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 Applications

The Clay Research Group
www.theclayresearchgroup.org

September 2007 – Issue 30

The Clay Research Group

This Edition

We re-visit the 35,000 or so tree records we hold to look at the height/distance relationship between trees and damaged houses, picking up on, and developing earlier work.

We are also looking at ABA production and the basic mechanics of building failure in terms of how structures might accommodate distortion and what the fulcrum has to do with risk.

Feedback

Jon Heuch of Duramen Consulting always provides challenging (and welcome) feedback and is wary of our willingness to arrive at conclusions about moisture uptake based on relatively little evidence. He points out that the Aldenham site and the one mentioned in the extract from last months journal share one characteristic – they both have low moisture availability. Aldenham because of the persistent deficit and the published one due to the shallow depth of soil.

Giles Biddle asked for the Issue number to be included on the newsletters and reiterates a point that Jon has already made about the graphs we produce. Too often they don't have the axis noted and lack an explanatory description. He challenges the notion that we have a persistent moisture deficit beneath the Oak – or at least, thinks it may have been replenished if there was one in 2006. He thinks we have full rehydration this year, following the rainfall and points to the levelling out of the latest readings. He agrees the tree takes up water early in the year, but explains this is simply because that is when it is readily available.

Giles also expressed concern that we might infer we can tell which tree will cause damage, and when. His work with the Arboricultural Association tells him otherwise.

Mike Lawson wonders if we have the climate/tree interaction right with regard to climate change. Is it the case some trees will survive and others may not in our climate change model? Or have we judged this badly and will natural selection save the day? If we understand him, he suggests the 'less aggressive' species (our terminology, not Mike's) will survive and he points to the plastic response of trees and their root systems to adjust to their environment. Hopefully more on this shortly.

The arborists are clearly active and concerned – not all of the assumptions we make meet with their agreement and we hope to persuade them to contribute to future editions. Although we share the same data we sometimes interpret it differently, and we welcome more contributors.

Small Changes

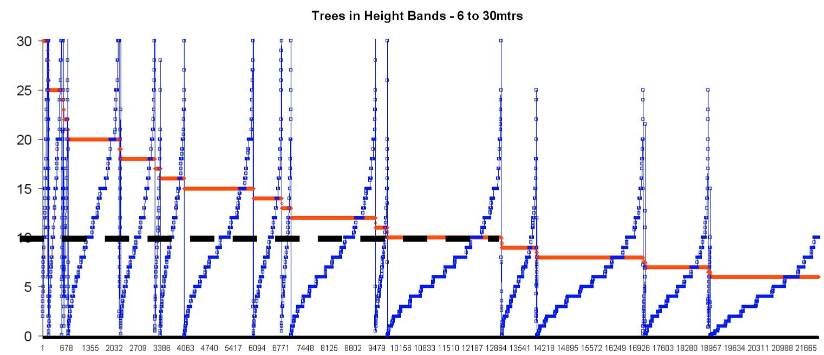
The appearance has changed a little to reduce printing costs. We have added the Issue Number as Giles suggested. Hopefully future graphs will be easier to understand. In addition we will be issuing some 'in-depth' analysis on certain topics, the first of which is due for release shortly and will cover the role of Abscisic Acid.

Hopefully the change in page layout and font may make the articles more readable.

