The Clay Research Group

RESEARCH AREAS

Climate Change ◆ Data Analysis ◆ Electrical Resistivity Tomography
Time Domain Reflectometry ◆ BioSciences ◆ Ground Movement
Soil Testing Techniques ◆ Telemetry ◆ Numerical Modelling
Ground Remediation Techniques ◆ Risk Analysis
Mapping ◆ Software Analysis Tools

October 2014

Edition 113

The Clay Research Group

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Issue 113, October, 2014

ER Mapping of Root Zones

Phil Atkins from Birmingham University is involved with a new research area at Aldenham – mapping root zones.

Subsidence Forum Training Day

The Subsidence Forum have agreed to fund the cost of a replacement weather station at Aldenham. The old one has expired and Tom Clinton, the PhD student from Birmingham University needed a replacement to supplement his work on EKO treatment of the soil.

The Forum are holding a Training Day on 21 October 2014 followed by a members' dinner to celebrate their 10th Anniversary.

Speakers include Derry Baxter, Financial Ombudsman Service and Dr. Neil Hipps. Neil will provide an update on the Hortlink II study. A copy of the program can be downloaded from the Subsidence Forum web site at:

http://www.subsidenceforum.org.uk/

October Edition

This month we re-visit the results of a study undertaken in April 2008 into the effect of disturbance when retrieving soil samples to measure desiccation.

Traditionally crews have used hand augers. Following the study, some site investigation companies changed to the driven, thin walled window sampler and began adopting hand penetrometer testing to assess desiccation whilst on site. The benefits of penetrometer testing are discussed next month.

Above average rainfall in August followed by the driest September since records began just about sums up the weather over the last few years. Intermittent but heavy bouts of rainfall have managed to keep subsidence claims at a low level. As global temperatures increase, the UK had the coolest August since 1993 and 156% of the average rainfall for the month.

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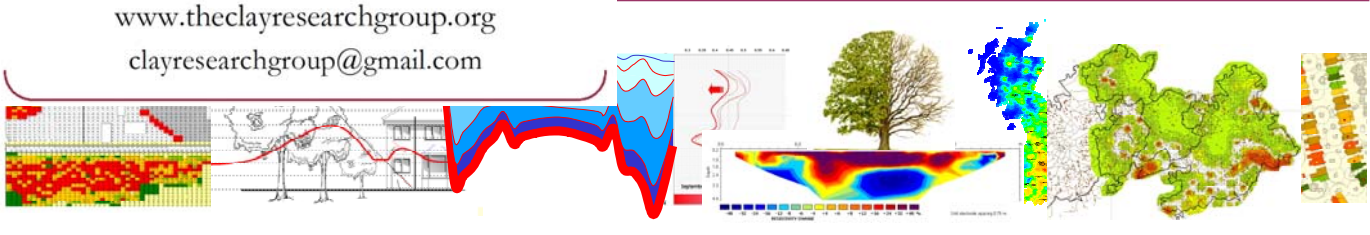

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ASSESSING THE UNDERWORLD

Assessing the Underworld (ATU) is a 10-year research programme largely funded by the EPSRC. The objective is to develop a multi-sensor device combining ground penetrating radar (GPR), acoustics and electromagnetic technologies to locate buried services, pipes and cables etc., to reduce the time and impact when underground works are planned.

A research team from Birmingham University will survey the ground in the vicinity of the Aldenham oak tree. The project is of great interest to insurers and engineers investigating subsidence claims because the team will be looking to map the extent of tree roots without excavation.

Two of the technologies are being tested:-

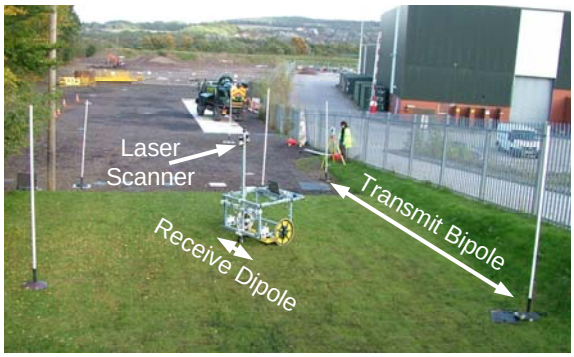
1) Vibro-acoustics – this has the potential to map the extent of a tree root system and changes to the ground. It uses a very small vibration (equivalent to a toothbrush), which when attached to the tree sends vibrations into the root structure, which can be measured by geophones around the tree.

2) Resistivity chart – which uses micro-amps to trace out resistivity across a defined area.

This is a practical extension of the earlier work undertaken by Keele University at Aldenham.

