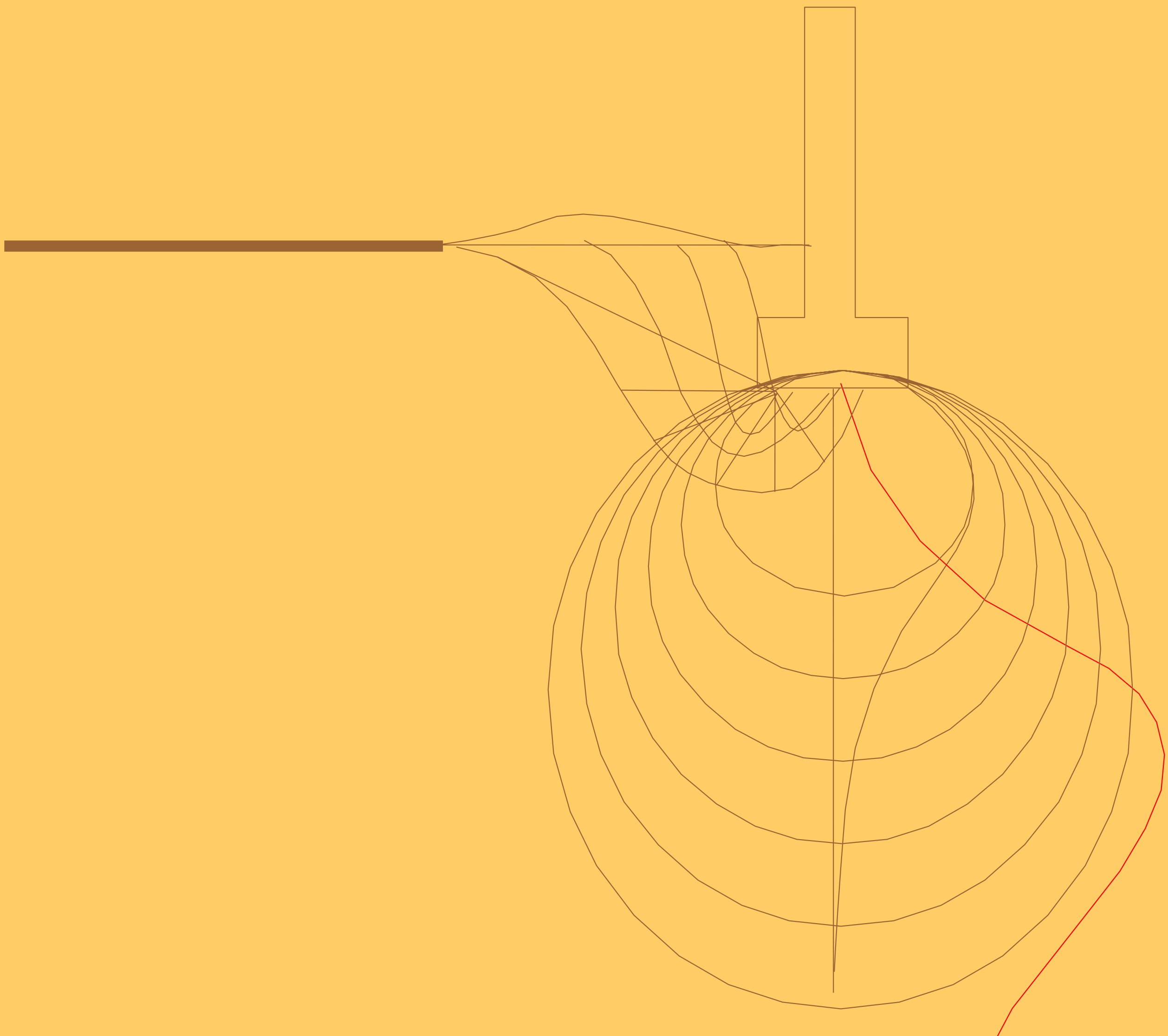
The Clay Research Group



Monthly Bulletin

Aldenham Data Update

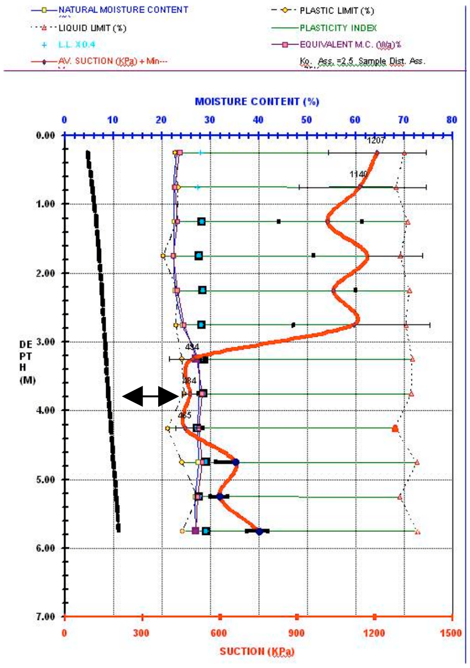
September 2006.

CONTENTS

The Aldenham Willow

Suctions –v- Oedometer

If you look at the comparison testing between the oedometer and the suctions on Page 7 you will see a close agreement in both the curves and the estimates of swell on rehydration. Both are testing disturbed samples. The possible exception is at BH1, where the filter paper method suggests an estimate of heave of about 101mm, compared with the oedometer value of 80mm.



Above is the plot of the suction graph, shown as a red line. We can see the Ko line to the left of the screen as a black dotted line.

The arrow indicates where the lower plot of the suction curve (from 3.5mtrs down) should coincide with the Ko line, and the over-estimate of swell is a product of this disjoin. If the suction plot is moved to the left, or more correctly possibly, the Ko line moved to the right so they coincide from 3.5mtrs down, the estimates of swell are very similar, as they are elsewhere.

Determining the exact location of the Ko line is well beyond the scope of any investigation for domestic subsidence, and we have to remember the value is largely theoretical for our purposes.

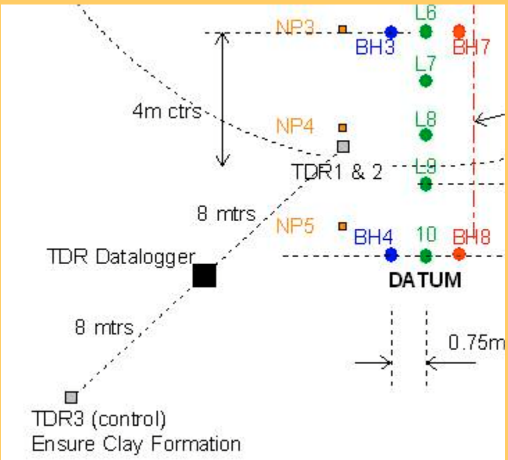
