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

The Clay Research Group
www.theclayresearchgroup.org

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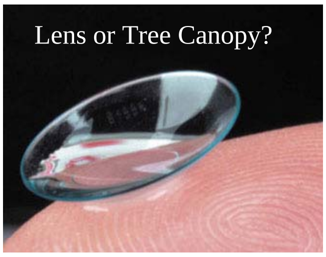
CONTENTS

If we told you that the best way to understand trees was through contact lenses, we can imagine the polite reply, but it may be true. Ask researchers at Cornell University.



Using hydrogel (a contact lens-like material), researchers have simulated water flow through the root/canopy and deduced it is an entirely physical process, with little (if anything) to do with biology. More inside.

TRAINING AIDS

Anyone interested in receiving Power Point presentations of ground movement profiles relating to the Aldenham Willow and Oak please contact us.

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Objectives for 2010

Continuing our work on the Intervention Technique will be a priority given its environmental and commercial value. The time it takes to assess the benefit or otherwise of any project has concentrated our minds on the need to move faster if we can, which has led us to consider the development of a Synthetic Tree.

Excellent work at Cornell University has provided some insight into the potential benefits of building a small scale model to replicate vegetation, climate and moisture flow through fine grained soils.

We are currently working with MatLab to explore techniques for the extraction of Class A, undisturbed samples, tested using the oedometer, at sensible prices. The objective is to deliver results in a few days for around £60, subject to trials. Field trials are underway and the aim is to be ready for the summer of 2010.

In the meantime, the penetrometer and oedometer (using disturbed samples) continue to perform well as can be seen in the Special Report on Aldenham Investigations which is ready for downloading from the web.

We are also working with others to develop a 'rapid deployment' sheet pile to act as a root barrier, where conditions and ground conditions permit.

2009 was spent completing commercial risk models for Innovation, recording data from electrolevels at the Intervention site in London and agreeing three more installations elsewhere, including one on the Mercia Mudstone series in the Midlands.

Glenda Jones had her paper published in *Near Surface Geophysics.* We concluded our work on the Triage application, estimated water uptake by the Aldenham Oak, mapped ground movement by month beneath both trees, considered the risk in Islington and Harrow, tested the penetrometer and compared precise levels with a range of soil tests and modelled the possible influence of Climate Change.

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The Annual Subsidence Conference

19th May, 2010

The conference is held every year, with many of the leading industry figures attending.

Past visitors include representatives from just about every major insurer and adjuster, as well as leading figures from the arboricultural community and contractor networks.

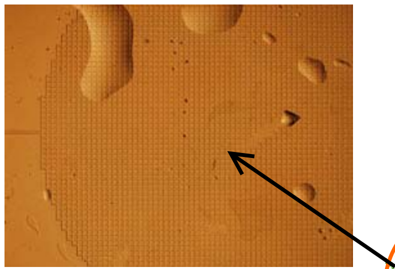
Speakers have included Richard Driscoll, Tim Freeman, Giles Biddle, Robert Sharpe, Hillary Skinner, Tony Boobier, Paul Thompson, Jill McLean, Gary Strong, Geoff Ball, Malcolm Cooper, Neil Curling, Peter Osborne and Nigel Barham, to name but a few.

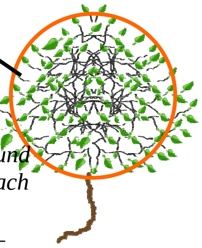
As usual, the conference will be hosted by Richard Rollit.

This years speakers will be covering the usual wide range of topics including current thinking on trees, non-invasive techniques for looking at the geology all with the objective of raising technical standards and exploring how we might settle claims faster and more economically. For details contact Helen Mallinson 0121 204 3593. Cost £165 per delegate.

MODELLING

Wheeler & Stroock (2008) *"The Transpiration of Water at negative Pressure in a Synthetic Tree"* Nature 455, at Cornell University have produced a relatively simple model of a tree. Using contact lens material, they have simulated water flow from root to canopy, and deduced that it is a physical process rather than biological. Put simply, the xylem acts as a tube through which water flows due to a pressure gradient.





