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

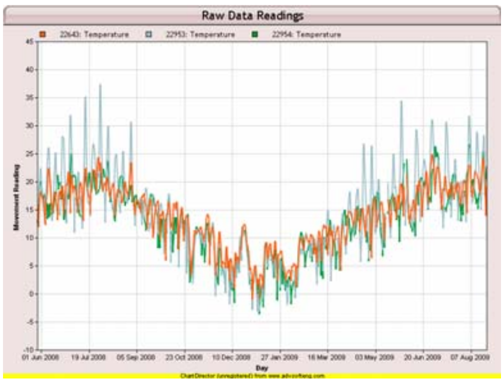
The Clay Research Group
www.theclayresearchgroup.org

September 2009

The Clay Research Group

CONTENTS

InterTeQ Data



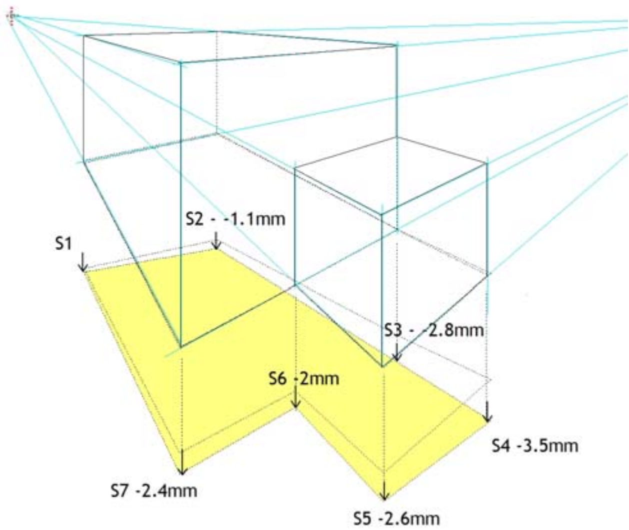
Data from the Intervention site shown above, with temperature (top) and rotation (bottom) plotted over time for the period late May 2008 to the end of August 2009.

www.theclayresearchgroup.org
splante@hotmail.co.uk

Intervention Update

Bullet points. Crack monitors installed at the junction between the extension and house recorded 5mm of movement in 2006, around (incomplete records) 3mm in 2008 and less than 0.3mm in 2009. Precise levels confirm that fairly low amplitude movement has taken place. Station 4 has subsided by 3.5mm, and Station 2, 2.6mm.

The important measure – the difference between stations around the extension – is small. Less than 1mm.



The movement between S2 and S4 for example, is uniform along the length of the wall. Using "L/360" as the limiting tensile stress, we see (below) theoretical permissible movement of 7.2mm, against actual movement at the end of August of 3.5mm. A drop of 2.4mm over a length of 10.45mtrs from the front corner of the house to the rear corner of the extension is hardly subsidence.

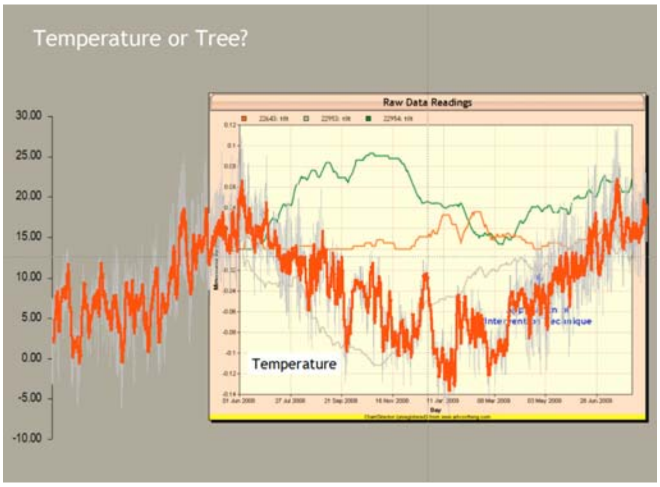
	30/04/09	26/06/09	21/08/09	Total	Deflection Coefficient L/360	Length	(between)
S1	0	0	0	0	0	-	
S2	0	-0.2	-0.9	-1.1	17.4	6,250	S1 - S2
S3	0	-1.2	-1.6	-2.8	21.1	7,600	S2 - S3
S4	0	-2.3	-1.2	-3.5	7.9	2,850	S3 - S4
S5	0	-1.6	-1	-2.6	7.2	2,600	S4 - S5
S6	0	-1.2	-0.8	-2	7.9	2,850	S5 - S6
S7	0	-1.5	-0.9	-2.4	9.0	3,250	S6 - S7