Professor Ian Jefferson and Phil Atkins from Birmingham explain, *"The aim of the experiments is to measure the electrical resistivity of the ground. For example, wet areas associated with leaks from pipes will lead to low values of electrical resistivity. Similarly, dry areas associated with tree roots will lead to high values of electrical resistivity."*

"The system operates by generating a few milliamps of current into two widely-spaced electrodes (known as a bipole). The voltage appearing at the surface is then measured using two mobile electrodes mounted on a cart (known as a dipole)."

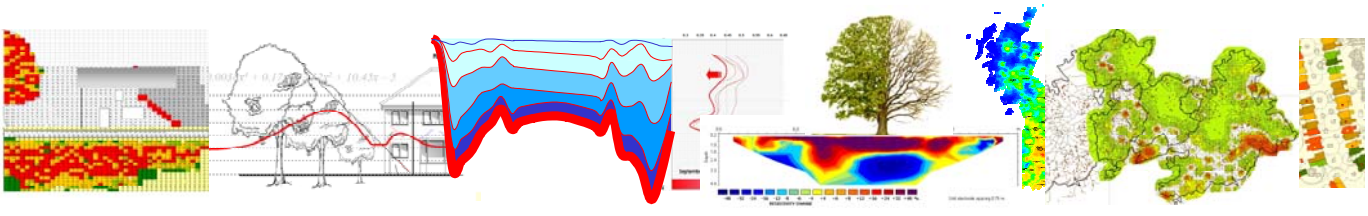


"The cart is then pushed around the site making as many measurements as possible. The position and heading of the cart is measured using a scanning laser system (as found in motorway toll booths for verifying the size of vehicles)."

This is an exciting project for the Clay Research Group with links to other aspects of data measuring that have been undertaken as described in the last edition.

For further information about the research team visit:

http://assessingtheunderworld.org/people/



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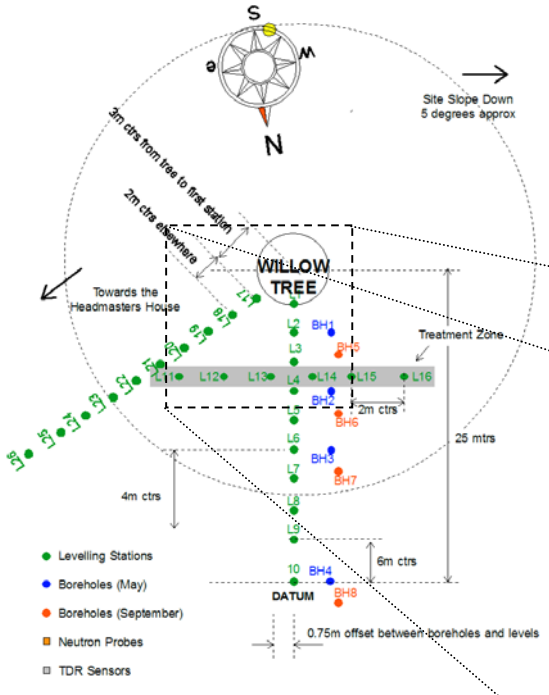
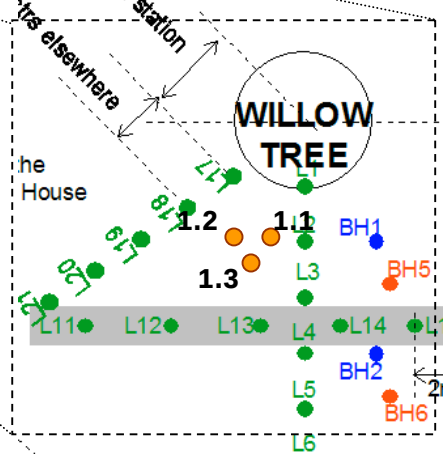
Sample Disturbance

It has long been known that sample disturbance can increase measured desiccation using most testing techniques, including suction measurements using the filter paper method and strains using oedometers.

To examine the effect of disturbance on these commonly used tests, three boreholes were sunk around 5m away from the Aldenham willow In April 2008. The retrieved samples were tested using the above techniques and the results appear on the following page.