A much magnified image of the 'tree canopy' from the Cornell slide. The slide measures around 60mm tall x 25mm wide and 1mm thick, with each channel measuring around 10μm in diameter inducing negative pressures of something like –1.0MPa

By cutting small channels into the hydrogen gel, their model draws water efficiently. Water transport is central to all that we do and this is an exciting development. The findings have attracted substantial grant funding for the authors work.

Can we learn anything from this? Can we model the interaction between climate, fine-grained soils and tree roots? If so, is it worth the effort?

For relatively modest cost we are proposing that a model be constructed to simulate water flow through a fine grained soil with a pressure gradient established using an "environment chamber".

This chamber simulates the trees moisture uptake and changing weather patterns. See the following page for details. The objective is to first 'fine tune' the model to replicate a tree, and then change the environment – add treatments to the soil and measure any change prior to rolling them out.

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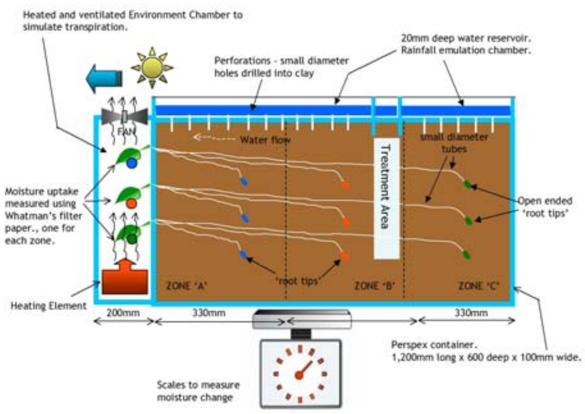
Synthetic Tree

A model of a synthetic tree is being developed to emulate field conditions in the hope that we can apply a variety of treatments and deliver results faster than can be achieved on site.

Typically (and the last few years have been a good example) setting up a test strategy can take several months. It can take several years to obtain any results.

A small-scale laboratory simulation, operating in a controlled environment, would allow us to measure water flow resulting from changes in temperature, rainfall and wind speed.



Diagrammatic view of the model showing (left) the 'environment chamber', enclosing the heater and fan, controlling relative humidity and right, the chamber containing the soil, treatment zone and 'roots'. The model includes a rainfall chamber situated above the soil. Tubes (roots) pass between the chambers to establish a flow driven by relative humidity.

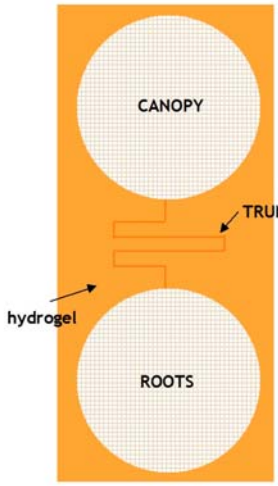
The objective is to build a pressure gradient between the root and leaf measuring 'transpiration' by soil zone (see above) in days rather than months.

The absorption characteristics of the synthetic roots will be characterised using the Disorder Model.

The system will replicate seasonal and diurnal change by varying the environment, emulating moisture extraction by a tree.

The length of the root system, moisture uptake and distribution are all taken into account. Over time, the system can be modified and enhanced to replicate 'real world' situations, and maybe even model complex ground conditions with variable strata etc.

The Cornell model uses very small discs of gel to replicate the behaviour of the root system and tree canopy. It does not take account of the soil but measures flow.



This is the rationale behind building our own 'synthetic tree'. As the environmental factors can be controlled it will form the basis of a mathematical model allowing us to understand better the complex interaction between rainfall, temperature, hydraulic conductivity and root absorption without having to worry about carbon fixing, hours of sunshine, stomatal response and photosynthesis.

