theGeotechnica

equip

inside this edition...

improving temporary works safety
are geogrids the answer?

tensar examine the benefits of using geogrids to aid the creation of safe, cost-effective temporary works

also included...

- how have methods of training changed?
- a look at effective stress testing
- GDS discuss the challenges involved in creating new advanced geotechnical equipment

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issue no. 11
may 2012

an introduction

Welcome to the May edition of **theGeotechnica**. This months edition has a strong laboratory flavour to it with three articles related to laboratory testing.

In the training section we have another article in a series written by Chris Wallace from Geolabs. His article will appear in two parts, and will look at the thorny subject of effective stress testing. Chris explains the numerous variations for the test and importantly discusses the information needed by the laboratory to carry out testing to provide those important parameters for design.

GDS Managing Director Karl Snelling gives an account of the difficulties faced while developing something completely new and innovative in the testing world. GDS have designed and built the first commercially available True Triaxial Test apparatus. It sounds simple and is something where the concept sounds quite straightforward but the practicalities are really very complex. Karl gives an insightful account of the development process which they overcame to produce the test frame. Karls' article is presented in the innovations section.

We have another article from Kieran Dineen on the NEC form of contract. The NEC family of contracts will appear more often in the coming months and years, being the ICE's preferred form of contract. Kieran continues his explanation of the contract and how it is intended to be used.

The Geotechnical section includes an article from Tensar which looks at the application of the geogrid to provide temporary works. The case histories offer some insight into the versatility and ability to provide solutions in many difficult situations.

As promised last month, the Environmental section discusses the potential hazard asbestos brings to the geotechnical laboratory. This is in the light of some recent revealing evidence on the frequency of asbestos in soil samples. The AGS's recent statement and re-launch of the asbestos subcommittee have heightened awareness. The article discusses the risks and looks for a solution to this issue.

Should you have any comments, views or suggestions on articles published or events within the geotechnical community, why not write or email the editorial team? We are always happy to publish the views of our readers provided they are not defamatory or blatant advertising.

It should be noted that the views expressed in any article in **theGeotechnica** are those of the author and do not necessarily reflect the views of the editorial team. Although every care is taken to ensure accuracy within articles, absolute accuracy is not claimed.

Editorial Board,
theGeotechnica

Contents: What's in this issue?

contents

This month, Tensar write for **theGeotechnica**, looking at the benefits of using geogrids to help improve the safety of temporary works.

One of the difficulties encountered by contractors in developing large civil engineering structures is access and operation of heavy plant where safe support during lifting and piling operations is a prime requirement.

For example, in a bridge crossing of a river, access to the working site may be across alluvial deposits with a high water table. With this most treacherous of soils, and with safe operation of heavy plant uppermost, a soundly-based methodology is needed to give engineers the confidence to provide working platforms.

In seeking a working platform solution that is fast, effective and low in cost, we should not forget our strong obligation to provide environmentally friendly methods with minimal use of materials.

Cost and environmental best practice

A simple, and common, solution is to lay down a heavy layer of mineral aggregate to act as a mattress; in very weak soil, this may be a case of loading the ground to refusal and the quality of support is variable

"Excavation of the weak soil and replacement with high quality quarried aggregate is also sometimes proposed."

and uncertain. Excavation of the weak soil and replacement with high quality quarried aggregate is also sometimes proposed. But this can be more costly than necessary in terms of both cash and the environmental impact associated with the carbon emissions involved in the process. Both these solutions consume large amounts of imported material, and both approaches leave a significant legacy if the materials cannot be reclaimed and re-used.

Proven time and cost savings

A Tensar MSL system, a mechanically stabilised aggregate layer incorporating TriAx® geogrid, provides that soundly- based methodology which meets a wide range of temporary working platform requirements, saves significantly on time and aggregate materials, and which requires little or no site excavation.

By exploiting the mechanical stabilisation achieved by a stiff polymer geogrid when incorporated in compacted

"...the geogrids enhance the modulus of the fill..."

aggregate fill, the geogrids enhance the modulus of the fill and therefore that capacity to carry the loads from heavy plant. The improved load spread through the mechanically stabilised working platform then requires significantly less mineral aggregate to ensure that the subgrade is not overstressed .

Technically advanced geogrid configurations, such as Tensar's TriAx™, offer the highest available stiffness solutions, and have been shown to reduce fill thickness requirements by as much as 50%.

Speed and sustainability

The resulting temporary working platform can often be installed in a matter of hours. In fact the installation time is so rapid that Tensar working platforms solutions have been used in emergency installations, where quick access for cranage and recovery was required.

"...the fill used need not be of the highest quality."

In addition, the fill used need not be of the highest quality. Locally won or reclaimed materials such as demolition rubble or colliery spoil may be suitable for creating the platform, when teamed with high performance polymer grids and properly designed and installed.

The combination of thinner layers of more environmentally suitable fill materials ensures a reduced carbon footprint for the installation.

Flood emergency

In 2009, the town of Workington was divided by the flooded River Derwent which had swept away the existing bridge. The Royal Engineers were commissioned to build a temporary footbridge within days, on a river bank comprising sandy clay soil with poor load bearing properties.