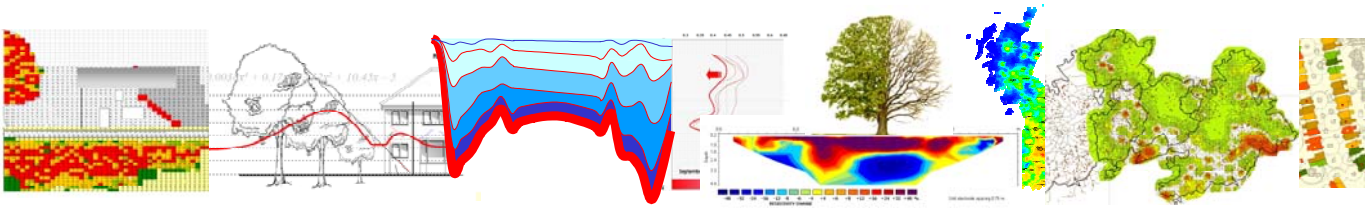


Plan of Aldenham willow, showing location of levelling arrays and earlier boreholes sunk in 2006.



Enlarged plan to show location of the three boreholes (1.1, 1.2 and 1.3) that form the subject of this report. They were sunk in April 2008.

The site of the Aldenham willow showing the borehole locations. Bores were sunk and samples tested in April 2008. Recording suctions and strains at that time of the year confirm the presence of a persistent moisture deficit.



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Strains – the Oedometer Test

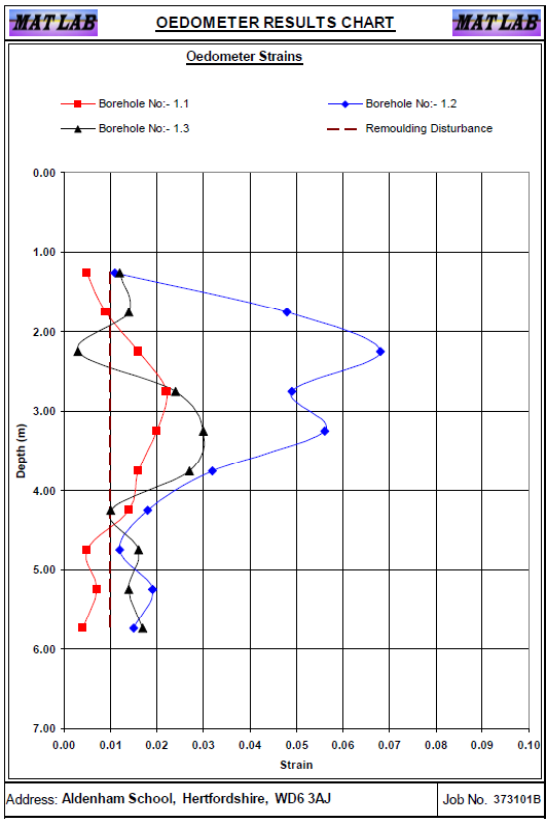
MatLab carried out carefully controlled tests on samples retrieved using three methods. BH 1.1 (red line) used undisturbed, cored samples. BH 1.2 plots data from disturbed samples (blue) retrieved using the hand auger. BH 1.3 used undisturbed samples that were remoulded in the laboratory, prior to testing.

Result of soil testing using the oedometer on a range of samples, retrieved in different ways, but at the same time of the year to assess the effect of disturbance.

Although all tests detected desiccation, and at similar depths below ground, the magnitude differed considerably and could have led to an incorrect resolution.

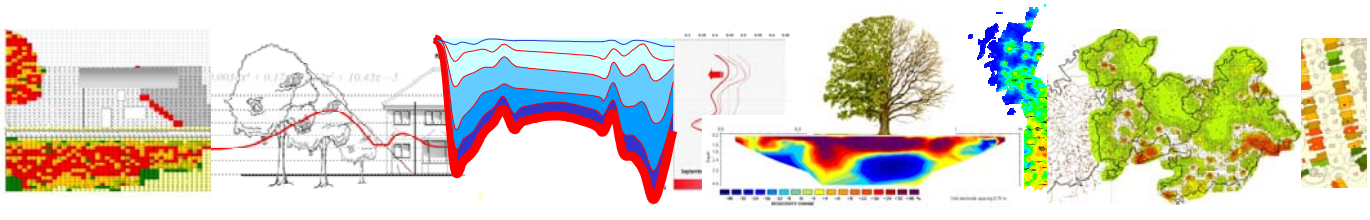
As the bores were sunk in April when the ground would normally be at field capacity, the estimate of swell obtained using disturbed samples would suggest (correctly) the presence of a persistent deficit but the estimate of heave might lead an engineer to implement the incorrect solution.

Sample retrieval and soil testing was funded entirely by C.P. Bennett Ltd., and MatLab Ltd.



The disturbed samples recorded the highest strains, whereas both the undisturbed samples (even those disturbed by hand in the laboratory) recorded swell, but of a much lower order. The results from BH 1.1 and 11.3 are comparable. In short, sample disturbance can greatly amplify recorded strains.