We are effectively removing the biological process, allowing the direct measure of water flow through the soil.

Our proposed model adds the variability of the soil – London clay. Can we influence the hydraulic conductivity?

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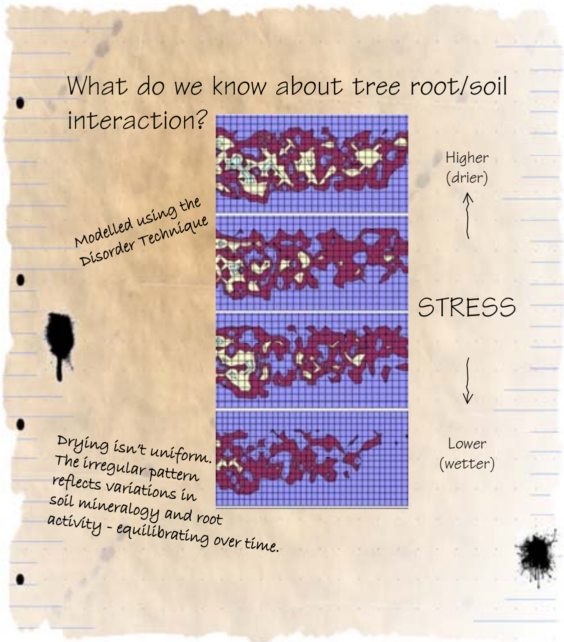
Characterising the Synthetic Root

How do we characterise the root system used in our model? Referring to the Disorder Model is a good starting point. Can we replicate this pattern of drying in the chamber?



The boundaries are, zero suctions in the winter, and the largest negative values in the summer, in the presence of an Oak. Everything else falls between these two extremes.

Put simply, by turning up the heat, and increasing the air flow, we will model the Oak tree. Drawing moisture through the root tip requires it to be primed first, ensuring no cavitation.

Silica gel initially appeared to offer an ideal replica of a root tip. Unfortunately, it is not easily dried following saturation. The crystals have to be heated to 120 degrees Celcius to ‘recharge’ them.

This led us to consider a simple, open tube. If there is no ‘biological process’ (as Cornell suggest) then an open tube may be all that is required.

Relative humidity will be regulated using the heater and fan, adding a filter papers to replicate leaf area and allow measurement of absorption by weighing ‘before and after’ in the same way that moisture contents are determined in the suction test.

Our understanding of water flow in vegetation is that relative humidity drives water flow from root to shoot, but local osmotic potentials ‘re-direct it’ locally to reach cells via the apoplast.

The outstanding issues to resolve are (a) avoiding cavitation in a fine bore tube, (b) avoiding blockages at the tip and (c) measuring filter paper moisture, avoiding equilibration.

Conducting vessels in the root might be around 100μm in diameter (varying greatly by species and age) compared with the diameter of a clay particle at 2μm.

The problem with the virtual filter paper ‘leaves’ is that they can’t be enclosed in individual polythene bags because the flow relies on relative humidity induced in the chamber and, if left open, the measure ‘per zone’ would be inaccurate

“The model includes a mechanism for regulating relative humidity, emulating ‘local’ osmotic change in potential at the leaf and flow through a fine grained soil.”

There are several issues yet to be resolved but the major benefit is, we can start at any time in the year, and not have to wait too long to determine the success or otherwise of our trials. More planning required and we would welcome hearing from anyone with expertise in modelling water flow and/or ideas on how we might resolve the practical problems listed above.

