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

October 2009

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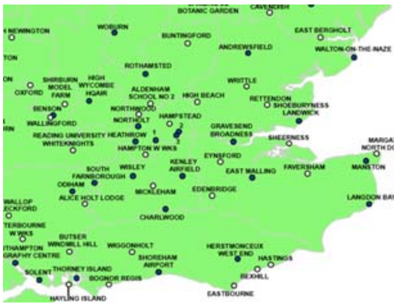
Aldenham School



Aldenham School is an accredited weather station and part of the UK network collecting data for the Meteorological Office.

INDUSTRY DATA

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This Month

This edition covers a wide spectrum of topics. The use of Bayesian probability to assess the likelihood of a valid claim at time of First Notification of Loss (FNOL), visit the effects of sample disturbance and looking at examples from the risk model, using actual claims to see how it fares.

We re-visit the 'risk by modelled root overlap" and update our earlier views, taking account of risk by height bands. More on this next month.

MatLab have provided an update on their developing program of site investigations and soil testing.

Finally, we look at published research confirming the period of maximum moisture uptake for particular species which reinforces the work we published last year using precise level data to deliver an estimate of 'uptake by month'.

InterTeQ

We should have an update from Jonathan Gray from Crawfords towards the end of next month if all goes well, when they take a further set of precise levels.

The last pictures from site told a story looking at the lawn. The grass is definitely greener on the other side of the trench. We understand matters may have been confounded a little by the neighbour trimming their Ash tree. The only reported case of co-operation, and it happens on our research project. Typical.

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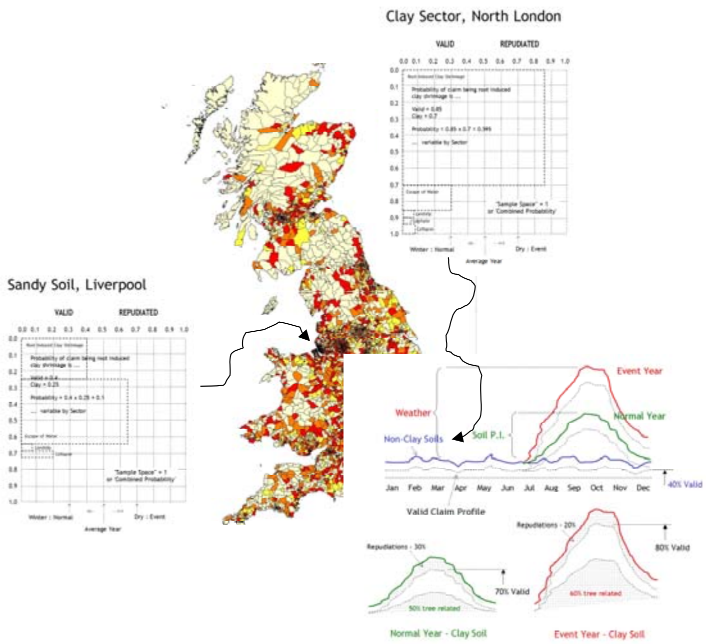
Triage and Probability Theory

~ Accounting for a Dynamic World ~

Calculating the probability of whether a claim is valid or not, and the operating peril, isn't easy. We have a 'prior probability' based on our experience of the sector and our knowledge of the peril. We know this might change by month, and by year but that change is determined by the geology.

Using a Bayesian technique we can assess the probability of whether a claim might be valid or not at First Notification of Loss (FNOL).

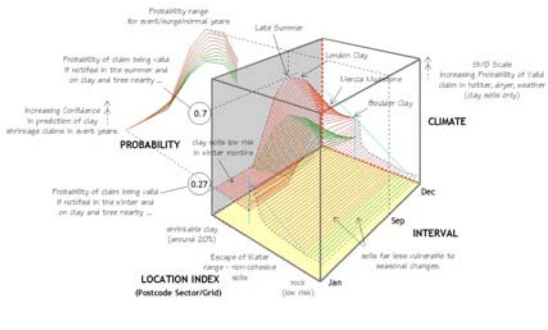


Top right in the above image we see how a probability is derived based on an event year, in North London using a one-dimensional sample space. The probability of the claim being root induced clay shrinkage and valid (assuming there is a tree nearby of course) is around 0.59 in this example, whereas in Liverpool the probability might drop to 0.1. In the alternative we see how this reflects on the likelihood of a claim being repudiated.