In addition to the bridge abutment supports, Tensar TriAx™ geogrid and locally sourced stone were used to construct a temporary working platform as the launch site for the bridge to be cantilevered across the river. The platform and abutment supports were constructed in 24 hours, and the river spanned within four days.

Rectifying a derailment

In another emergency situation, a freight train had been derailed on a bridge crossing The River Ouse near Ely; eleven freight cars filled with mineral aggregate had left the track, damaging the bridge and also blocking the river. The track was too unsafe to allow a close approach, and the surrounding fenland com-

prised a deep and very soft marsh.

The requirement was for a temporary working platform for a 1000 tonne mobile crane with a maximum 90m lift radius, with additional 100 and 200 tonne cranes. Sited on the bank adjacent to the bridge, these were required to lift the rail vehicles and also damaged parts of the bridge.

The Tensar Technology design comprised a 1 metre thick platform of imported aggregates mechanically stabilised with two layers of geogrid. Kier Construction noted at the time that a proof test loading at maximum reach and load resulted in a deflection of

"...30% was saved on the 20,000 tonnes of high grade aggregate that would have been needed for an unstabilised platform."

only 10mm. They also estimated that around 30% was saved on the 20,000 tonnes of high grade aggregate that would have been needed for an unstabilised platform.

Large scale projects

Tensar technology is also used on large scale projects. In 2006, the Guardsmill Bridge was constructed across the River Solway estuary to help extend the M6 northwards from Carlisle. As the bridge construction was across soft alluvium and poor ground, a 35,000m2 temporary piling platform was required, constructed from three layers of Tensar geogrid, and a platform of around 1200mm thick, compared to a conventional unstabilised platform

"This saved large quantities of fill, as well as being quicker to construct."

which could have been up to twice as thick. This saved large quantities of fill, as well as being quicker to construct.

Faster Olympic Access

The 2012 London Olympics has breathed new life into much of East London's rail infrastructure, but reuse of a Victorian corridor between Broad Street and Dalston required a new bowstring arch bridge across the Regents Canal to replace the old structure.

Piling was required to support the abutment, and the retaining structure of unconfined aggregate constructed as a temporary working platform for the 80- tonne piling rig would have been 3.5m thick. The weight of this would have threatened the integrity of the gas, telephone, drainage and other buried services in the bank of the canal.

Consultants FaberMaunsell proposed a reinforced soil solution using Maxit aggregate and Tensar geogrid technology with a compacted weight of around 300 kg/m3, which is around 80% lighter than conven-

safe working platforms needn't cost the earth

geotechnical

contents

tional mineral aggregate, and so would not disrupt the buried utilities.

Rapid, sustainable and economic

By offering a cost effective and safe method of facilitating major construction in difficult locations,

"...temporary platforms are often an essential part of project strategy."

temporary platforms are often an essential part of project strategy. However, the design and installation of these platforms needs to address safety, speed, costs and sustainability issues, as with any part of a civils project.

Geogrid based platforms have demonstrated significant advantages in low cost, rapid construction with a low environmental footprint, while offering all the performance and safety required. These benefits mean that geogrid technology should be considered wherever an aggregate platform solution is proposed to combat poor ground conditions. If you don't normally do this already, contact Tensar for the design of your next Tensar working platform incorporating a Tensar MSL.

For more information on Tensar temporary working platform solutions, please visit www.tensar.co.uk. ■

LANKELMA

Lankelma sends 20 tonne CPT truck to Christchurch New Zealand to support the Christchurch Earthquake Recovery Project

Lankelma, with its strong base in the UK and Europe, offers CPT services worldwide and has a 20 tonne all-terrain truck available in Christchurch, New Zealand as of mid April 2012.

Lankelma offers high quality CPT services utilising a range of geotechnical tools such as piezocone, seismic cone and pressuremeter to define ground conditions. Reports are customised to client needs and can range from the delivery of standard factual data to detailed interpretation of soil properties through the application of geo-statistics and CPT based analytical research.

For more info contact carltonhall@lankelma.com
or call our office on +44(0)1797280050

During 2011, Lankelma routinely worked in the UK and Europe plus overseas in Africa, China, Mauritius and Oman.

Avoiding Danger from Underground Services

This course is aimed at anybody involved in specifying, instructing, managing, supervising or actually breaking ground.

This course is definitely not another CAT and Genny course and is the only externally verified course in the UK carrying the IOSH badge.

The course is built around HSG47 and current industry best practice.

Next course dates: 31st May & 29th June

Safe Supervision of Geotechnical Sites

The three day course is designed for managers and supervisors in any organisation within the Drilling and Geotechnics sector.

The course is aimed at anyone who is or will be expected to run sites where geotechnical works are carried out.

The course meets all of the requirements of the UKCG and has been approved by The Environment Agency and Thames Water.

Next course dates: 4th - 6th June

To book your place, please contact Equipe Training:

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part 4 - what are the secondary options in NEC3 contracts?

specification and contract

contents

Writing for **theGeotechnica** once more are Kieran Dineen and Robert Gerrard from Thomas Telford Training. Here, they speak about NEC contracts and what the secondary options are when using them.