Far too early to determine whether the treatment would work in a dry year but it would appear that the treatment has reduced the amplitude of movement that has taken place.

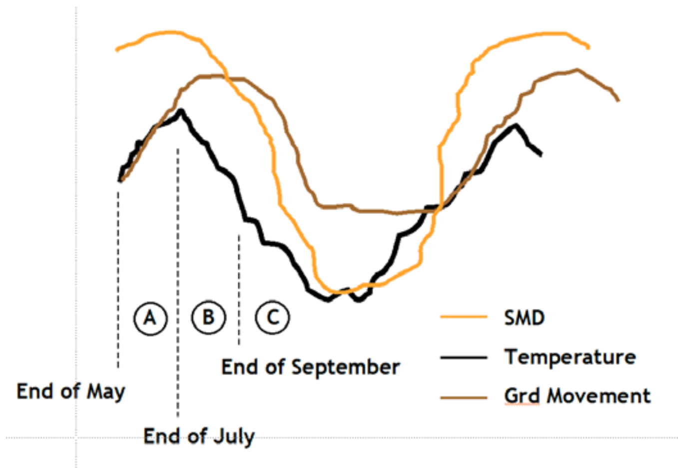
The Clay Research Group

Temperature or Tree?

We recognise that trees and temperature play a significant role in causing ground movement but can we quantify their contribution? Can we understand when the tree becomes the dominant influence?



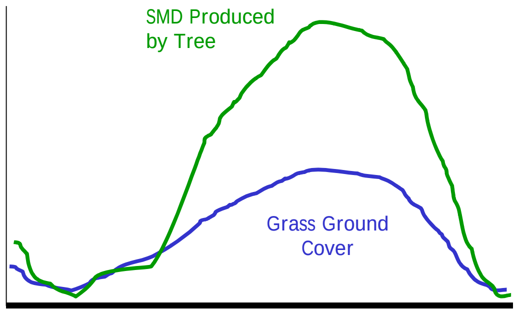
SMD, temperature and ground movement profiles are plotted below to understand the relationship. The SMD deficit rises first, and the combined influence of trees and temperature results in ground movement in the interval 'A' below, between May and late July.



Ground movement continues even as the temperature begins to drop (interval 'B'), and the energy to drive this has to be the tree. No other element (wind, relative humidity or solar radiation) accounts for this relationship.

Rainfall exceeds moisture loss in interval 'C'. The relative weighting of each can bee seen by comparing SMD figures – see following column.

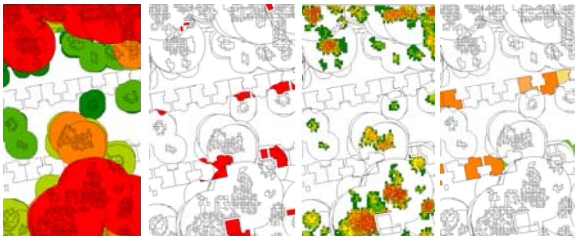
The relationship has been simplified for clarity.



Convergence until May/June

Trees can generate an SMD that is between two and three times that of grass cover, variable by location, species and climate of course.