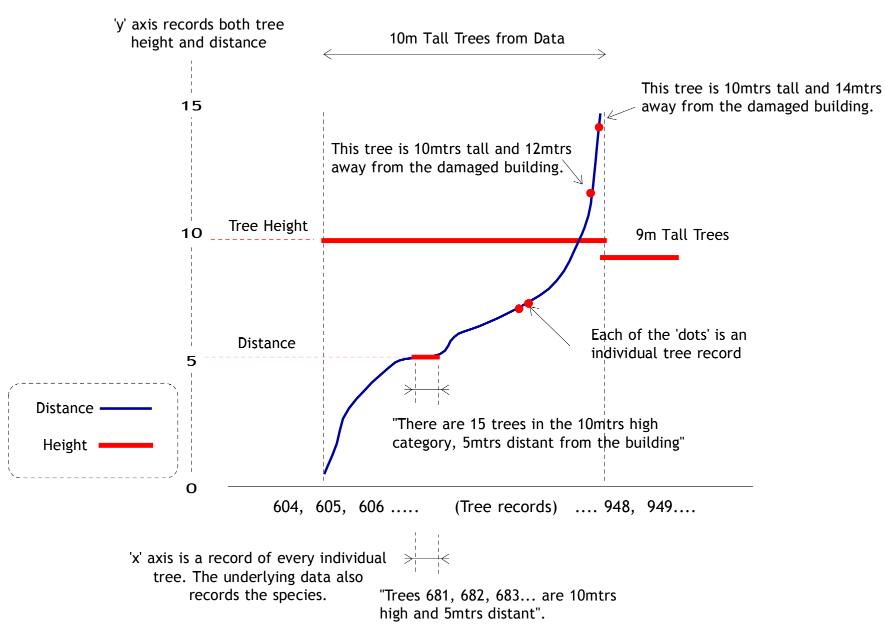
The Clay Research Group

Height/Distance Analysis

Using claims data, the top graph plots the tree heights in bands (each red horizontal line represents a height of tree). The blue line represents the distance from the building for that height of tree. The 'y' axis is used for both height and distance to allow a comparison to be made.



The 'x' axis is the count of trees. This extract plots trees from No. 1 through to No. 21,965. No account is taken of species at this stage although it is recorded in the underlying tables. 10mtrs tall trees are indicated by the black broken line above. The blue line plots their distance from the building and we see that some are close to the building, and others are further away but there are records across the entire root zone of trees, 10mtrs high, that have been implicated in damage to property. Some are further away than their height. To clarify, the diagram below illustrates how we use individual trees to build the graphs.



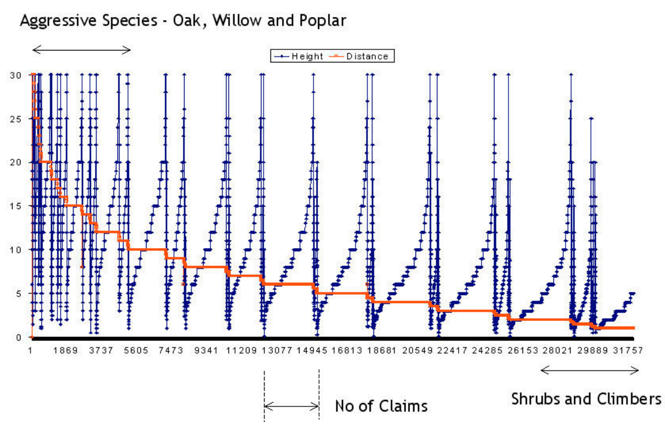
The Clay Research Group

We see a very similar pattern developing across all heights. Our conclusion, setting aside species and frequency, is that trees pose a risk across their entire root zone, and sometimes well beyond. Examining the underlying tree table, and looking at the latter category – those trees that cause damage to buildings that are further away than the tree height – we begin to understand the risk that certain species pose. See table below.

H	D	H/D	Owner	Species
10	18	0.56	Owners	Oak
10	18	0.56	Owners	Willow
10	18	0.53	Owners	Willow
10	19	0.53	Owners	Willow
10	19	0.53	Owners	Oak
10	19	0.5	Neighbours	Willow
10	20	0.50	Council	Oak
10	20	0.50	Council	Oak
10	20	0.50	Neighbours	Willow

This extract records trees with a "distance exceeding height" for trees 10mtrs tall. The high water demand species appear most often as we would expect and include Oak, Willow and Poplar. It can be seen that in 90% of all cases, the distance is equal to or less than, the height. Around 10% of records reveal a 'distance > height' relationship.

Below we have used the same data as the previous page, but sorted first by distance and then height. Again, a uniform signature emerges which, because of the regularity across all ranges and the large amount of data, suggests the relationship to be robust.



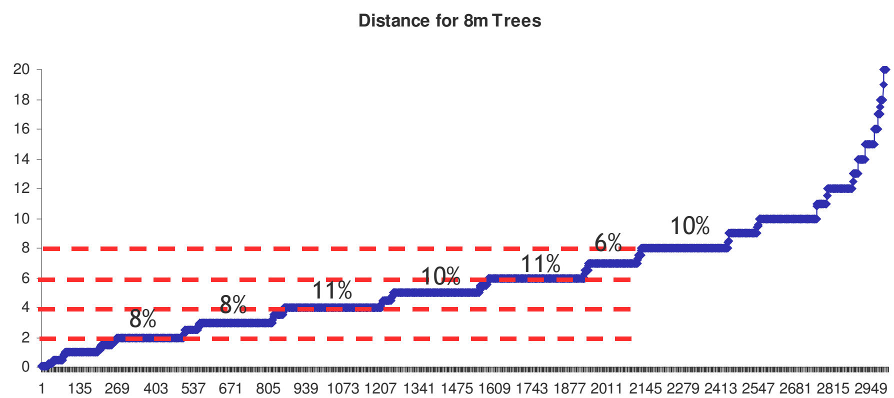
The regular signature across differing height ranges illustrates the point that the average tree poses a threat to a property wherever it is situated within a radius equal to, or less than, the tree height.