Bottom right of the above image we track the dynamics of the estimate, tracking change by month and by year.

This isn't a predictive risk model – it is for use in Triage when damage has occurred and we want to understand the probability of whether or not it is a valid claim, the operating peril and likely cost.

Using what are termed 'joint probabilities' we can build a 3 dimensional model enabling us to combine the various factors, accounting for time. For example, the 'Location' axis combines geology and claim experience.



VALID CLAIM PROBABILITY CUBE

The cube above allows us to manipulate the elements we have described, normalising each onto a 0 – 1 scale.

Some soils have a periodic signature linked to seasons, and others do not. The confidence in our prediction relating to clay shrinkage claims is far higher in the summer than in winter months or 'normal' years.

The probability cube takes account of all of these elements.

Additional layers might include delivering an estimated settled cost and we could add in the age of house, time on cover, whether trees are present, and if so, their height, distance and species etc.

$$P(A_2|B_1) = \frac{P(A_2)P(B_1|A_2)}{P(A_1)P(B_1|A_1) + P(A_2)P(B_1|A_2) + P(A_3)P(B_1|A_3)}$$

As well as use in Triage, this tool would be useful in audit, running claims through the parameters to find exceptions. The odd claim where the output as delivered by the engineer doesn't match the probability.

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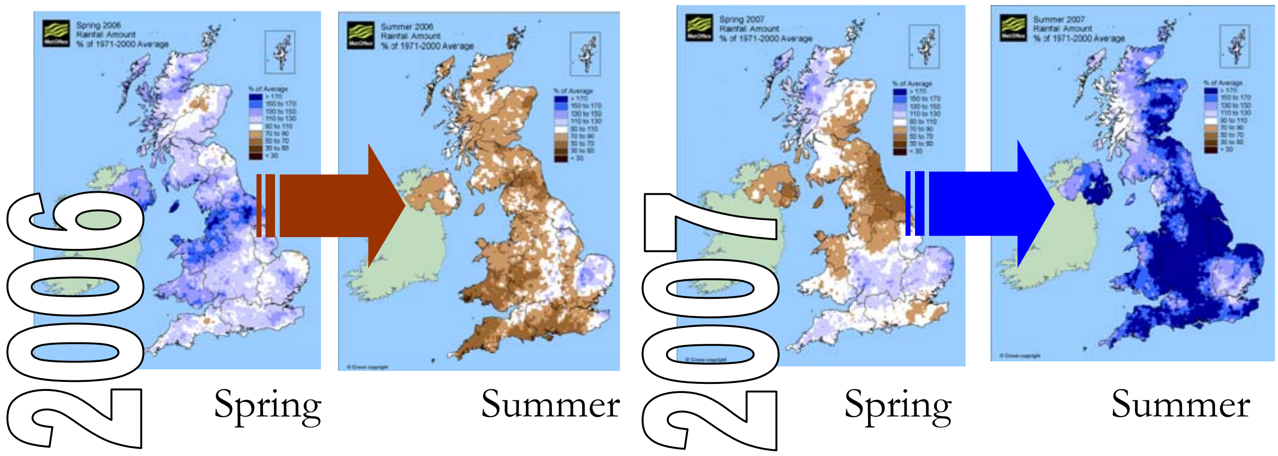
Meteorological Office – Development Profiles