"Things that Stick Out"



Our recent study of damage to buildings revealed that - put crudely – "things that stick out" present the greatest risk, and the list included porches, bay windows, extensions and so forth.

How do we cater for this using digital data, comparing literally millions of trees and houses, and variable soil types?

We use the modelled root overlap – see above. Because the model tends to be conservative, we have settled on around a 20% overlap to capture the structures that appear to be most vulnerable.

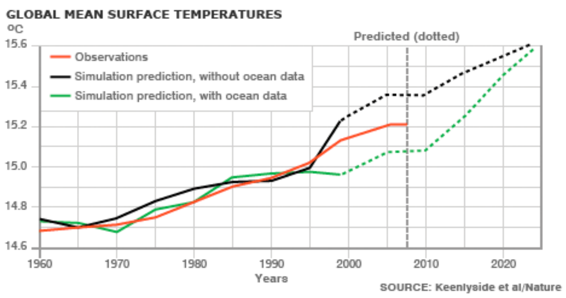
See the image second from the left, above. The red shaded areas are our estimate of tree root zones beneath buildings, and the output corresponds with claims data.

The Clay Research Group

Climate Change Resume

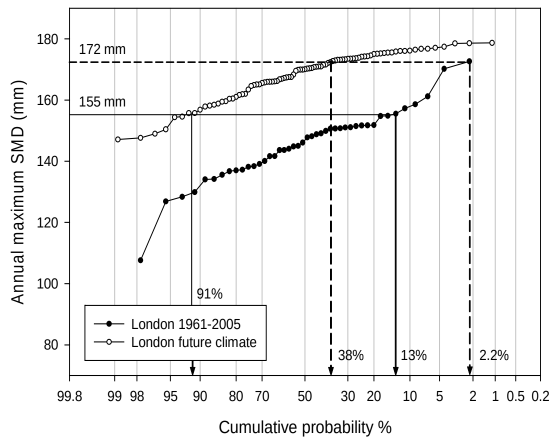
Continuing on from the edition last month, where we touched on a method of estimating the cost of Climate Change, below we review previous articles.

In "Climate Change on Hold", Edition 39, we mentioned the work of Noel Keenlyside's team from the German Institute of Marine Science, published in Nature (2008, Edition 453), saying "The Earth's temperature may stay roughly the same for a decade, as natural climate cycles enter a cooling phase"."



We have seen evidence of this since 2007, with hot weather interrupted by heavy rainfall and flash flooding.

The team at Southampton have been plotting longer term trends, and Dr Derek Clark and Dr Joel Smethurst gave us an insight into their work which was published in Edition 38.

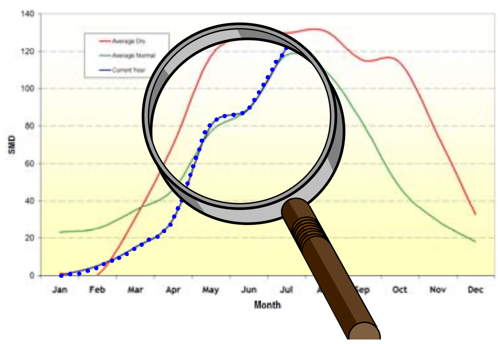


Their model has been "run forward to the year 2100 using synthetic climate data sets based on the UK Climate Impact Programme for a range of CO_2 emission scenarios."

Their model tells them that "if the expected changes in climate do occur then what is at present a 1 in 33 year dry summer in London is likely to become the average summer and a moderately dry summer (currently a 1 in 10 year event) is likely to occur 9 years out of 10."

Another team from Southampton have undertaken research into trees, and we reported on their work in Edition 32 … "Southampton have recorded that trees are coming into leaf earlier and stay in leaf longer. They suggest we may have to be more selective when considering which species to plant to deal with these changes. The cause is rising levels of CO_2 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 CO_2."

Conclusions?