Although the effect of tree roots can be seen in every bore, the estimate of swell could lead an engineer to think that the amount of heave that would take place on tree removal meant that piling was the only alternative, when in fact other options might be available.



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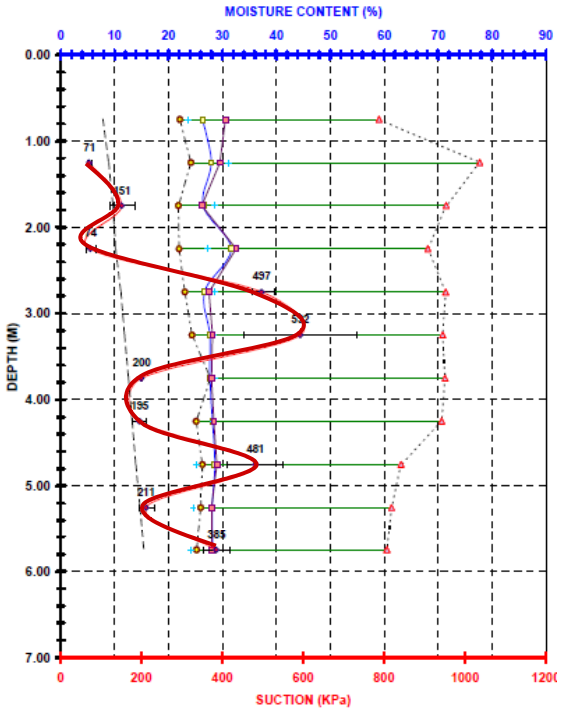
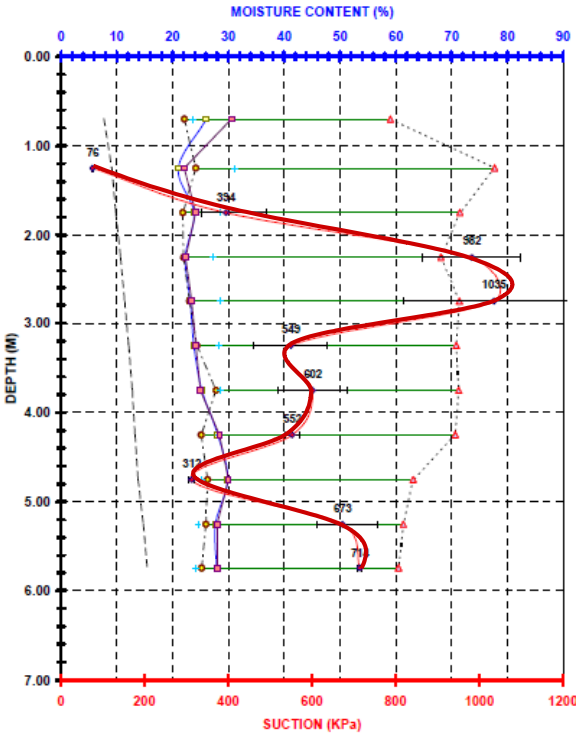
Filter Paper Suctions

The results from BH 1.1 using the core sampler ('undisturbed' samples) suggest a peak deficit of 590kPa at around 3mtrs.

This is similar in terms of depth and degree of desiccation as the strains recorded on the previous page.

There is clear evidence of a persistent moisture deficit beneath the willow at a distance of around 5mtrs as described in earlier articles.



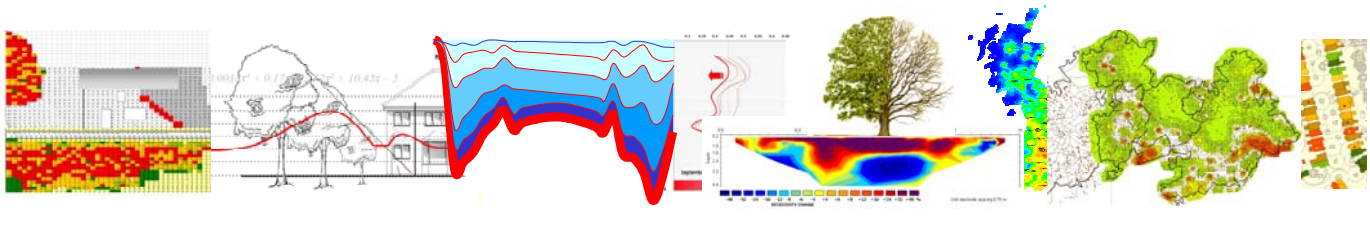


The results from BH 1.2 using disturbed samples retrieved by the hand auger.

The peak deficit of 1035kPa is nearly twice that recorded above, at a similar depth.