In Part 2 we looked at the different forms of NEC3 Contract currently published. If you recall, there are main contracts, subcontracts, short contracts; contracts for buying goods, works or services on a 1-off, term or framework basis.

In the subsequent notes, we will focus on the more likely NEC3 Contracts to be used in this industry. Before we get into this there's just one other drafting convention/principle to explain. In part 3 we looked at the Option structure found in the main contracts (not the short contracts). The ECC, ECS, PSC and TSC offer up a range of Options to select from that builds up the contract terms to suit the works or services. At the heart of the contract conditions are the core clauses, which contain the essential common terms. To this must be added a main Option, which will determine the particular payment mechanism. Finally, the selected secondary Options are combined with the core and main Option clauses to provide a complete contract.

This approach gives even greater choice to contracting parties to assemble the appropriate contract conditions to suit. The ECC, ECS, PSC and TSC offer different basic allocations of financial risk between the parties through the main Options and further refinements of risk through the secondary Options. ■

Secondary Option Title	ECC	ECS	PSC	TSC
X1 Price adjustment for inflation	✓	✓	✓	✓
X2 Changes in the law	✓	✓	✓	✓
X3 Multiple currencies	✓	✓	✓	✓
X4 Parent company guarantee	✓	✓	✓	✓
X5 Sectional Completion	✓	✓	✓	x
X6 Bonus for early Completion	✓	x	✓	x
X7 Delay damages	✓	x	✓	x
X8 Collateral warranty agreements	x	x	✓	x
X9 Transfer of rights	x	x	✓	x
X10 Employer's Agent	x	x	✓	x
X11 Termination by the Employer	x	x	✓	x
X12 Partnering	✓	✓	✓	✓
X13 Performance bond	✓	✓	✓	✓
X14 Advance payment to the Contractor	✓	✓	x	x
X15 Limitation of the Contractor's liability for his design to reasonable skill and care	✓	✓	x	x
X16 Retention	✓	✓	x	x
X17 Low performance damages	✓	✓		✓
X18 Limitation of liability	✓	✓	✓	✓
X19 Task Order	x	x	x	✓
X20 Key Performance Indicators	✓	✓	✓	✓
Y(UK)2 The Housing Grants, Construction and Regeneration Act 1999	✓	✓	✓	✓
Y(UK)3 The Contracts (Rights of Third Parties) Act 1999	✓	✓	✓	✓
Z Additional conditions of contract	✓	✓	✓	✓

Table 3. Availability of secondary Options in NEC3 Contracts.

should we be concerned about asbestos?

environmental

contents

In this foreword to AGS Chairman Seamus Lefroy-Brooks' statement concerning asbestos, Pete Reading of Equipe explains for **theGeotechnica** the results of new research into asbestos levels in made-ground samples.

There is nothing new about asbestos and the risks it poses - however, is the geotechnical community taking enough notice of this potentially very serious hazard? Perhaps not. Suffice to say there does appear to be sufficient concern that the AGS has decided to reform the Asbestos in soil subcommittee to consider the implication of startling new information. Recent studies

"...20% of all samples taken from made-ground for soil analysis can contain particles of asbestos..."

have shown that as many as 20% of all samples taken from made-ground for soil analysis can contain particles of asbestos, where it was originally considered that the particles were not likely to be present.

For the most part, good ground investigation practice will recognise the potential risk well before anyone sets foot on site and will have appropriate procedures in place to protect the workforce and the surrounding area from the potential hazard. Appropriate information will be passed to the testing laboratory to enable them to make appropriate decisions with respect to the test they might be asked to perform. In many cases this would mean that the laboratory would not carry out any testing on affected samples.

"... the particles we need to prevent any human contact with, are very fine..."

The difficulty arises because the particles we need to prevent any human contact with are very fine and often cannot be seen with the naked eye. On site, good practice will demand appropriate dust suppression PPE and welfare facilities in place in from the very start of site works. This is in order to eliminate the risk for site workers and the surrounding environment. The real risk will arise if the presence of asbestos is not recognised at site level and samples are recovered and sent to the laboratory for testing. It would appear that this scenario covers some 20% of the samples which are obtained within made ground.

"...the HSE would take a very dim view of any company who blatantly ignores the potential risk."

As the AGS statement indicates, the HSE would take a very dim view of any company who blatantly ignores the potential risk. The recent court ruling on how long the liability will run for is a stark reminder that we cannot put our heads in the sand and hope that the risk will go away, because even if the effect does not materialise in the unfortunate employee for several decades, the compensation claim will still need to be met by the employing company.

So what can be done to remove the potential risk to our laboratory staff? Perhaps one answer to test all made-ground samples for the presence of asbestos. By

"Surely the additional cost is relatively small compared to the potential cost which may be waiting for us?"

doing this we will remove any uncertainty. Surely the additional cost is relatively small compared to the potential cost which may be waiting for us? One thing is certain we cannot do nothing.

The AGS statement, calling for contributions if you have something to contribute either contact the AGS see below or the editorial team at theGeotechnica

FIELDWORK RISK ASSESSMENT FOR ASBESTOS

Seamus Lefroy-Brooks (Chairman AGS Contaminated Land Working Group)

28 March 2012

THE ISSUE

As a result of heightened awareness and increased screening, there are much more widespread occurrences of asbestos in soils being reported.

