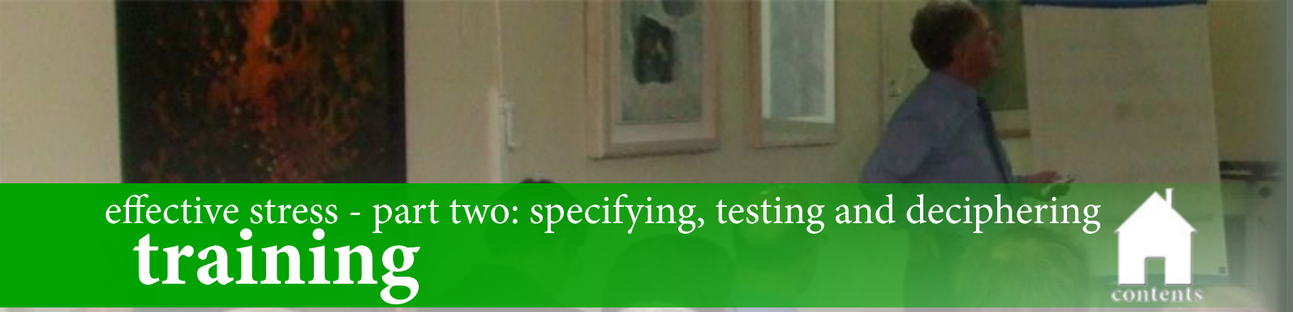
"The onerous requirements that UKAS place on an accredited laboratory help to ensure that your valuable specimens are tested correctly."

accreditation for just the simpler tests). The onerous requirements that UKAS place on an accredited laboratory help to ensure that your valuable specimens are tested correctly.

Do specify ALL the parameters the laboratory needs at the time of scheduling:

- Test type: Drained or Undrained
- Specimen type: single, set of 3, or multistage
- Specimen size: usually 38mm or 100mm (although other sizes can be accommodated)
- Effective consolidation pressure(s)
- Remoulding parameters (if applicable)
- Whether filter drains should be used
- Which failure criteria you wish to be adopted:
  a) maximum effective principal stress ratio - often shortened to just 'maximum stress ratio'.
  b) maximum deviator stress.
  c) when shearing continues with constant shear stress at either constant pore pressure (for an undrained test) or no volume change (for a drained test).
- Any non-standard requirements, such as shearing to 20% axial strain regardless of when the peak occurred

This avoids any misunderstandings or the possibility that your test is delayed while queries and replies go



up and down through the communication chain.

"A chemical laboratory may be able turn around 10 tests in the blink of an eye..."

Do talk to your laboratory about test choices and estimated durations and costs. A chemical laboratory may be able turn around 10 tests in the blink of an eye: an effective stress test, however, can take from 3 or 4 days to several weeks in the triaxial cell (depending on the test/material type).

Do remember: effective stress tests in particular are material dependent, in both results and test durations. Allow extra time if your material has a very low permeability.

Don't let wax impregnate a porous material when sealing an undisturbed sample. Wax that has worked its way deep into sample is almost impossible to remove without destroying the sample and will result in a testing restriction.

Do keep very soft material upright with ends well sealed when transporting undisturbed tubes. We have seen many examples where water escapes and the sample settles in the horizontal tube to give a D-shaped profile!

Do visit your chosen laboratory and ask questions. Effective stress tests are sophisticated. Being able to follow a standard is one thing: having the necessary experience and knowing how to apply it is another. Satisfy yourself that your tests are in safe and knowledgeable hands. ■

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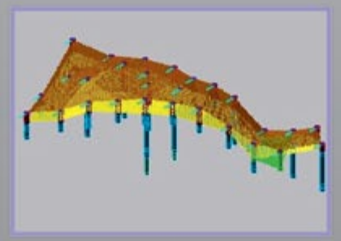
"Keynetix conducted a Data Checkup for Rodgers Leask Environmental in Feb 2011 which highlighted some shortcomings within our previous data trail. The review has saved us time, money and frustration and we recommend the service to any laboratory, contractor or geotechnical consultant."

Stewart Friel - Director - Rodgers Leask Environmental

- Paper or electronic at source
- Log production
- Sections and fence diagrams
- AGS reporting of Field data



- Site plans and GIS
- Presentation of data in AutoCAD
- 3D modelling
- Geotechnical BIM integration

- Electronic scheduling of Lab testing
- Staff, resource and sample management
- AGS reporting of Lab data
- Centralised laboratory management

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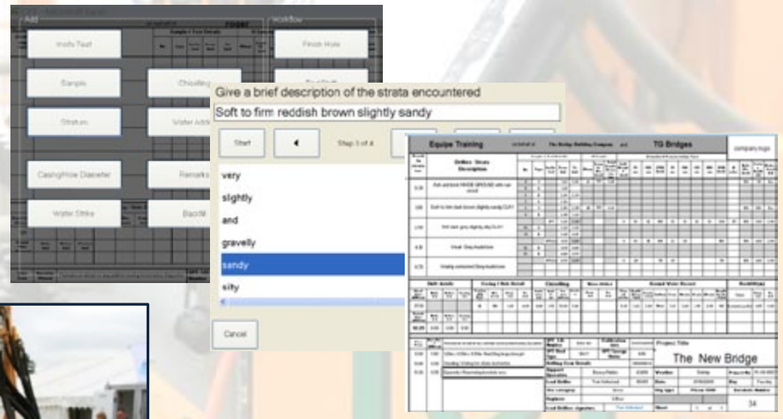

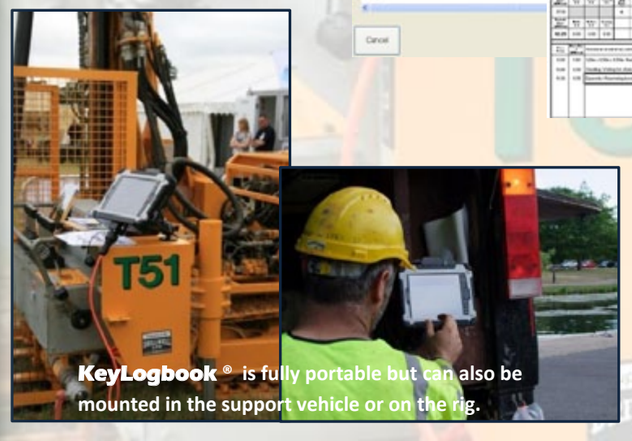

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