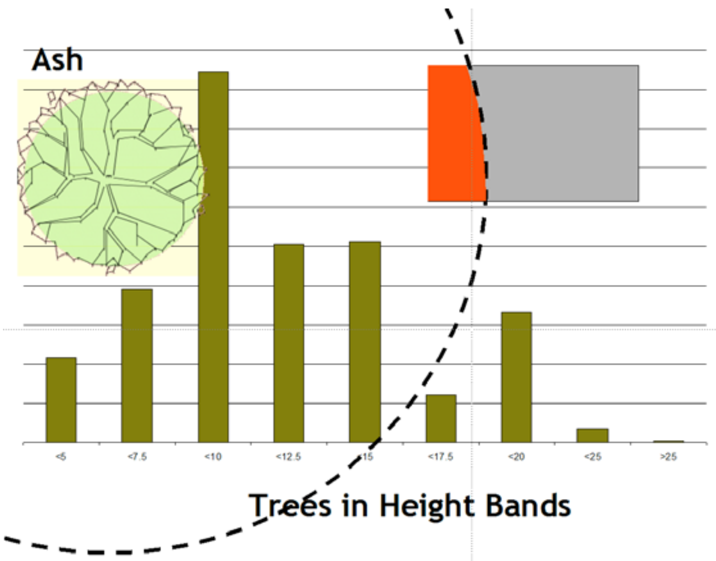
The Meteorological Office provide a wide range of useful data covering rainfall and sunshine patterns over the year, and by location. Below we see how 2006 differed from 2007. A reversal of rainfall patterns. Their web address is http://www.metoffice.gov.uk/

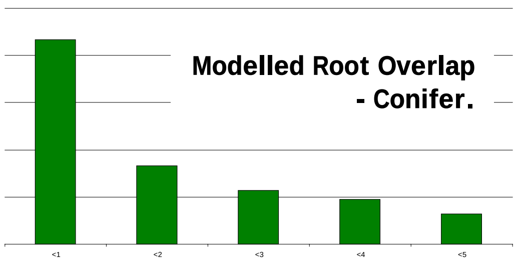


Risk by Root Overlap – Analysis

We have further refined our view on the risk presented by modelled tree root overlap beneath the building footprint to take account of variations between both height bands and species. This is explored in more detail next month.

The initial analysis considered the count of claims associated with projecting parts of the building – bay windows and porches etc., and inferred this was the danger zone. It added a "vulnerability" factor. Below we see the variation in distribution of risk across the range and next month we look at a different way of estimating root overlap.





Above we see how this distribution changes by tree height, broken down in bands of estimated root overlap.

Accounting for the increased risk posed by each category of tree, expressed as frequency of tree population, we may deduce lower overlaps are more dangerous because they are more likely to be associated with trees in the higher risk category.

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SAMPLE DISTURBANCE

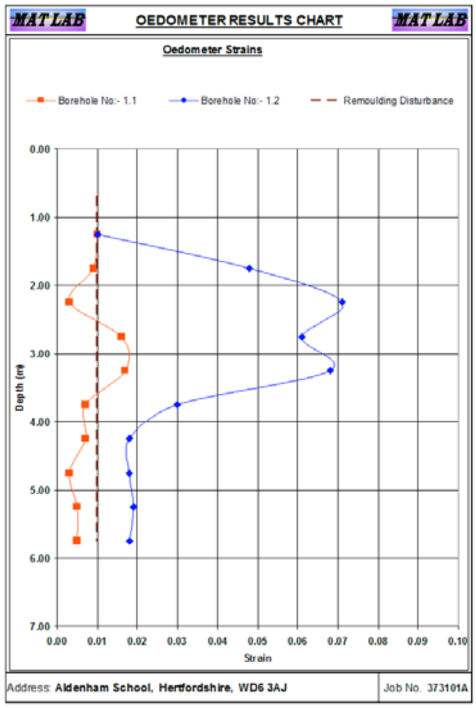
In "*Site Investigations and Soil Testing*" - *November 2007,* differences were described between various techniques of sampling and testing from investigation undertaken at Aldenham in May 2006 and June 2007.

The results of further investigations undertaken in April 2008 are reproduced here from a bore sunk 4mtrs away from the Willow tree, retrieving undisturbed and disturbed samples from adjoining bores.

Right are strains measured using the oedometer. Sample disturbance (blue line) increases peak strains by a factor of around x 3 when compared with samples from the undisturbed core.

Below are soil suctions measured using the filter paper technique. The difference between disturbed and undisturbed sampling is an increase in peak stress by a factor of x 2 when compared with the undisturbed samples.

In all cases, root induced desiccation is evident, peaking at between 2 and 3mtrs bGL.