Again, this is similar in terms of depth and degree of desiccation as the strains recorded on the previous page. In both tests sample disturbance doubled the measured desiccation of the undisturbed samples.

Both means of testing reveal problems that can be associated with sample disturbance.



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Implications of Research into Sample Disturbance

Our research confirms the works of others. Sample disturbance can influence both strains and suctions. In this limited study, the increase using disturbed samples doubled the value obtained when using undisturbed samples.

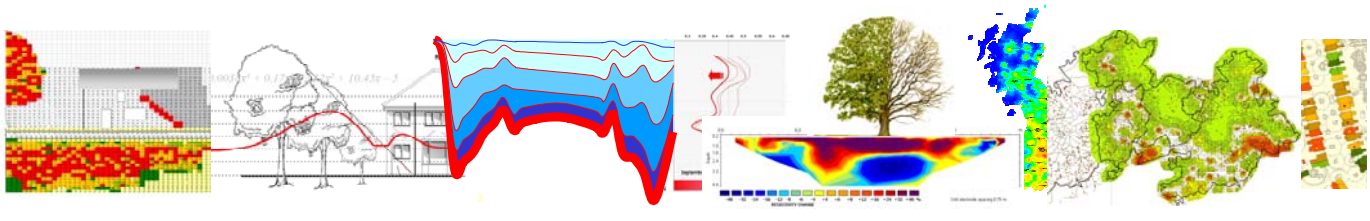
Strains using undisturbed samples were 0.03. This increased to 0.07 for the disturbed samples. Using the filter paper method, suctions were 590kPa using undisturbed samples, and 1,035kPa using disturbed samples.

We shall be looking at how the estimates of swell compare with readings using precise levels in a future edition.

Aldenham Willow – EKO Treatment Site

Tom Clinton from Birmingham University has designed a picket fence to enclose the test rig and dummy foundations on the site of the Aldenham willow, and below is an illustration of the proposed layout.

The willow is situated in the Headmaster's garden and the fence will hopefully make the presence of the rig more acceptable.



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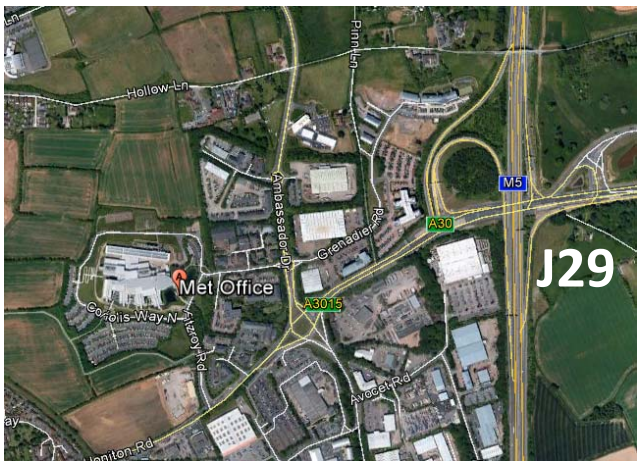
UK Met Office

"World Leaders"

The Met Office college is celebrating its 75th anniversary this week and journalists were invited to see the scope of their work.



Apart from the more obvious weather tracking and interpretation for a wide range of industries, the Met Office run a college with students from around the world. Attendees have included Ant and Dec, as well as William the Duke of Cambridge and Prince Harry.

Ruth Hammond, their marketing manager, explained that they were regularly voted one of the top two meteorological services in the world, the other being Japan.

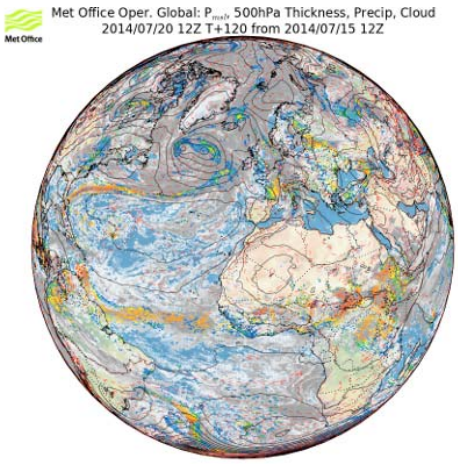
The college trains some of the top TV weather presenters as well as servicing a wide range of clients. Ruth mentioned supermarket purchasers as an example. They want to know what the weather is likely to be ahead of the weekend so that they can stock up with suitable lines. Other less obvious clients include wind farm operators, road gritters, airline operators - and of course, insurers.

The international standing is demonstrated by the diverse nationality of its students. Apparently, one year they had students from Bahrain, Malaysia, Georgia and other countries around the world.