For a review of the benefits of testing with the oedometer refer to Page 7.

TDR Supplement

September 2006.

TDR Installation

TDR1 & 2 are situated close to NP4 for correlative purposes, and TDR3 is the remote, well away from the root system of the Oak tree.



The Time Domain Reflectometry sensors propagate a high frequency transverse electromagnetic wave that is passed through four parallel ‘prongs’ buried in the soil. They measure the dialectric constant of the soil.

The dielectric constant is inversely related to this propagation velocity, i.e., faster propagation velocity indicates a lower dielectric constant and thus a lower soil water content. Or, as soil water content increases, propagation velocity decreases, and dielectric constant increases.

The device measures volumetric moisture content and the output can be compared directly with the output of the neutron probe.

In the publication “Soil Water Monitoring & Measurement”, Ley et al say “*the TDR technique is highly accurate*”, and is also rated highly in terms of cost, installation, maintenance and accuracy when compared with alternative techniques for establishing moisture in the field.

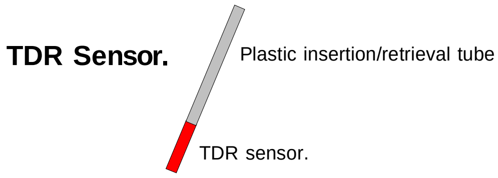
For the Aldenham site we have selected a battery powered datalogger that charges the sensors periodically, take a reading, and then ‘powers down’ to conserve energy. There is no mains power needed.