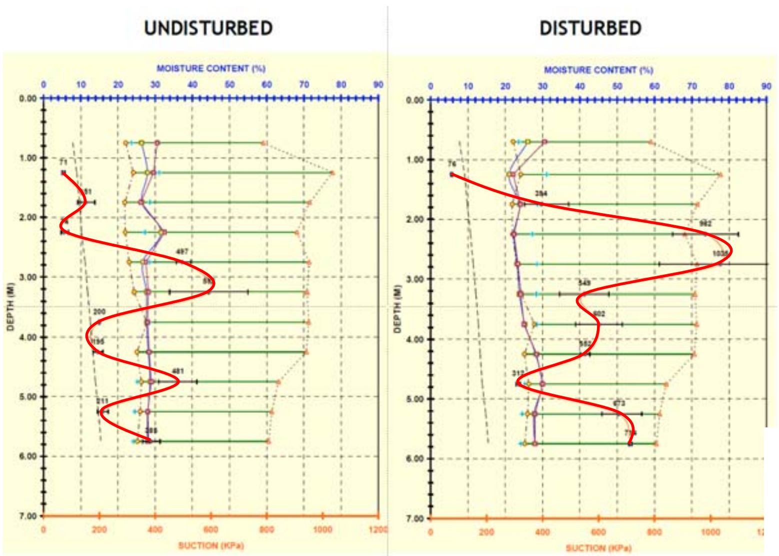


Measured Strains

Disturbed samples (blue), and undisturbed (red) results using the oedometer.

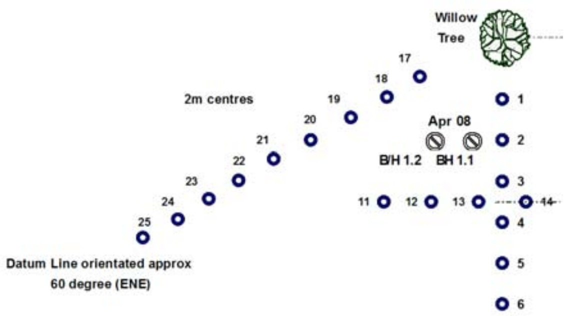
All procedures confirm root induced desiccation at the same depth below ground level. The estimates of swell vary – undisturbed samples (irrespective of test) are similar, as is the prediction for the disturbed tests.

Precise levels suggest the lower value (around 20mm) is more likely to be correct.



Estimates of Swell

Estimates of swell varied between 20-30mm (undisturbed) and 50-60mm (disturbed). Precise level data supports the lower values provided by the undisturbed sampling technique.



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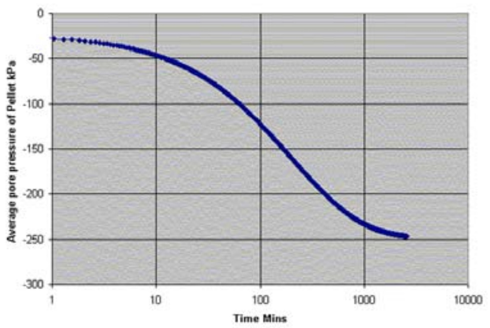
Soil Suctions

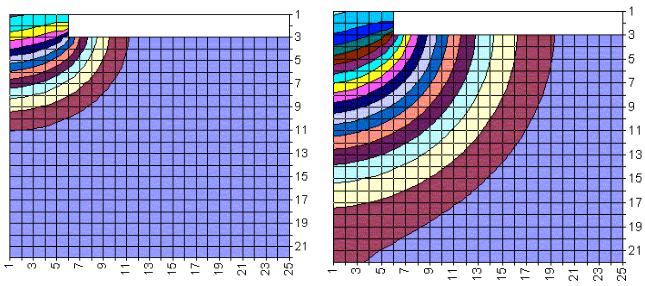
MatLab continue to develop new techniques for site investigations and soil testing with the objective of delivering a robust result, faster and at a sensible cost.



They are aiming for a 24 hour turn-around to test and deliver suction results using a new technique to cater for the difficulties we encounter at times of surge. The new test reaches equilibrium in less than 24 hours – see timeline, above.