While this may not in itself be surprising, the HSE are likely to take a dim view of the reports that asbestos is being found in some 20% of made ground soil samples that have been sent to laboratories without any evidence of there having been any consideration of a possible asbestos presence by the site investigation firm involved.

THE LEGAL REQUIREMENT

An assessment of the likely presence of asbestos within the soils at a site is a mandatory pre-cursor to any fieldwork, for the protection of all the site investigation personnel directly involved and for the safety of others, including both the geotechnical and chemical laboratory technicians who may subsequently handle samples from the site.

GUIDANCE

While many AGS members have developed their own in-house procedures, the AGS feel that there is a need for some industry guidance and standard setting. The AGS Asbestos-in-soil sub-committee is being reformed to produce practical guidance for these assessments in advance of the EIC/CL:AIRE Code that is to be developed and the Client's Guide that is currently being prepared by CIRIA.

If you have some in-house guidance to share, or wish to contribute to the preparation of the planned fieldwork guidance, then please contact Seamus@LBH-GEO.co.uk

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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 **Andy Howley** - *Geothermal Codes: Where are we?*

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

11:30 - 12:00 **Prof. Rory Mortimore** - *Geotechnical Design in Chalk*
Independent Consultant

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 **TBA** - *Intelligent site investigation using new technology*
Soil Engineering

14:30 - 15:00 **Dr Roger Chandler** - *Data Handling from Site to Office*
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 - TBA)

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** - *Geotechnics for 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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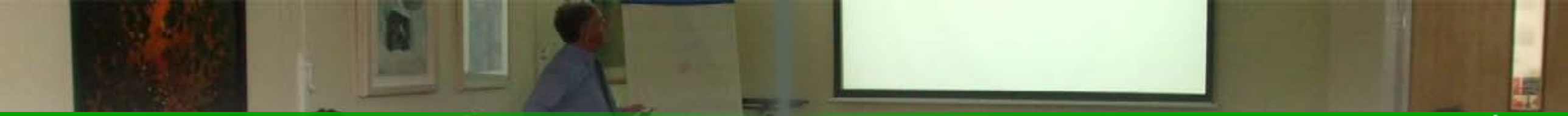
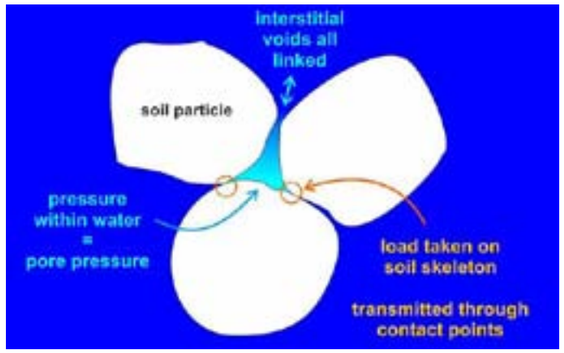


Writing on behalf of GEOLABS Limited, Chris Wallace writes for **theGeotechnica** about effective stress testing. Part one in this issue goes into what effective stress actual is, and why it matters. Part two will go into practical considerations when specifying effective stress testing.

What is Effective Stress?

At its most basic, the effective stress in a soil is the stress taken by the soil's skeleton, transmitted by particle to particle contact. As well as the stress on the skeleton, stress can also be taken by the pore fluid – the air and water in the voids between the particles. This stress is called the pore pressure.



Adding together the stress taken by the skeleton (effective stress) and the stress taken by the pore fluid (pore pressure) gives us the total stress. So in calculation terms:

effective stress = total stress – pore pressure

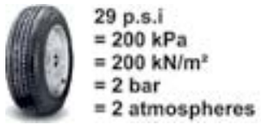
By convention we use σ (sigma) to represent a stress, with a dash added to represent an effective stress: σ' (sigma dash). The last symbol we need is u to represent the pore pressure. Using these symbols gives us the equation you'll see in text books:

$\sigma' = \sigma - u$

We usually measure the stresses in units of kPa, (kilopascals), the SI unit derived from another SI unit, kN/m² (kilonewtons per square metre). To get from imperial p.s.i. (pounds per square inch) to kPa, multiply by 6.8948.

What Does a Stress Feel Like?

For those of you, like me, who like to visualise stresses and get a practical feel for them, a typical car tyre might help:



So next time you specify a 200 kPa cell pressure on your quick undrained triaxial test, the water in the cell surrounding the specimen will be pushing with a similar pressure to pushing the side wall of a tyre with your thumb (or, equally, the weight of the car spread over the contact area of the tyres with the road).

In the laboratory

Let's consider a soil sample in the laboratory, set up in a triaxial cell:

A triaxial cell allows us to apply stresses in three axes:

σ1	vertically
σ2 & σ3	horizontally (and equal)

The horizontal stresses, σ2 & σ3, are equal since they are applied by the cell pressure, which acts in all orientations. The vertical stress, σ1, is the combination of the cell pressure and any load applied by the sliding ram via the load measuring device (either a load cell or a load ring). In the cell shown previously the pore pressure is measured at the base via a port running from the base pedestal to a pressure transducer visible towards the back left of the cell.