2009 is following the pattern of a 'normal' year. We were thrown off course temporarily when we recorded higher temperatures for a short while, but the data speaks for itself.

The next month will tell, but so far claim numbers remain low and if we are correct, the model continues to deliver robust predictions towards the end of May. Dry possibly, but not an event.

The Clay Research Group

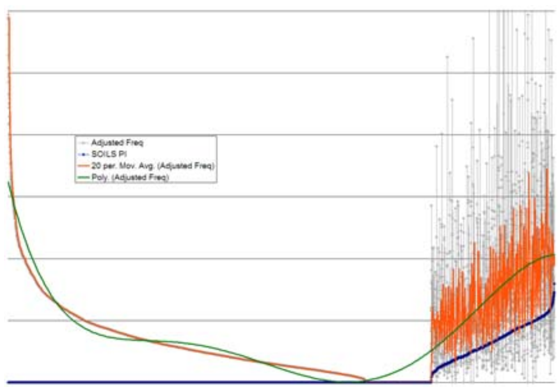
Soils and Perils

~ the geological imperative ~

The graph below illustrates the link between classes of claims and the underlying geology.

The shrink/swell characteristics of the soil are shown by the blue line running along the 'x' axis at postcode sector level. To the right of the graph, the blue line follows the P.I. of the soil that is found in around 22% of the sectors.

In contrast, the grey line plots claim frequencies in those sectors. We have sorted by rank order of soils first, and claims second.

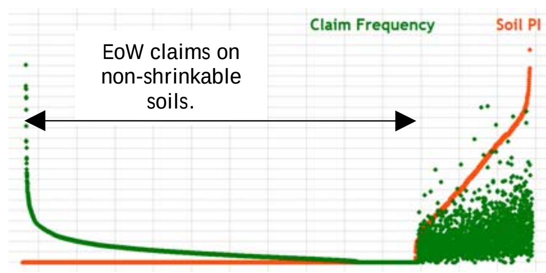


Claims on non-shrinkable soils increase steadily (to the left of the graph). Claims on the shrinkable soils form an irregular but dense pattern to the right.

Because of the variance of claims on the clay soils, straightforward correlative techniques might not reveal any relationship. If we sample 1 in 20 points (the red line) we see a pattern emerging, and using a 6th order polynomial (green line) enhances this relationship. The green line follows the soil PI, linking claims with soils.

The 'interference' relates to the variability of the clay soils and their relationship with the nearby trees, but there seems to be little doubt that the risk increases with the soil P.I., even if the relationship is complex.

The average claims frequency (using our sample data) for escape of water claims on non-shrinkable soils is around 0.003, and for claims on clay soils it increases to 0.007. Clay soils are 2.38 times more risky than non-clay soils – on average and by frequency. More if we consider their relative settled costs.

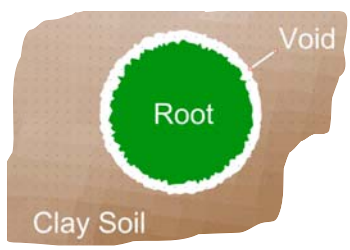


The same data, but with trendline analysis omitted to clarify the relationship. Claim frequency data is plotted against the soil Plasticity Index

Root Soil Contact

Intuitively one might expect that a gap would develop around the soil/root interface at times of drought.

As the clay soil shrinks, as the cell turgor decreases, it seems inevitable, and scientists have produced a Technical Note in the Vadose Zone journal, reporting on this effect using x-ray tomography and image analysis. Andrea Carminati et al, ***"When Roots Lose Contact"*** (August 2009).



"Gaps were larger for the taproot than the laterals and were caused primarily by root shrinkage rather than by soil shrinkage. When the soil was irrigated again, the roots swelled, partially refilling the gaps. Gaps are expected to reduce water transfers between soil and roots. Opening and closing of gaps may help plants to prevent water loss when the soil dries, and to restore the soil–root continuity when water becomes available. The persistence of gaps in the more proximal parts is one reason why roots preferentially take up water from their more distal parts" - as we have seen at Aldenham.