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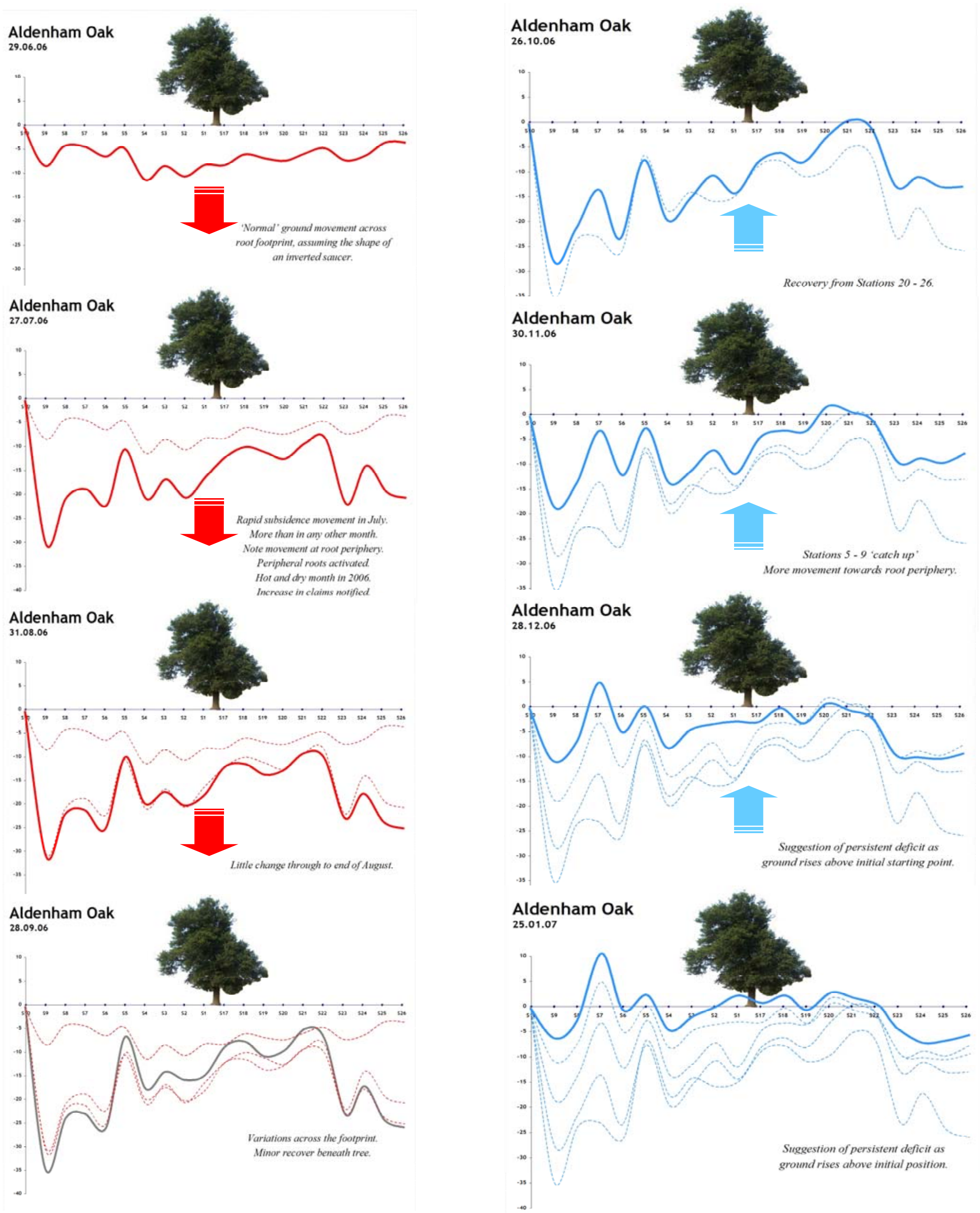