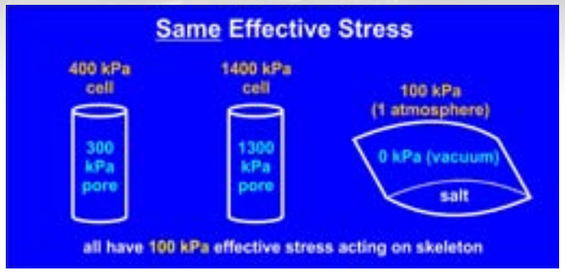
When we apply a cell pressure, a stress is put on the periphery of the specimen (which is wrapped in a latex membrane to prevent water going into or out of

"This stress causes the skeleton itself to be squeezed, increasing its resistance..."

the specimen from the confining water). This stress causes the skeleton itself to be squeezed, increasing its resistance, and the pore voids to be squeezed also, so increasing the pore pressure. Unless the specimen is soft and saturated, initial applications of cell pressure squeeze the skeleton more than the pore voids,

"The specimen can be saturated either just by cell pressure increments, or by additionally introducing water into the specimen..."

so increasing the effective stress. The specimen can be saturated either just by cell pressure increments, or by additionally introducing water into the specimen – more on that in Part 2. With water being virtually incompressible, once the specimen is saturated then further increases in cell pressure cause the pore pressure to rise, but the effective pressure to stay almost constant. So if we had a saturated specimen with 400 kPa cell pressure applied and 300 kPa pore pressure, this would give 400 kPa – 300 kPa = 100 kPa effective stress acting on the skeleton. A 1000 kPa increase in cell pressure would result in a 1000 kPa increase in the pore pressure, but the effective stress would remain constant at 100 kPa (1400 kPa – 1000 kPa)



The oddly shaped 'salt' example on the right is an experiment you can try for yourself if you have a kitchen or industrial vacuum bag sealer. Fill a bag with ordinary cooking salt or sand and then vacuum seal it. With the air surrounding the bag being at atmospheric pressure, 100 kPa, and the inside being a vacuum, 0 kPa, then the effective stress will also be 100 kPa.

"You will probably be surprised as how hard and rigid the bag of salt or sand will become..."

You will probably be surprised as how hard and rigid the bag of salt or sand will become with 100 kPa effective stress holding those particles together.

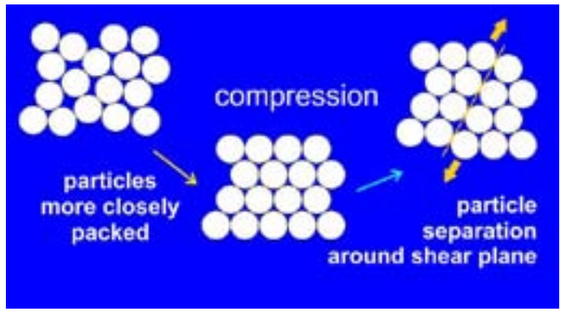
But it's Just Another Faceless Parameter…

…No it's not! An appreciation of how effective stress affects your tests can be crucial in understanding the results. Even something as familiar as walking on a beach can be explained by effective stress.

contents

We all know how difficult it is to walk on the dry sand, and how much easier it is to walk near the water's edge where the sand is saturated. The total stress, our weight, is the same for each footstep (ignoring dynamic effects). When walking on dry sand the pore fluid, air, can freely move between the sand grains, so the effective stress stays constant. However, at the water's edge the pores are saturated and filled with water. For the sand to collapse under our weight the sand particles would have to move:

"When walking on dry sand the pore fluid, air, can freely move between the sand grains, so the effective stress stays constant."



Initially the sand particles can pack together a little more tightly. This squeezes the pore voids and increases the pore pressure, so the effective stress goes down (remember: effective = total – pore). Soon, though, the sand particles can't pack together any closer - the only way to get more movement is for the sand particles to ride over one another. This requires the pore voids to get bigger at the shear plane: but they are filled with water. Unlike the air filled voids of the dry sand, water can't easily expand, so as the particles try to separate, the pore pressure plummets.

"...the only way to get more movement is for the sand particles to ride over one another."

"As the pore pressure goes down rapidly, the effective stress increases rapidly, holding the particles together..."

As the pore pressure goes down rapidly, the effective stress increases rapidly, holding the particles together and enabling them collectively to support your weight without collapse. Of course, the region of low pressure can't remain in the porous, high permeability sand: water will flow in from the surrounding area. This is why if you keep walking it will support your weight – there is not enough time for water to flow in and equalise the low pressure region under your foot.

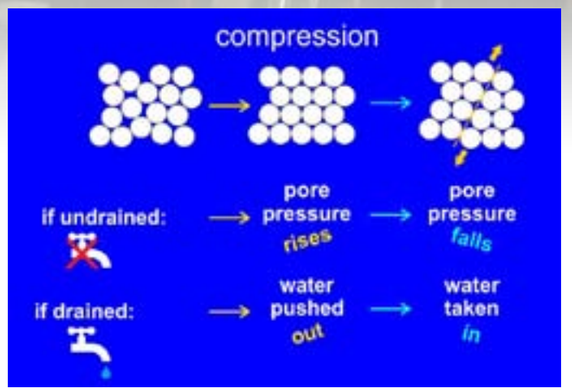
"Stand still, however, and water will rush in, equalising the pore pressure and allowing the particles to move apart."