The Clay Research Group

Mechanical Reinforcement of Soil by Willow Roots: Impacts of Root Properties and Root Failure Mechanism

Slobodan B. Mickovski[a,b,c], Paul D. Hallett[a,*], M. Fraser Bransby[d], Michael C. R. Davies[e], Rene Sonnenberg[d] and A. Glyn Bengough[a]

Extract - Soil Sciences Journal of America
June 2009

"Plant roots have considerable impact on the mechanical stability of soil, but to date the underlying mechanisms have been poorly quantified. In this study, controlled laboratory studies of soil reinforced with willow trees (Salix viminalis cv Tora) found a strong correlation between the cross-sectional area of soil covered by roots and shear reinforcement.

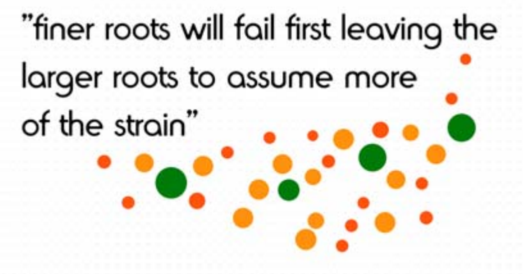
We separated broken versus pulled-out roots and measured individual root diameters crossing the shear-plane. The shear strength of planted specimens compared with non-planted specimens increased eight-fold at 0.10-m shear depth, more than four-fold at 0.25-m depth, and more than doubled at 0.40-m depth.

These data were used to evaluate several models of root-reinforcement. Models based on catastrophic and simultaneous failure of all roots overpredicted reinforcement by 33% on average.

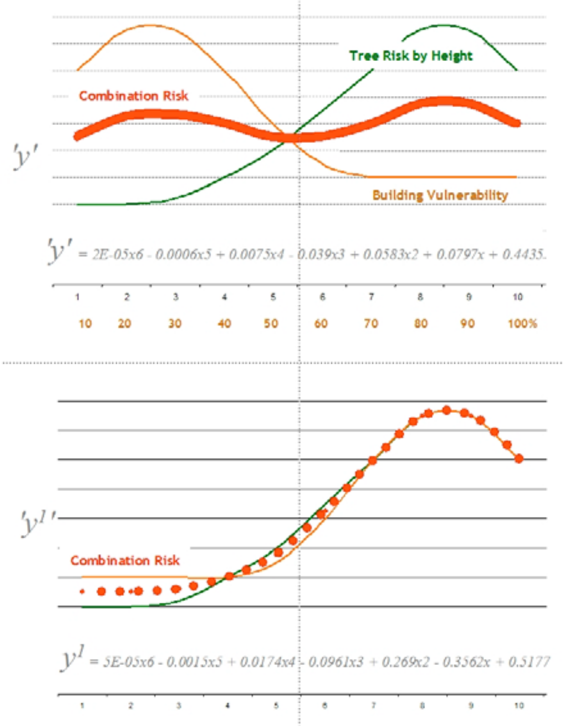
Better agreement between experimental and model results was found for a stress-based fiber-bundle-model, in which roots break progressively from weakest to strongest, with the load shared on the remaining roots at each step.

Roots have a great capacity to reinforce soils, with existing models providing reasonable predictions of increased shear strength. However, deterministic understanding and modelling of the processes involved needs to consider root failure mechanisms.

In particular, the role of root stiffness and root–soil adhesion is not considered in existing models of soil reinforcement by plant roots."