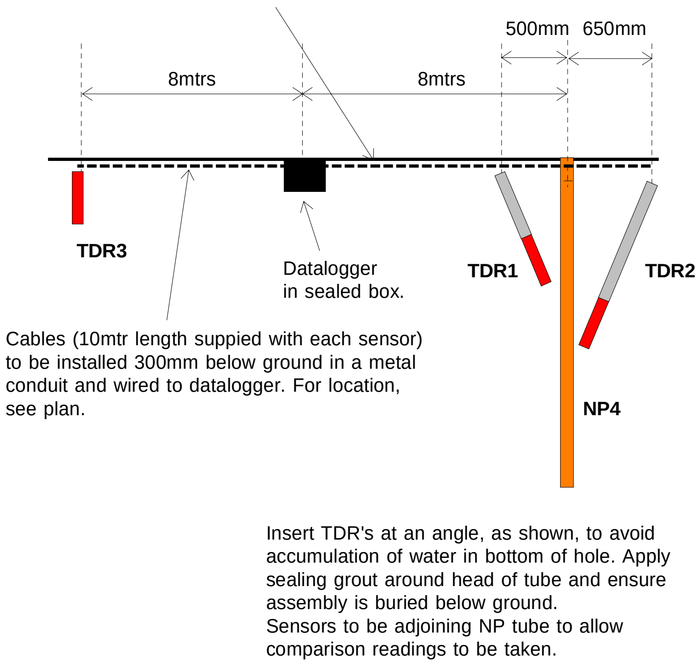
Because of the exposed situation, the datalogger has been buried in a waterproof container. The installation is completely concealed below ground.

TDR Moisture Sensors

These have been delayed a little but are due to be installed very shortly. The arrangement is shown below. We have two sensors close to neutron probe NP4 for corroboration, and then TDR 3 will act as the remote, away from root influence of the Oak tree.

Data is to be transmitted from site via a buried datalogger.





Southampton University are undertaking corroborative evaluation of the sensors measured against the NP data and in parallel we will be writing the web based application to interpret the output.

TDR sensors have been extensively tested and measure the volumetric moisture in the same way at the neutron probe.

Ground Treatment

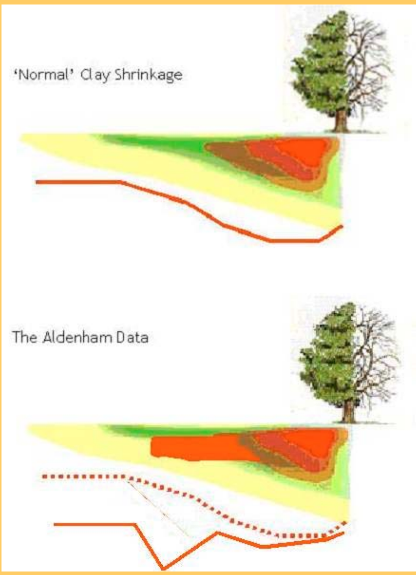
It is almost impossible to counter the forces exerted by the tree root. Although the osmotic potential plays a large part, the tree suctions are high in relative terms.

However, if we can trigger the hormonal response of the tree (see earlier editions), we may be able to mediate the situation, reducing the amount of moisture extracted.

The laboratory work has taken longer than we hoped and there may be some delay in transporting the technology to site.

Accounting for the 'Odd' Precise Level Readings

Top we see the more traditional situation with the levels (red line) reflecting the zone of desiccation.



Below we have the situation that we think exists at Aldenham. The dotted line represents ground movement that has already taken place, without recovery. We are measuring the seasonal movement at the root periphery. See Page 4.

Laboratory Results

Below are the initial results of the laboratory test that are being run by MatLab. The samples have been treated with a variety of solutions before being consolidated in two stages. The first loading cycle has been from 100 to 200kPa, and then from 200 – 4-00kPa prior to allowing the sample to rehydrate on unloading.

This process is carried out several times, for each of the solutions.

Using a bank of oedometers, each fitted with a transducer to measure and record swell automatically, and going through repeated cycles of shrink/swell we can obtain a lot of information fairly quickly, modelling three or four years in the space of a few weeks.

We can determine the effectiveness of the treatment by recording the swell on rehydration and if it has been successful, it will be less than the amount of consolidation and the overall movement will diminish with time.

This reflects any mineralogical change that might have taken place - which will also be reflected when we measure the P.I. of the samples before and after treatment.