The Clay Research Group

Implications of Findings

Below is the distribution – how many 'distance away' records - for each value at metre intervals. This refers to the 8m high trees. 8% of 8m high trees are 2mtrs away, 10% of 8mtrs high trees are 6mtrs and so forth.

The average is 8.5% per height band. 21% of cases in this category have a 'distance away' exceeding the tree height, which we assume suggests a Borough with mature street trees – and possibly of an aggressive species.



The species is important but we would suggest more so at the data extremes – deciduous trees in the mid-range have similar signatures across the height bands, although the count by height varies. There are fewer taller trees, and the more aggressive are in the range 8 – 10mtrs. This isn't a frequency estimate and will in any event vary by Borough and age of property.

Tree heights are usually estimated by surveyors and engineers in relation to the height of a nearby building, and are subject to error. This also applies to the 'distance from building' value. They are rarely measured accurately. Arborists would take greater care we assume.

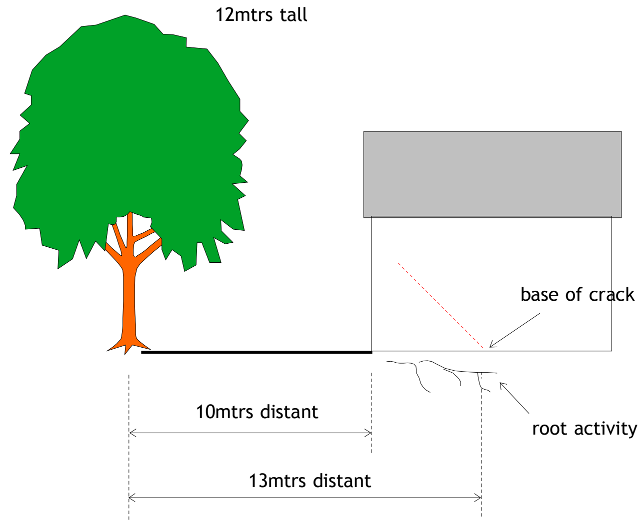
We would suggest the value of this analysis lies in the sheer number of entries and the regular signature that is described. It may be that we can't rely on the fact that a tree 8mtrs high is riskier than a tree that is say 9mtrs high because of issues around data collection, but we can hopefully detect trends and relationships.

The Clay Research Group

Height/Distance Analysis

Plotting the data provides a glimpse of the interaction, but needs further consideration before we review 'safe distances'.

Taking an example of a 12m tall tree causing damage to a building 10mtrs away, we see the 'distance to building' is useful, but doesn't fully reveal the risk zone. As reviewed in an earlier edition, it is far more meaningful to measure the distance to the base of the crack.



The sketch above illustrates why 'distance to building' generally under-estimates the influence of the tree. In this case, the tree root influence on the ground (by which we mean the abstraction of moisture from clay soils by roots sufficient to cause damage) is 13mtrs, not 10mtrs. An increase of between 20 - 30% compared with the 'distance to building' figure.

The root system of trees is greater than previous studies that have relied on the H/D ratios suggest. Sometimes by a significant amount.

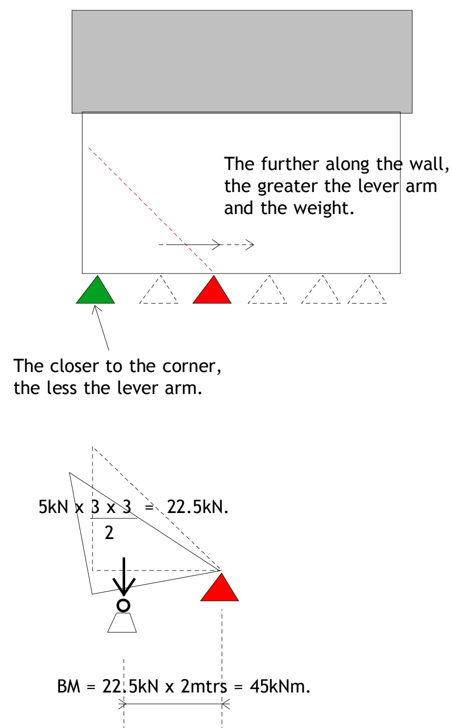
Failure Mechanism

The location of the fulcrum – that is, the periphery of ground movement associated with root drying – is important in determining the buildings response as we see on the following page.