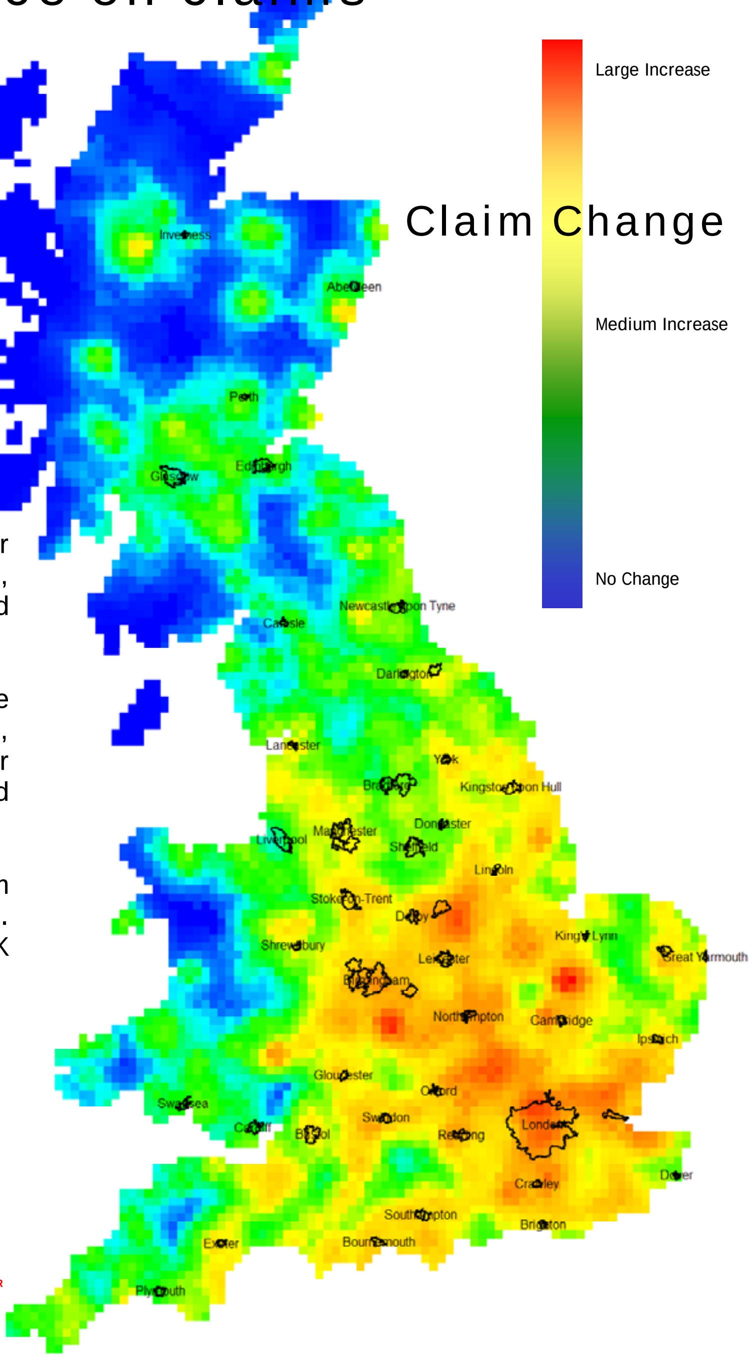
Combining Elements



No single factor predisposes a tree to damage a house – or so it would appear from our research so far. But we do see patterns emerging from complex combinations. Above we show how combining the risk as a function of tree height, modelled root zone and percentage overlap can improve the match with claims experience. We can weave in climate, take account of "bits that stick out" (Page 2), and species etc., and then add in the soil shrinkability). Lots of houses with these factors remain undamaged of course.

The Clay Research Group

PATTERNS of UK CLIMATE CHANGE and their influence on claims



Climate Change would have a greater impact on some parts of the country, and the impact for insurers would increase where there are clay soils.

Scotland may get warmer, but the geology doesn't change. In contrast, southern regions will see greater increases both in temperature and claims.

This map shows the areas at risk – from an insurance/subsidence point of view. The vertical section through the UK graphs the risk.