Days instead of weeks – or even months as was the case in 2003. The time taken to obtain the result is a function of the Liquid Limit. The higher the LL, the longer it takes to reach equilibrium.

Below is a Finite Element model of the increasing suctions travelling through the sensor – each grid represents 25kPa. The starting point is a sensor at 25kPa, and we see radial flow developing against a clay sample at a suction of 250kPa.

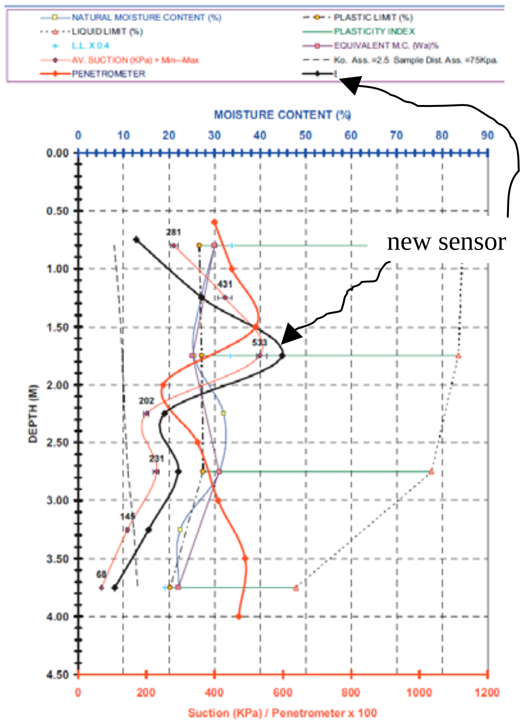


Further testing is underway and we hope to have final calibration in the next six months, followed by the publication of a paper.

When used in conjunction with the penetrometer (following item) MatLab will be able to provide a full range of tests very quickly, and at a reasonable cost.

Penetrometers

On site assessment of the shear strength of soil is underway, supplemented with a full range of comparative tests which include moistures, equivalent moistures, soil suctions (filter paper test) and oedometer.



Opinions and interpretations expressed in the chart above are outside the scope of UKAS accreditation.

Initial results are encouraging, as we see above. All of the tests identified a zone of increased stress at around 1.75mtrs bGL.

The amplitude of the curves are similar with the new sensor (bold black line) matching those of the suction curve (using calibrated filter papers) and the penetrometer (bold red line – values factored x 100 to convert values to kPa). The dial gauge of the penetrometer is calibrated to read in kg/m² - to convert to kPa, multiply by 100.

Although the moisture profile dips slightly, it is percentage points that can be harder to detect and to agree as evidence of desiccation between engineers.

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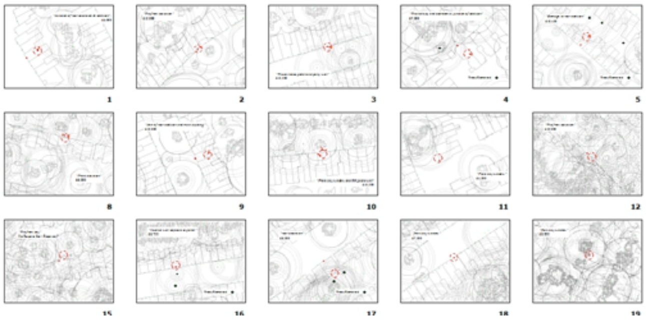
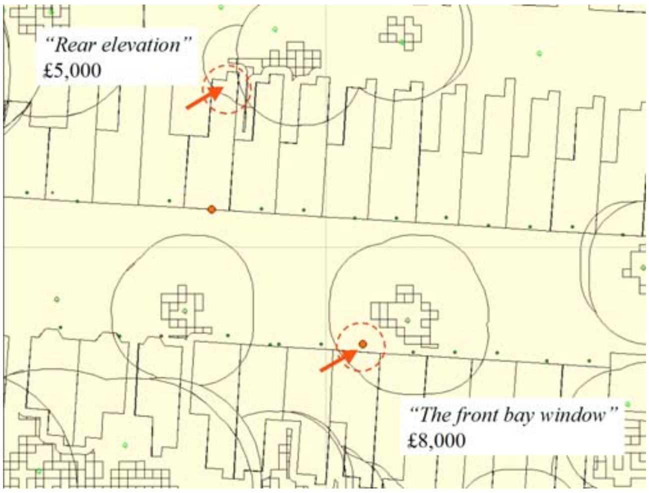
Modelling Risk

Our audit of the predictive power of the subsidence risk model includes comparing the output with settled claims. Below is a small extract of the sample we have reviewed from the NW area of London.