Ground Movement Profiles for the Aldenham Willow - Precise Levels

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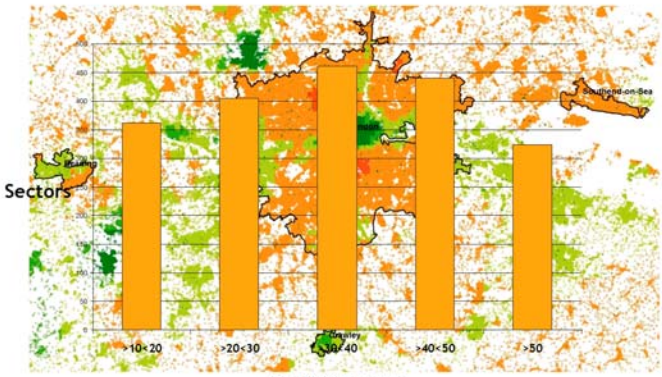
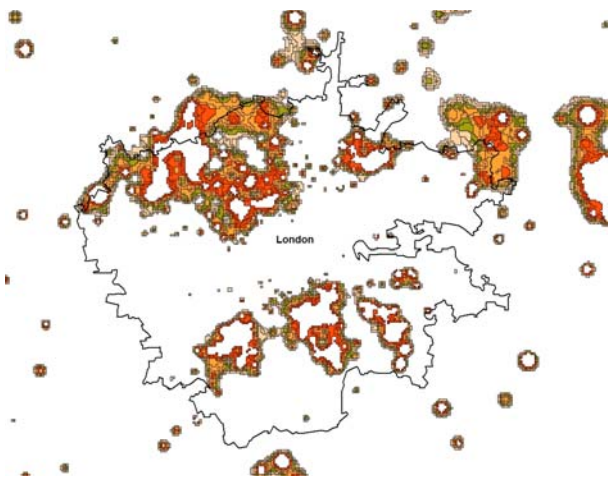
Soil Distribution in the UK by Plasticity Index

Around 21% of postcodes sectors in the UK are on soil with a clay fraction. Of those, around 80% have a Plasticity Index greater than 20%. The distribution is shown below.

Distribution of PI by Postcode Sector



The spatial distribution below is a screenshot of London, showing the location of soils with a P.I. in the range 40 – 50%, representing the London Clay series, but also superficial deposits with a highly shrinkable clay fraction. This is particularly relevant south of the Thames.

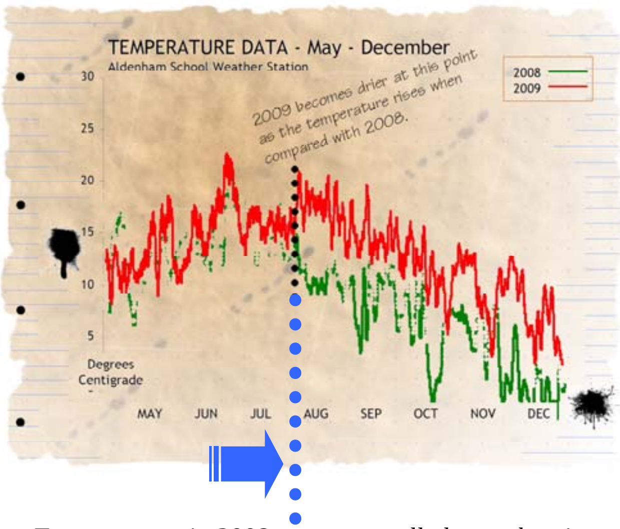


Soil Distribution 40 - 50% PI

Temperature Patterns Drive Claims

Data from the Aldenham Weather Station shows the difference between 2008 (green line) and 2009 (red), and the point of change.

More work needs to be undertaken to explore the influence of relative humidity. This is the driving force behind transpiration, combining the effects of rainfall and temperature etc., and RH generates much high suctions than the tree canopy in adverse situations.



Temperatures in 2008 were generally lower than in 2009 at Aldenham, and the difference is clearly distinguishable. Increases in claim numbers were recorded late in 2009,commencing in August, coincident with higher temperatures.

Download “Aldenham Investigations– Special Edition” from the CRG website at www.theclayresearchgroup.org for comparisons between various soil tests and between soils tests and precise levels. Power Point presentations are available for training purposes, showing the ground movement profiles beneath the Oak and Willow. E-mail splante@hotmail.co.uk.