MatLab have recorded significant reductions in swell prior to 'washing through' the sample with disturbed water to see what happen four or five years on. Does the ground return to its previous level of cyclical movement, or is the change permanent? This is closely linked with an earlier study at Imperial College in which we investigated the 'high linear suction' anomaly, and we have taken advice from Prof. Tanton at Southampton University, to whom we are indebted.

Aldenham Data Update

September 2006.

Feedback

Neil Curling has been exceptionally sharp eyed and spotted a real corker. In the last edition we said "the roots are no doubt exploring the avenues of least resistance". Neil corrected this when he says "surely you mean exploiting, not exploring", and how true. Apologies.

Neil puts forward a neat theory about root tips and osmosis which we thought was worth further exploration. It has triggered the review elsewhere in the newsletter.

Jon Heuch continues to probe, and has forwarded a case history which confounds prediction by even the most sophisticated of models. Jon believes 'each case on it's merit' and is suspicious of the modelling approach, but keeping an open mind. Nigel Cassidy shares this scepticism a little.

We have been asked – by more than one person - 'interesting, but to what end?' As an academic exercise it has value, but what is the relevance to engineers investigating subsidence claims?

First, over 70% of claims are related to root induced clay shrinkage, we really should know how water moves through the ground in the vicinity trees if we are ever to find a 'neat solution'.

Second, we are looking at emerging technologies and how we might use hitherto expensive techniques (electrolevels and moisture sensors) on the humble domestic claim.

Third, if we ever hope to resolve surge and stop falling over every fifth or sixth year, then telemetry must be a practical answer?

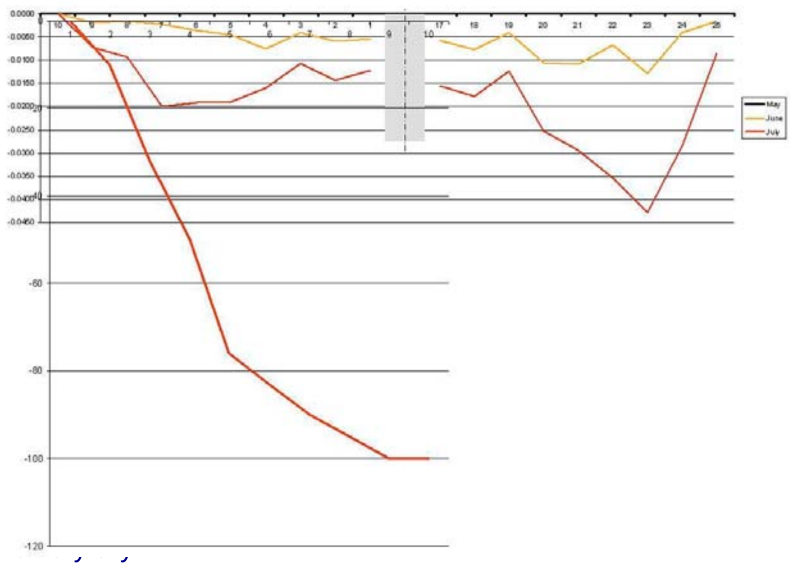
In summary, the project has everything to do with handling claims. Gathering more data, of a higher quality more often at less cost has a significant commercial benefit. It means everyone benefits. The homeowner, the insurer and the engineer/adjuster.

Having the technologies validated by a leading team of academics to ensure we don't 'run before can we walk' is the only way to proceed.

Account for the Persistent Moisture Deficit when reading Level Data

We have an unusual situation at Aldenham because there is a persistent moisture deficit beneath both the Oak and Willow tree.

This suppresses the output from the precise levelling. We see lower amplitude movement over desiccated soils than we would if the ground had fully rehydrated over the winter.



Here we have sought to correct the situation by adding the estimate of soil swell form the laboratory results undertaken in May 2006, to the precise level readings.

Instead of low amplitude fluctuations, we see what effect adding the two together has on the base line survey and we see the more characteristic line with subsidence being greater closer to the tree, reducing with distance.

What is happening below ground is postulated on Page 3. We have a residual zone of desiccation which is relatively stable. It doesn't rehydrate much in the winter, and can't shrink much further in the summer. In May there are suctions of around 1,200kPa close to the tree.