The results reaffirm the suggestion that the periphery of the root zone can be a dangerous location, and particularly for projecting parts of the building – bay windows and so forth.

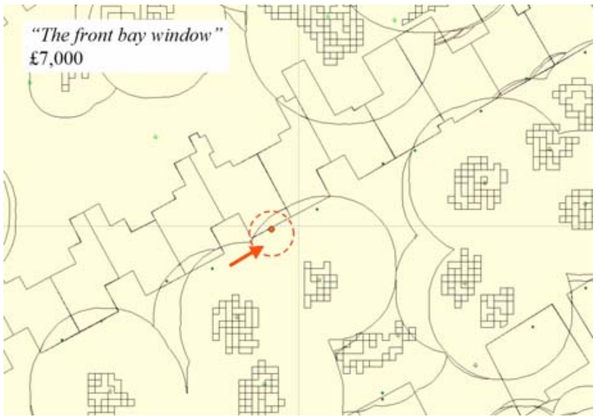
The extracts below illustrate both the efficiency of the model and the appropriateness of the root zone.

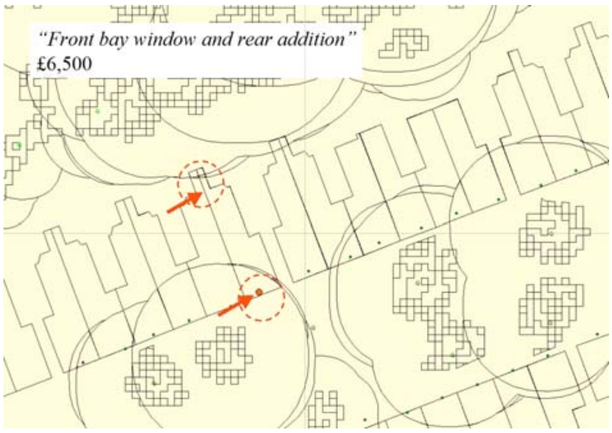


Above are two buildings across the road from one another in the same road. The top one has damage to the rear elevation (the engineer has set a reserve of £5k) and the bottom one has damage to the front bay window (reserve of £8k).

These results have been modelled 'blind' with the location of the properties supplied and the outcome predicted prior to reviewing the claim details.

The two examples below show similar outputs with the modelled root zone almost defining the area of damage. The engineers description is shown on each image, along with their reserve. The description "*front bay window and rear addition*" has been taken from the engineer's report.





As can be seen from this brief extract, the root zone estimate – or "the zone where roots exist sufficient to cause ground movement resulting in damage a low rise building" – appears to be satisfactory.

The statistical model encapsulating all known possibilities – houses with no roots beneath them, those with roots and no damage, houses with roots that have been damaged, frequencies of claims by geology and taking into account time – is discussed elsewhere in this edition.

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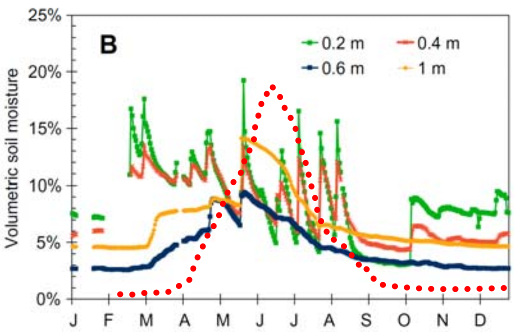
"Seasonal Changes in Depth of Water Uptake for Encroaching Trees Juniperus Virginiana and Pinus Ponderosa and two dominant C4 grasses in a semiarid grassland"