Stand still, however, and water will rush in, equalising the pore pressure and allowing the particles to move apart. This lets the structure collapse and your foot to sink into the sand.

Drained or Undrained?

Before we shear an effective stress triaxial specimen we consolidate it: this means we let water in or out of the specimen to achieve a specified effective stress. This will be covered in more detail in Part 2. When we come to shear a sample (once it has been consolidated) we have the option of closing the drainage to specimen so the water content stays constant during shearing. This is undrained shearing, and movements of the particles cause changes in pore pressure: the volume remaining virtually constant (particles and water are assumed incompressible). The alternative is drained shearing. For this method the drainage tap is left open during shearing and the pressure going into the specimen (known as back pressure) remains constant. If the test is run sufficiently slowly the pore pressure remains constant – water can go in and out of the specimen as necessary to let the pores contract or expand as driven by the particles' movements. The volume of the specimen is, therefore, variable during shearing.

"If the test is run sufficiently slowly the pore pressure **remains constant – water can go in and out of the specimen as necessary...**"



In Part 2 we'll look at how this knowledge is put into practice in specifying and performing effective stress testing. ■

products and innovations

contents

Managing Director Karl Snelling, Technical Lead Dr Ben Hutt and Design Team Leader Jeff Gray of GDS Instruments write for **theGeotechnica** for the first time. In this article they discuss the challenges posed by the development of new geotechnical lab equipment.

GDS Instruments are no stranger to developing advanced laboratory equipment for geotechnical engineers. The company was created in 1979 for exactly that purpose. For the first 25 years of their life, GDS created advanced computer controlled testing systems primarily for use in Universities by research engineers. GDS estimate at least 500 Phd's have been obtained through the direct use of their equipment. In April this year, the Hong Kong University of Science and Technology took delivery of GDS's latest creation, the True Triaxial Apparatus (see Fig. 1).

Fig. 1: Setting up a test sample for the 4 paired actuators ready for testing.

"The defining characteristic of a True Triaxial Apparatus (TTA) is that... all three principal stresses can be controlled independently."

The defining characteristic of a True Triaxial Apparatus (TTA) is that, unlike conventional triaxial apparatus, all three principal stresses can be controlled independently. In conventional triaxial apparatus, the radial stress applies equal pressure around a cylindrical sample in the σ'_2 and σ'_3 axes, and an axial ram takes care of any load control requirements for the direction of σ'_1 (see Fig. 2a). A True Triaxial apparatus is designed to independently control stresses on a soil sample in the σ'_1, σ'_2 and σ'_3 axes (see Fig. 2b), allowing a wider range of complex stress paths to be performed.

First developed by Kjellman in 1936, the idea behind the True Triaxial Apparatus was to enable researchers to investigate stress paths beyond that which could

"As with many testing devices developed before the availability of low cost electronics... the TTA has been reborn as a viable testing system..."

be investigated in conventional triaxial apparatus. As with many testing devices developed before the availability of low cost electronics (or even the existence of electronics at all!), the TTA has been reborn as a viable testing system, albeit more likely to be used at present as a research tool. Kjellman's instrument utilised a fixed boundary approach whereby 6 platens would slide across each other to create the 3 axes of

"GDS have designed a system using a more typical approach to the application of stress by using a mixture of boundaries..."

stress (see Fig. 3a). GDS have designed a system using a more typical approach to the application of stress by using a mixture of boundaries, 2 fixed (σ'_1 and σ'_2), with the final axis (σ'_3) being applied using a constant hydraulic pressure. One of the greatest challenges for GDS with this new TTA was that it would be designed to perform dynamically with loading frequencies up to 10Hz, whilst maintaining the ability to load quasi-statically for low strain shear testing.

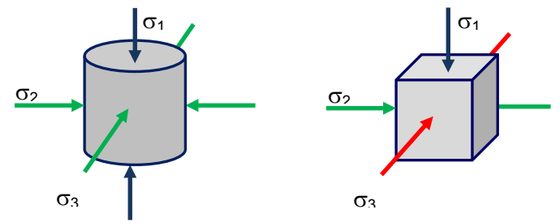


Fig. 2: a) Stress conditions on a conventional triaxial sample ($\sigma'_2 = \sigma'_3$), b) Stress conditions on True Triaxial Apparatus sample ($\sigma'_1 \neq \sigma'_2 \neq \sigma'_3$).

Fig. 3: a) Cross section of fixed boundary method, b) Cross section of the GDS approach which uses mixed boundaries, but does not suffer with friction problems associated with fixed boundaries.