Elsewhere, in zones where there is winter recovery, movement is still taking place and this is where we are detecting the movement.

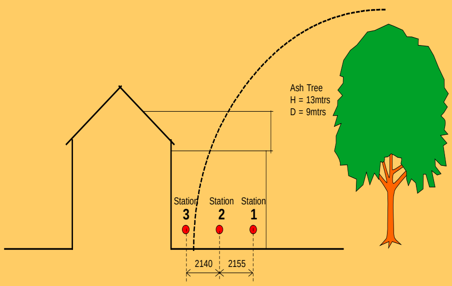
Any other suggestions welcomed.

Telemetry or Remote Measuring

September 2006.

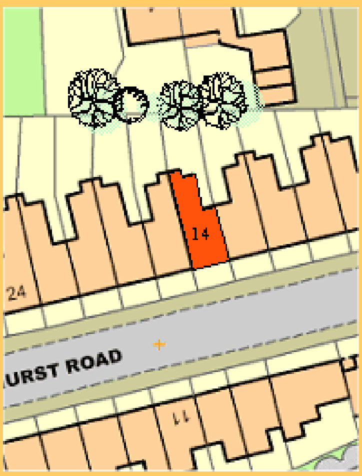
STUDY DETAILS

The monitoring stations were spaced at just over 2mtrs ctrs. The dotted line plots the height of the tree on the basis that the root radius = tree height, which self-evidently is a little conservative in this case as we have movement at Station 3.



The Ash tree roots took approximately one month before influencing the moisture content of the soil sufficient to cause ground movement 2mtrs along the length of the wall between Stations 1 & 2.

The roots were there all along of course, but their drying action commenced closest to the tree first, working along the side wall from May through to July and no doubt beyond.



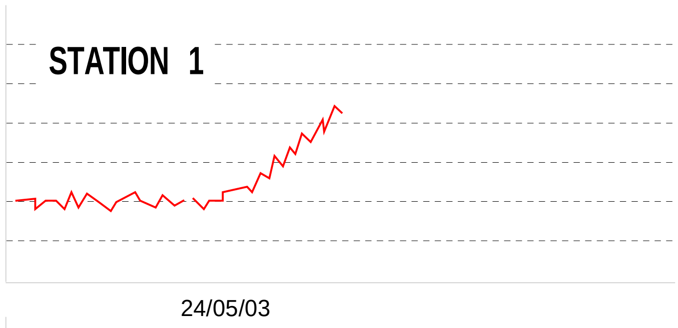
Plan of the building showing the relationship with the trees along the rear building, 9mtrs away.

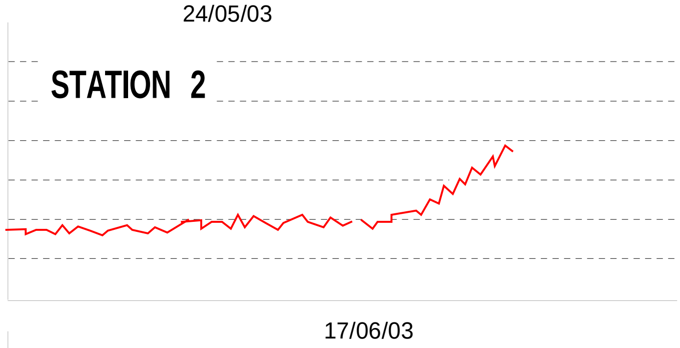
TELEMETRY - AN EARLY STUDY

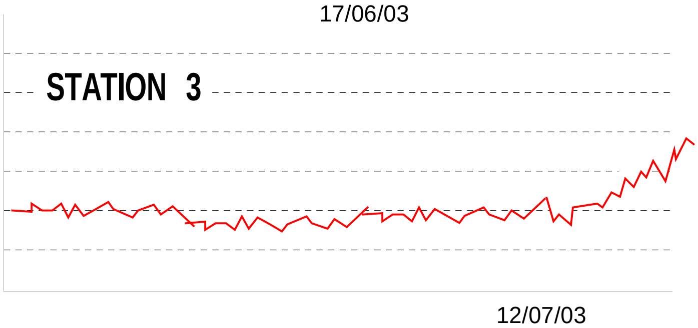
Some of you may recall this study from earlier work but it is well worth repeating because it links the benefits of telemetry and 'black box' technology with ground movement associated with moisture uptake of tree roots. It illustrates just how sensitive and useful the emerging technology is in bringing about a much quicker diagnosis more effectively and cheaply.