EGGEMEYER *et al*
Tree Physiology 29, 157–169 (2008)

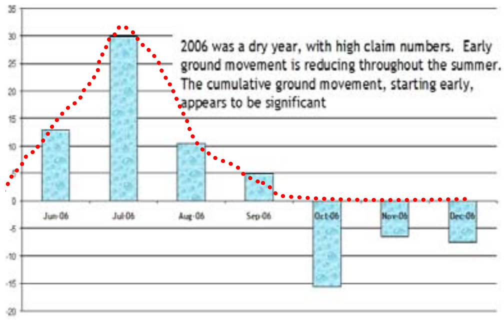


This paper illustrates water uptake by month for two species of tree and reaffirms the peak demand in spring, diminishing as negative porewater pressures are increasing, and as available water reduces.

Water abstraction at 0.6 and 1mtr below ground level are attributable to the trees. Grasses exerted an influence down to around 500mm below surface level.

The pattern of moisture uptake mirrors our own findings using 'ground movement by month' as a proxy, although the Oak and Willow peak a little later - as we see below.

The dotted red line in the graph above has been taken from the profile at Aldenham, below.



Relevance to InterTeQ?

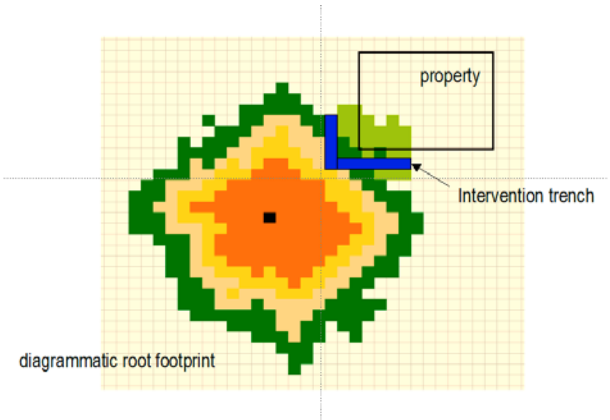
The soil moisture loss over time can be estimated using these 'change by month' values provided by the precise levels. This is not a measure of tree water consumption, which will be significantly more.

The harvesting chambers and bores, assuming a 7mtr run, have a capacity of nearly 3 cu mtrs. They would have to provide the difference between a normal and a dry year (around 20 cu mtrs in June) to replenish the full soil moisture loss. Applied across part of the root plan - say 5% maximum = 0.05 x 20 = 1m^3.

	cu mtrs	gallons
Jun	30	7,841
Jul	69	18,095
Aug	24	6,333
Sep	22	5,730

Distribution of Soil Water Loss 2006 by Month

Clearly this is far too simplistic - soil suctions will redistribute the moisture towards the tree and overall consumption will be higher. The aim of the Intervention Technique is not to remove ground movement entirely, but reduce the amplitude. Much depends on root distribution and soil mineralogy.



	SMD Aug-06	SMD Aug-07	DEPTH (mtrs)	Grd Movement 2006	WsF_2006	Grd Movement 2007	WsF_2007
NP1	-0.0156	-0.0179	1.5	-23.4	-5.85	-26.85	-6.7125
NP2	-0.073	-0.02	1.75	-127.75	-31.9375	-35	-8.75
NP3	-0.0504	-0.027	2	-100.8	-25.2	-54	-13.5
NP4	-0.0551	-0.0135	2	-110.2	-27.55	-27	-6.75
NP5	-0.0284	-0.0077	1	-28.4	-7.1	-7.7	-1.925
Averages =	-0.0445	-0.01722	1.65				
Water Deficit =	-144	-56 cu mtrs					
Dry Soil Volume =	3245.34	cu mtrs	(assuming 25mtr root radius)				

The area of treatment suggests that rehydration works well and our work on 'turning trees off' is ongoing.