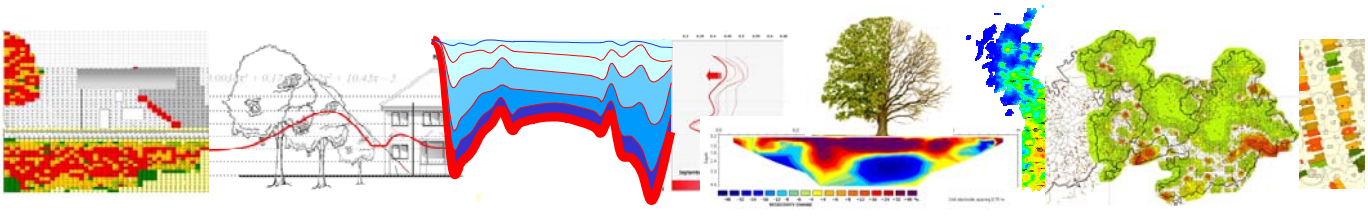
ENDGame

On a slightly different but related topic, the Dynamics Research team at the Met Office and Professor John Thuburn from the University of Exeter have developed "ENDGame"' (Even Newer Dynamics for General atmospheric modelling of the environment).

This took nearly 10 years and in the past two years staff from across the Met Office have tested and evaluated its impact and prepared their operational systems for its implementation.



Apparently, ENDGame is now being used for global weather and climate prediction work and system integration is already underway.



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Tree Relocation

Allan Tew has provided details of a scheme to relocate a 10m tall monkey puzzle tree that has caused damage to a detached bungalow situated on the east coast of the UK.

10m high monkey puzzle tree situated about 5mtrs from the damaged bungalow.

Allan reports that the bungalow was damaged years ago due to root induced clay shrinkage, and was piled as a result.

For some reason, the tree was retained.

More recent damage has led to a proposal to fell the tree, but it also presents the opportunity to research an alternative method. Tree relocation.

Due to the cost and the fact that gardens are rarely large enough to re-plant mature trees further away than their zone of influence this isn't going to be a widely adopted solution, but Allan feels we do need an understanding of the circumstances where it might be possible.

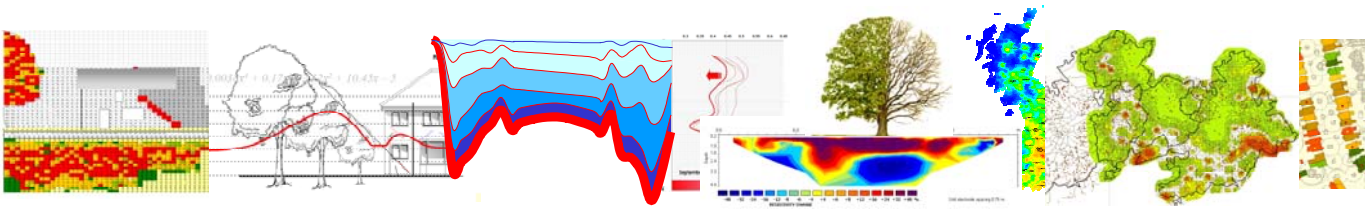
Dr. Jon Heuch is providing advice and support for the project.

Several speciality contractors have been approached for advice and a scan of the web sites revealed Nature First, Ruskins Trees and Heritage Tree Services. The following pictures have been taken from their sites.

The 'Nature First' web site reports having "Europe's largest tree spade with a massive 3m diameter rootball weighing nearly 12 tonnes."

The tree is shown as a yellow arrow on the aerial image below.

More on this topic in a future edition.



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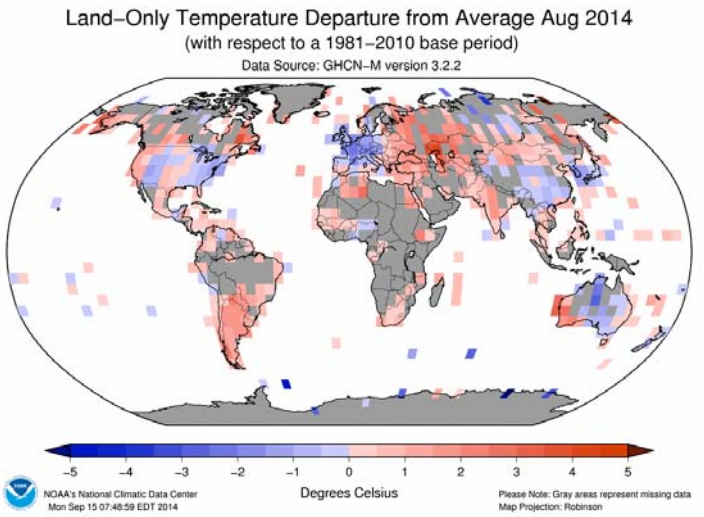
Weather Update

Although the National Oceanic and Atmospheric Administration (NOAA) reported that the globally averaged temperature for land and ocean surfaces for August 2014 was the highest for this month since record keeping began in 1880, here in the UK the situation has been a little different. "The cooler-than-average August temperatures in the U.K. were accompanied by wet conditions. August tied as the seventh wettest such period since national records began in 1910, thanks in part to Hurricane Bertha passing over the UK on the 10th and 11th."