The rear two-storey wing building of a large terraced property in Hampstead was damaged by root induced clay shrinkage. A 13m high Ash tree was the cause of damage, situated 9mtrs away. We had evidence of desiccation, monitoring and root I.D. etc.

Installing the electrolevels provided compelling insight into the way buildings move in relation to root uptake of moisture. See the data plot below.







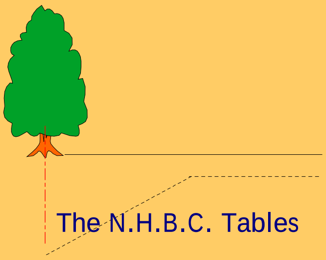
The station nearest the tree (Station 1) registered movement in late May. Station 2 followed less than a month later, and Station 3 registered movement on the 12th July. The roots of the Ash tree had changed the moisture content of the soil nearest to the tree first, and furthest away, last.

Root Zones

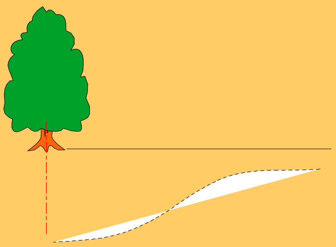
September 2006.

Root Influence Profiles

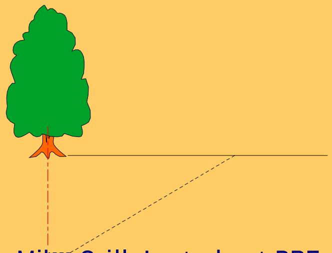
The following illustrate, very simplistically, our evidence for a ‘traditional view of root influence’.



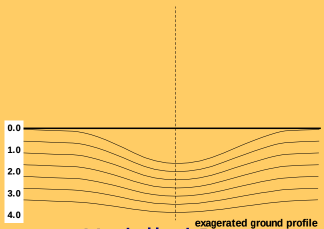
The N.H.B.C. Tables



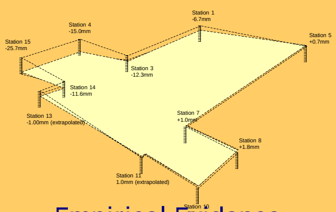
Giles Biddle’s Published Work



Mike Crilly’s study at BRE



Modelled Data



Empirical Evidence

GROUND MOVEMENT BENEATH TREES

Several people have queried a comment in the last edition when we said “the traditional view of ground movement”. What is ‘the traditional view’? Perhaps it needs re-visiting.

Well, we can start off with the N.H.B.C. guidelines which draw simplistic (but clearly effective) lines below which root activity has nominal effect. These tables give no guidance in respect of annual movement patterns, simply the fact roots have an influence that is deeper closer to the tree, diminishing with distance.

The excellent work by Giles Biddle records seasonal moisture change, and broadly (with the usual exceptions we expect when dealing with trees and soil and climate), we see similar patterns. The soil is dryer closer to the tree than further away.

To support this we can add the precise levelling exercise carried out by Mike Crilly when he was at the B.R.E.. Mike recorded an almost linear pattern on rehydration associated with felling of a Poplar tree, and again with the most movement taking place nearest the tree.

Empirically when we take precise levels around buildings we often see a similar, often linear pattern emerging. The building quite literally dips towards the trees.

Recent attempts at building models to emulate tree root activity in fine-grained soils (see immediately left) show similar patterns, with a ‘bowl’ profile and the tree sitting centrally. The work on the previous page supports the suggestion as do soils reports. See following page.

So, to summarise, we think there is ample evidence of how ground moves in normal circumstances, and all of the examples cover seasonal movement when the ground either (a) rehydrates fully every winter or (b) in the case of Crilly, where the ground recovers following a persistent moisture deficit due to the tree being felled.

At Aldenham we are seeing a different pattern because we are measuring ground movement where the ground hasn’t rehydrated fully in the winter. We have a persistent moisture deficit which is confirmed by the fact that (a) levels have recorded continued upward movement from the datum in the period between April and May and (b) the soils data shows a marked deficiency before the tree came into leaf.