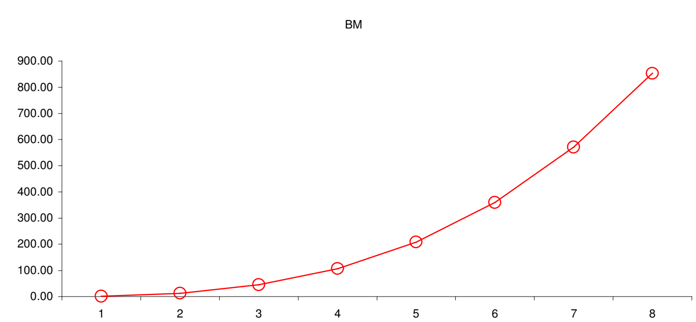
The building will be stiff enough to resist bending close to a corner. Moving the fulcrum a distance away not only increases the lever arm, but also the weight and the risk.

The Clay Research Group

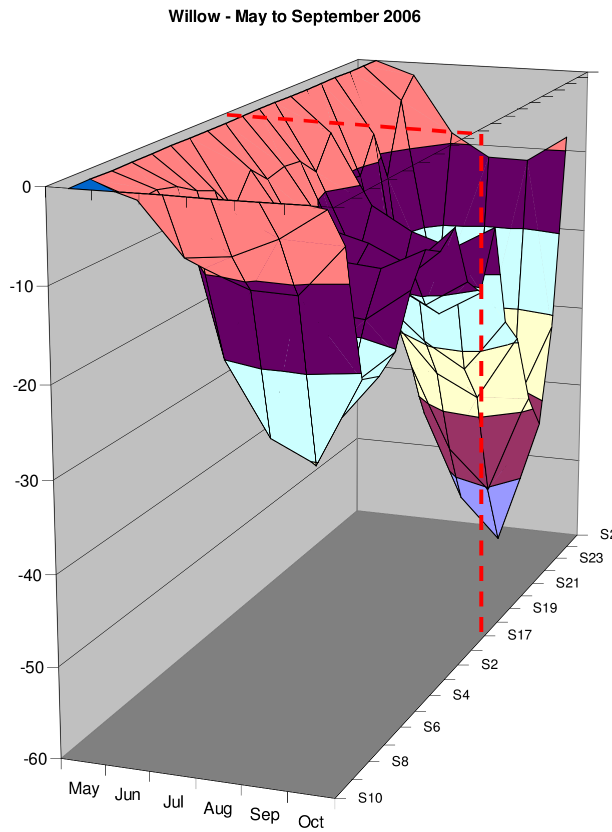
A simple calculation, assuming a fulcrum 3mtrs from the corner of the building and a 45 degree tension release profile, produces an increasing BM with length, and is another measure of risk for the release of tension – a measure of risk for cracking.



Below we plot the BM (y axis - kNm) at various lengths along the wall (x axis - mtrs). This illustrates one of the modules behind the numeric method of assessing risk using the statistical data from previous pages to utilise the H/D ratios. Plotting the relationship between trees and buildings, knowing the soil type and tree height leads to a scientific method of risk assessment.



The Clay Research Group



Ground Movement

Left we have some idea of ground movement both over time, and by station. A 3D grid showing the variability across the levelling stations and the relative amplitude.

This graph plots movement for the Willow. The red dotted line indicates the position of the tree. Station 10 (closest) is the datum.

This isn't a view beneath the entire root zone. Just the ground movement along the levelling stations, over time.

Looking at the data in various ways helps to understand what is happening and below we have plotted the data using a grid. By filling in the remainder of the root zone with notional interpolated values we can see the form ground movement might take.

It is unlikely to be a uniform bowl (as we see from both the Oak and Willow sites) and the image takes account of variations in the soil mineralogy and root influence. This image isn't meant to illustrate what is actually happening but instead, the variability.

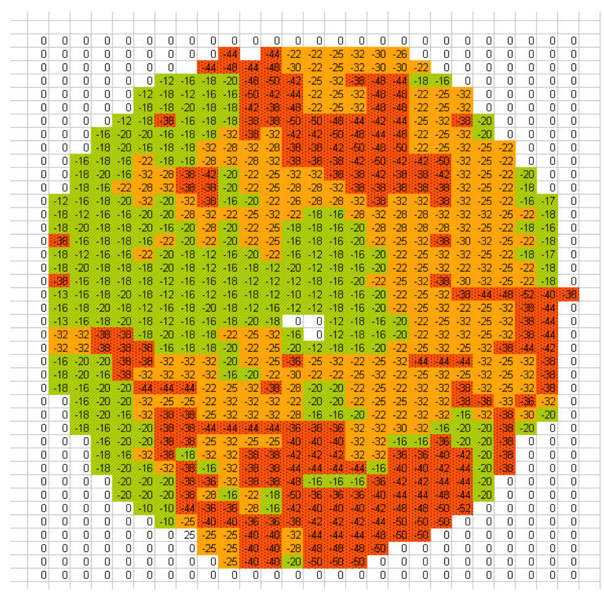
Disorder Modelling

We have extended the disorder model (see Newsletter 18) to build this plan of the root zone.