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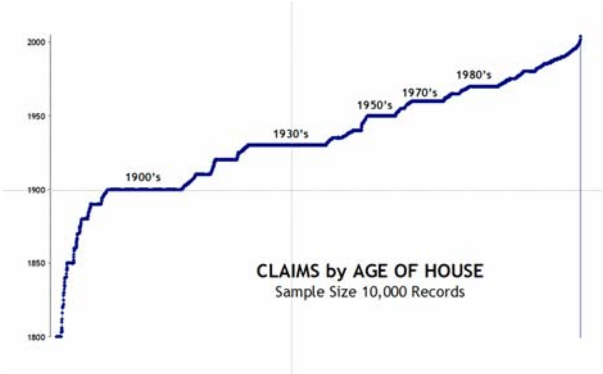
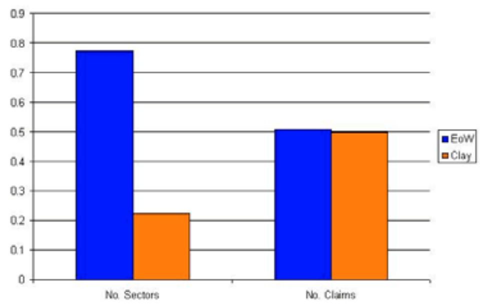
Claims by House Age



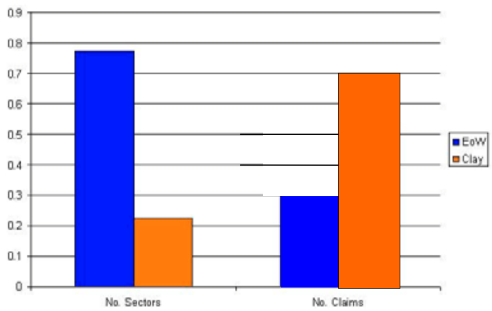
This sample of 10,000 claims shows the distribution by age of property, not sorted by peril. Frequency distribution - the number of houses damaged divided by the house builds by year – appeared in an earlier edition.

Risky Sectors – Normal Years

This graph illustrates the 'peril by sector' distribution. Escape of Water claims are shaded blue, and clay shrinkage claims, orange.

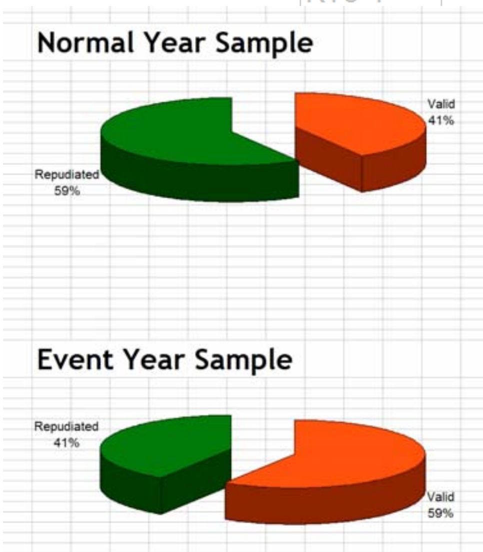


With regard to clay shrinkage, around 20% of the UK postcode sectors deliver half of the industry claims. The often-quoted figure that 70% of valid claims are due to clay shrinkage will include event years – see below.



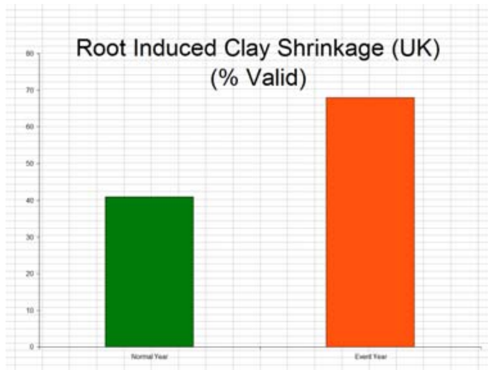
A Footnote on Risk

Examining a decent sized sample of claims (10,000 in total, valid and repudiated) delivers the following information, which supports current thinking and the earlier work of the BRE.



In a 'normal' year, the percentage of valid claims is around 41% and in an event year, this rises to nearly 60%.

Of the 60%, the number of 'root induced clay shrinkage' claims amounts to nearly 70%.



This translates to a probability that a claim in an event year will be clay shrinkage of 0.7 x 0.6 = 0.42, increasing in some sectors, and decreasing elsewhere.