The Met Office web site says "provisional UK mean temperature was 13.9 °C, 1.0 °C below the 1981-2010 long-term average. This was the coolest August for the UK since 1993, ending a sequence of eight warmer than average months. Rainfall was above average … The UK overall received 156% of average rainfall and this was equal-seventh wettest in the series."

In contrast September was the driest since records began with only 20% of the normal rainfall for the month and it looks like being in the top five warmest.

Growth Rate of Trees Increasing

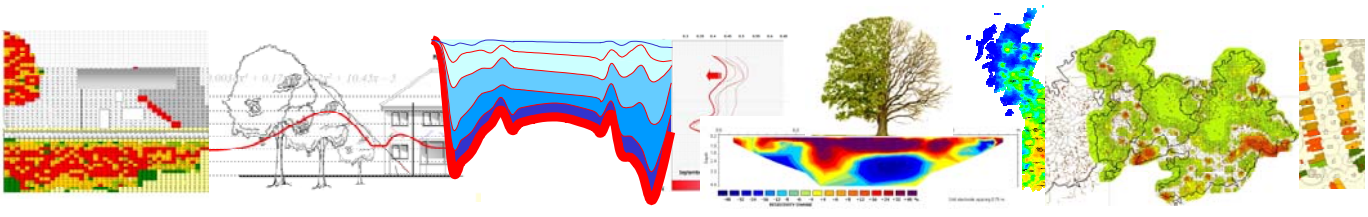
Researchers from the Technical University of Munich have reviewed 130 years worth of data and concluded that the rate of growth of some trees has speeded up quite dramatically – something they attribute to Global Warming with longer growing season and atmospheric changes.

According to a paper published in Nature Communications, the rate of growth of the common beech has increased by 27% since 1960, and the Norwegian spruce has increased by 32%. In an earlier study, the group measured an increase in two species of the oak at 37%.

This links in with the work undertaken at Southampton and reported on in Issue 32 …

"Trees are coming into leaf earlier and stay in leaf longer according to research published by Southampton University."

"The cause is rising levels of CO2 rather than increases in temperature, and they report a delay in leaf drop of between 1.3 and 1.8 days per decade, accompanying a 13.5% increase in CO2."



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Moisture Contents and Soil Index Properties

Contributed by Clive Bennett

There is no doubt that the "0.4 x LL" test is useful in assessing whether a soil is desiccated or not. It has been in use for many years, although reliance on the test has diminished with the development of alternative and economical means of making the assessment.

Today we are more likely to rely on the filter paper test and/or the direct measurement of swell using the oedometer.

BRE Digest 412 issued in 1996 said the following:-

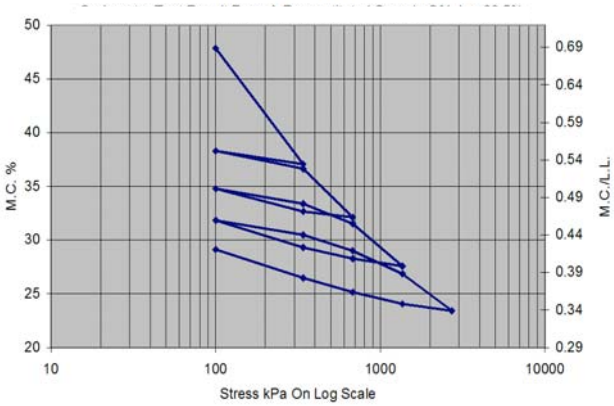
*"Because M.C. < 0.4 * L.L. is entirely empirical, it cannot take account of the differing stress histories to which natural clays have been subjected. Differing stress histories (or degrees of over-consolidation) may result in two soils in identical states of desiccation with identical index properties having different water contents; no criterion based on Atterberg Limits could hope to account for these differences."*

"Furthermore, it does not take account of the general decrease in soil water content with depth encountered in most over-consolidated clays."

*"Clearly, M.C. < 0.4 * L.L. should be used only as a rough guide and it is unwise to base an assessment of desiccation solely on this criterion, particularly if desiccation is slight."*

But why is this so? The relationship between the Atterberg limits and moisture content appears, on the face of it at least, to be sensible.