By running several iterations of the cross section we can populate the cells with mathematically derived values that take account of variations in soil mineralogy and root distribution.

This is a stochastic view and doesn't claim to deliver actual values. However it does provide an estimate of the sort of movement – and variations within the root zone – that are expected for a statistically 'normal' tree.

It is probably the first 3D visualisation and we can see how the zone changes seasonally and over time.

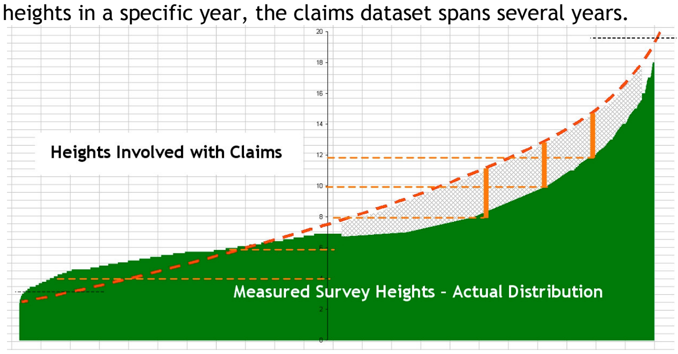


Issue 30 – September 2007

The Clay Research Group

Tree Height Study

Calculating tree frequency accurately is economically impossible. There is an absence of good data on planting and felling. Trees are continually growing and whilst a surveyed dataset reflects tree heights in a specific year, the claims dataset spans several years.



The 'y' axis records tree heights and the 'x' axis reflects the number in each height band. We are trying to understand the correlation between our claims data and the surveyed and measured tree population using a crude technique based on the value of large numbers. The survey measured the heights and location of all trees within the M25, on London clay and within influencing distance of a building, but did not identify species. Our claims data records trees implicated with subsidence across the UK.

The count of surveyed trees in this extract is nearly 2 million compared with 33,500 claim records. We recognise that London trees may be taller than the UK population – mature species related to the age of the street planting. On the other hand London accounts for the majority of root induced clay shrinkage claims. Much of the claims data will have come from within the M25.

The relatively large sample means we can see some general relationships even though we are not comparing like for like. Plotting the tree height data for claims (red line) against the survey study gives some indication of correlation. The largest population of surveyed trees are between 6 – 8mtrs in height, and can be seen where the green plot flattens to the right of the central axis.

We can see an over-expression of damage relating to taller trees – above 7mtrs – in the grey shaded area. This is an increased frequency of claims in respect of the surveyed population.

The orange lines indicate that 8mtr tall trees are marginally riskier than any other, ignoring species. If we use 7m tall trees as our average risk, graded as '1', the risk attribute of an 8m tall tree would be 1.3 – a 30% increase. At the left of the graph, a tree with a height of 6mtrs would have a risk value of 0.85.

SUMMARY

Comparing claims with the surveyed dataset isn't conclusive evidence of anything, but the numbers alone make the exercise interesting.

We believe the data is probably useful in arriving at some idea of risk when looking at H/D assessments, although we do miss the refinement of understanding the species. Taller trees are riskier because we have more claims expressed as frequency of the tree population, and conversely, smaller trees may pose a slightly reduced risk. Our 'break point' between small and tall is 7mtrs. Elsewhere we see that trees nearer to houses than their height pose a threat and that threat is fairly evenly distributed along the root zone radius. No particular distance appears to be safer than another. We do see elsewhere Oak, Willow and Poplar trees often account for damage when the distance to the damaged property is greater than the tree height.

ABA Production

~ a possible model? ~

We are told ABA production commences at low stress levels. In fact, it is constantly produced, but the 'effective ABA' - the hormone not dissipated into the soil or lost elsewhere in the cell structure – is where our interest lies.

Here we draw some early conclusions based on the difference between water uptake (which we define as the 'moisture uptake sufficient to cause ground movement' rather than transpired water) and the climate/tree interaction.

From the assumption drawn earlier from the precise levels, we anticipate hormone productions starts early in the year, probably peaks around July/August and then remains fairly stable depending on the prevailing weather.

ABA Production Envelope