Challenge 1: Mechanical design

The main challenge in the mechanical design of the system was to produce reliable actuators that can

"Design of the hydrostatic bearing arrangement required the use of exotic materials and multiple finishes..."

operate at the high frequencies required. Design of the hydrostatic bearing arrangement required the use of exotic materials and multiple finishes, as well as extremely tight control of sizes, concentricity's and their tolerances. Each hydraulic actuator is controlled by an individual high-response servo valve that is required to operate at the high frequencies that we need

"Keeping all hydraulic lines as short as possible is necessary in this sort of high-speed hydraulic system..."

to achieve. Keeping all hydraulic lines as short as possible is necessary in this sort of high-speed hydraulic system as the oil back pressure needs to be maintained to provide instant responses – to this end the shortest pipe runs need to be calculated as well as the use of accumulators and hydro-cushions such that hydraulic drag and pressure drop is reduced to an absolute minimum.

Four such hydraulic actuator units were mounted around the pressure-cell body, which was constructed

"Easy access to the sample via the doors was of paramount importance..."

with 2 sample access doors. Easy access to the sample via the doors was of paramount importance, as was the requirement to see the sample at all times when shut, therefore large windows that could take the internal pressure were also a design consideration.

The sample is mounted via platens (see Fig. 4 and Fig. 5b), and various user-tools such as a datum setting kit had to be designed to help set the sample up in a nominal central position. The sample restraining membrane arrangement was a new design challenge for GDS as the square sample proved more difficult to hold and seal than the a conventional normally cylindrical sample. The top caps were designed to taper

contents

away from the sample in order to keep their weight to a minimum, as with a high frequency systems, the moving items need to be as light as possible to keep their inertia to a minimum.

Fig. 4: Unlike conventional triaxial testing, vertical and horizontal platens have the potential to collide.

Challenge 2: Synchronising paired rams

When development started it became obvious that GDS existing hardware solutions could provide excellent control on a single axis, but were not a suitable

"The existing firmware/software simply wasn't designed to deal with this."

solution in a multi-axis dynamic scenario. The existing firmware/software simply wasn't designed to deal with this. GDS has always controlled all aspects of its products - mechanical, electronic, firmware and software – and are not restricted by dependence on 3rd party products - so they took some of their existing hardware modules and then used them in an entirely new way to solve the problem. In doing so GDS rewrote their firmware and created brand new support software so it could achieve what was needed.

The GDS TTA solution utilises one dynamic controller per hydraulic ram – these are linked together by a high speed real time local bus network which allows each dynamic controller to share real-time (sub millisecond) information about what it is doing with all the other dynamic controllers on the local bus network.

"Firmware uses this information to ensure the dynamic controllers all remain synchronised and work together as a team..."

Firmware uses this information to ensure the dynamic controllers all remain synchronised and work together as a team to perform the test and prevents platen collision should a sample fail under load tests. PC based software co-ordinates the overall behaviour of each individual controller informing it of what role it should play in an overall test and collecting and collating data that each controller has collected.

Challenge 3: Keeping the sample central

Even with full software and firmware co-ordination in place – the control of the rams themselves is a challenge in itself. Displacement control of paired rams

"If the left hand actuator moved by 1mm, then so does the right hand actuator, thus maintaining the sample central."

was relatively easy. If the left hand actuator moved by 1mm, then so does the right hand actuator, thus maintaining the sample central. When trying to apply load control, there was always the possibility that even very slight differences in calibration between for example the left and right hand load cells, that the central position of the sample could shift. For example if exactly 2kN is applied to the left hand ram but 2.01kN is applied to the right hand ram perhaps due to very slight but inevitable differences in calibration, the sample would drift off to the left.

In load control mode, one ram was dedicated as the load control master, whilst the opposite ram moves under position control, mirroring the displacement of its opposite in real-time, thus keeping the sample in the central position. At lower frequencies this worked perfectly, however above 1Hz it is simply not possible to just follow the measured position due to the time it takes for a hydraulic ram to actually respond – there is always a time delay (albeit small) between targeting a position and reaching that position. With this simplistic approach one actuator will always be playing "catch-up" – however what the application demands is that they both maintain mirrored displacements with full synchronism, whilst controlling the master load value.

"The TTA solves this problem by using an intelligent nested feedback approach..."

The TTA solves this problem by using an intelligent nested feedback approach so when a ram is under load control it is really under both load and position control – this means that the feedback process itself generates the correct reference position which can be shared with the ram tasked with mirroring displacement. Utilising this strategy both rams can remain perfectly synchronised in terms of displacement even though one is targeting load and the other targeting displacement.

Challenge 4: Collision prevention

The GDS TTA design required four hydraulic rams to be operated with perfect synchronism at up to 10Hz whilst ensuring the machine is protected by making it impossible for platens to collide with one another.

"To avoid collision, the position of each controller had to be resolved in real time..."

To avoid collision, the position of each controller had to be resolved in real time such that the sample and the machine cannot be harmed. The collision reference point around the platens always lags behind the actual position, therefore a variable virtual safety zone is generated around the platens which triggers as any platen approaches potential collision. Fig. 5a shows the software collision state form which clearly informs the user when a platen is in the potential collision zone, and which platen is the offender.