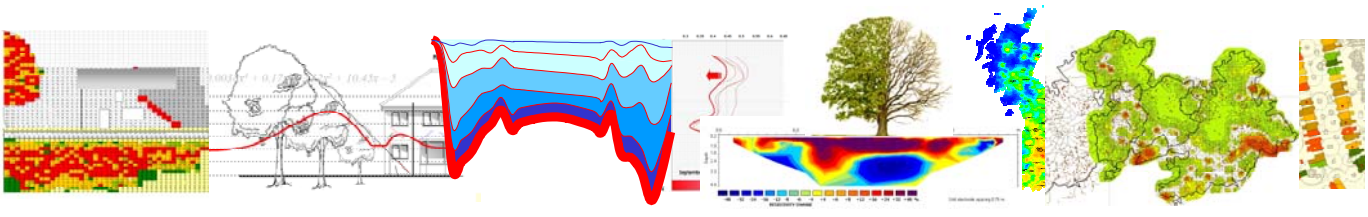
Clive Bennett from MatLab produced a paper to explain the problem, and it relates to the stress history of the soil.



Oedometer Results from a Reconstituted Sample with a Liquid Limit of 69.5%

Previous Max. Stress kPa	Overburden kPa	OCR	Excess Suction Kpa	Total Kpa	Void Ratio	M.C. %	M.C./L.L.
340	40	8.5	100	140	1.019	37.7	0.54
680	40	17	100	140	0.922	34.2	0.49
1360	40	34	100	140	0.840	31.1	0.45
2720	40	68	100	140	0.765	28.3	0.41

Table showing variations in moisture content for the test sample over a range of stress histories. See following page for explanation. Although the moisture content varies, the suctions remain constant at 100kPa.



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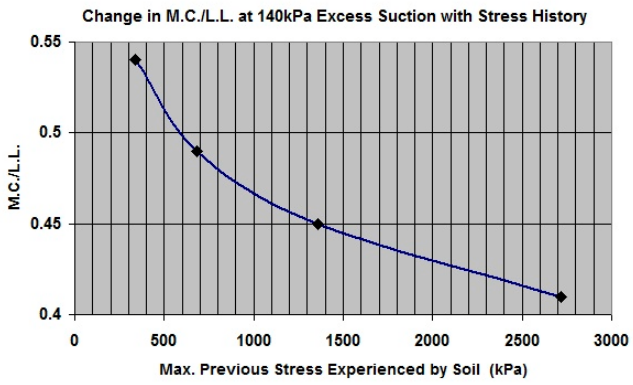
Mc –v- Index Properties

Clive explains. *"The above shows the results from an oedometer test carried out on a sample taken from postcode KT3 4. The sample's liquid limit was accurately measured prior to being consolidated in stages from the L.L. down to a maximum stress of 2,720 kPa."*

"The sample was then allowed to swell back to 100kPa. The virgin compression line can be clearly seen with the branching unloading and reloading lines."

"This is not representative of its undisturbed natural state but it does show the general signature of the consolidation process. This plot is known as the soils intrinsic properties having been totally remoulded for the preparation of the L.L. test."

"For example, assume a sample of this soil at around 2m below ground level with a equilibrium overburden stress of say about 40kPa and an excess suction of 100kPa ("onset of significant desiccation") the table on the previous page (see graph below) shows the moisture contents and M.C./L.L. values calculated from the best fit equations for this soil sample taken from Figure 2."



"It can be seen that with different stress histories and corresponding OCR's the values for M.C./L.L. at an excess suction of 100kPa from an overburden pressure of 40kPa vary from 0.41 to 0.54."

"The apparent previous maximum stress can be anywhere from zero to four figure numbers for UK clays and can vary within the same strata from location to location and the OCR varies accordingly."

"Example for Canons Park, North London the apparent maximum stress is approximately between 1500 to 1900kPa above its current vertical effective stress."

The apparent previous maximum stresses can be caused by many factors such as:-

- *Glaciation*
- *Weathering*
- *Desiccation due to drying*
- *Desiccation due to plant life*
- *Salt Concentration*
- *Ion Exchange*
- *Ageing, Creep, cementing agents*
- *Mass movement*
- *Removal of overburden*
- *Past Structures etc…*

To conclude, Clive says, *"The use of the 0.4 * Liquid Limit rule for the detection of the onset of significant desiccation could only be applied to this soil sample if it had experienced a stress of around 3000kPa (OCR=75) at sometime in its past."*

"Therefore the use of this rule without knowledge of previous stress history could be misleading."