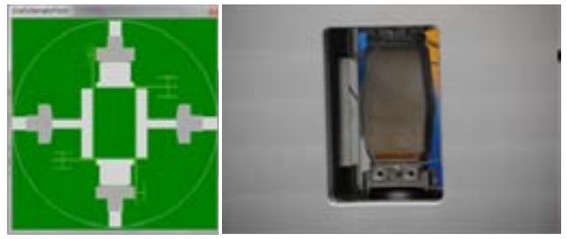


Fig. 5: a) Platen status window displays collision status at all times (green for not in collision), b) Cubical sample can be viewed through the specimen viewing window.

Fig. 6: GDS TTA, True Triaxial Apparatus.

Predicting when a potential collision may be about to occur, also takes significant logic. A collision resolution mechanism ensures the path of least resistance is taken to resolve the potential collision before it can occur by looking at and then actioning the axis that needs to move the least to ensure platens will never collide.

The TTA is probably the most complex and sophisticated machine that GDS has ever designed and built posing new challenges in multiple areas – mechanical, electronics, firmware, control algorithms, sample preparation and software, allowing a wider range of complex stress paths to be performed over and above conventional apparatus. ■

has the way we train our staff changed?

products and innovations

contents

Dr Roger Chandler, Managing Director of Keynetix and member of the AGS data management committee talks to **theGeotechnica** once again. This month, he asks whether we, as an industry, have changed the way in which we train our staff

Over the last few years we have seen training budgets slashed across our industry and we all know how difficult it can be to get training and time out of the office

"... many of the training providers have changed the way they deliver training and seminars."

approved. As a result many of the training providers have changed the way they deliver training and seminars. But is this at the expense of good old fashioned classroom based training?

I want to start this article with a very positive report on what I see happening in our industry. Firstly training providers such as Equipe have reduced the cost of training to be free in many cases and have instead sought to gain sponsorship from exhibitors at their events. This appears to work very well as the events

Training at Equipe's offices.

that I have attended at Equipe's offices, both as a delegate and as an exhibitor, have been well attended with very knowledgeable speakers and happy exhibitors. However this approach still requires the delegates to arrange for a day out of the office and travel expenses signed off. As good as Equipe are, they are unable to remove this hurdle.

"The biggest change in the market is the advent of the Webinar, often called an online seminar."

The biggest change in the market is the advent of the Webinar, often called an online seminar. If you have never attended a webinar before you simply click on a link that is sent to you by the organiser and your screen shows the presentation and you hear what is being said through your computer or via a phone connection, just like a conference call.

"Well run webinars are interactive events so you don't just sit and listen..."

Well run webinars are interactive events so you don't just sit and listen – you can take part in polls, chat forums or dialogue with the presenters and their teams via the interface or raise your hand electronically and speak. At Keynetix we run one free webinar a month and these have proved very popular, with 230 delegates registering for our largest webinar last year.

Training companies are now moving a lot of their traditional sit down courses to this environment either as free events or as pay as you go training.

Have you noticed that video is taking over the internet? YouTube is now the third most visited website in

"People are now expecting video content to be delivered to them via on-demand."

the world. People are now expecting video content to be delivered to them via on demand. At Keynetix we believe we are leading the way with on demand training with The Keynetix Knowledgebase – an online archive of training material that allows the user to search for what they want then watch it there and

"Everything we used to cover on our HoleBASE courses is now available free online..."

then. Our archive now has over 140 videos on it. Everything we used to cover on our HoleBASE courses is now available free online for our customers!

With the adoption of online video and webinars is the classroom training environment dead?

If you had asked me this a few months ago I may have

"I don't think the personal touch and interaction you can get when you have a small training group in the room can be replaced by technology."

said yes, but I don't think the personal touch and interaction you can get when you have a small training group in the room can be replaced by technology. When you attend a classroom based training course you usually learn from the other delegates as well as the presenter.

On the 29th May we are running our "Excel Master-

class for Geotechnical and Geoenvironmental Engineers classroom course" again. We announced the course on the 8th May and sold half of the places within 2 hours of the course information going online. With the number of enquiries we have had we

Microsoft Excel 2003 and 2007.

are currently looking to run it again the following day.

"...73% of all enhancement requests made by users to Microsoft for Excel 2007 were already in Excel 2003!"

One of my favourite facts is that 73% of all enhancement requests made by users to Microsoft for Excel 2007 were already in Excel 2003!

It is one of those programs that is used every day but what we don't realise is what we are not using it for. The course is classroom based for up to 8 people and after each technique is taught we openly discuss how

"Most of the Eureka moments come from the interaction between delegate and the trainer..."

we could use it in our day to day jobs. Most of the Eureka moments come from the interaction between delegates not between delegate and the trainer and it is always a pleasure to see people leave the day with a set of worked example spreadsheets and lots of ideas and enthusiasm for improving their use of Excel.

I don't believe that this level of interaction and corporation is yet possible in our online/inoffice world and probably never will be.

"In conclusion there are lots of exciting ways to increase your knowledge around at the moment..."

In conclusion there are lots of exciting ways to increase your knowledge around at the moment that were not available a few years ago. I hope you get the opportunity to make the most of them without having to beg your boss for time and money. Maybe one day I will get the opportunity to impart my enthusiasm for Excel to you face to face in a classroom! ■

directory

contents

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