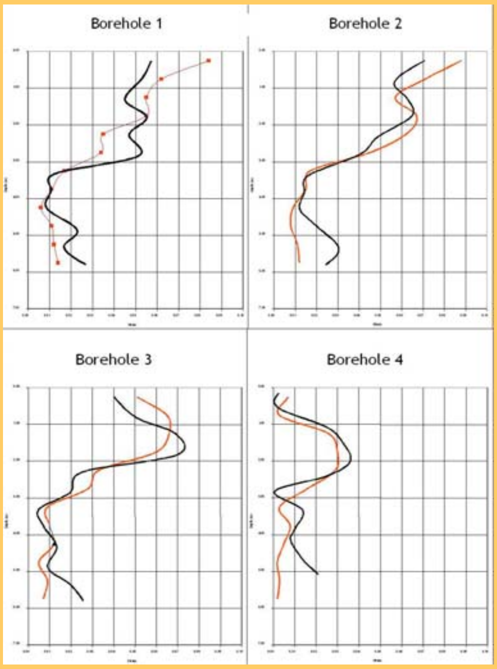
Aldenham Data Update

September 2006.

Suctions -v- Oedometers

There has been much discussion over the last few years about sample disturbance in general, and testing disturbed samples using the oedometer in particular.

The key benefits of the oedometer test are (a) we don't need to establish the plasticity index of the soil because we have the empirical values of swell, (b) the test is a lot quicker than the filter paper method, (c) it does not suffer from anomalous results in the presence of gypsum, (d) it requires fewer staff, resolving the problems every laboratory faces when we have peaks and troughs throughout the year, but also varying year by year and finally, (e) the test is less prone to the sensitivities of passing filter paper between the sample and the scale, and the method of preparation.



	Suction	Oedometer	Model
BH1	101	80	106
BH2	89	94	85
BH3	71	76	64
BH4	26	32	18

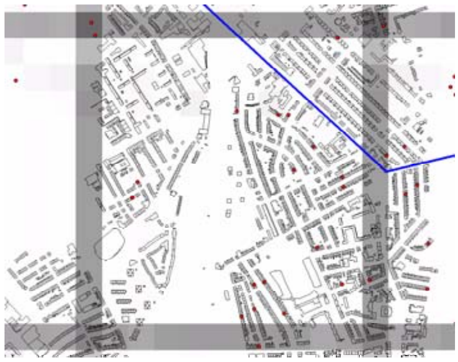
There is very little difference, and where there is it is related to the positioning of the Ko line on the filter paper test. See Page 1.

Comparisons with undisturbed samples will be made in September.

CLAIM COUNT

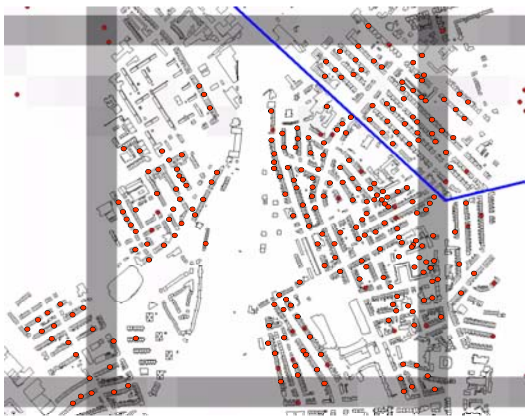
Below we see the results of a study accessing 30,000 valid root induced clay shrinkage claims. If there are say 35,000 claims p.a., and 50% of those are valid (using rounded figures for simplicity), it means we have 17,500 valid claims p.a., of which say 75% are root induced = 13,000 claims in a typical year, excluding surge.

So, the sample of 30,000 would be representative of 30/13 = 2.3 years.



Subsidence cover was introduced in the early 1970's. To estimate the number of claims over that term we have to multiply the above count by 35/2.3 = 15.2 to arrive at some idea of how many houses have been damaged over the last 35 years.

In the area (below) we have researched, we counted around 30 claims from our 30,000 sample. The number would have to be increased to 30 x 15.2 = 456. An entirely different view.



Any study of this sort has to be simplistic. It doesn't take account of new trees, growth, species or trees are felled in the period or surge years, but the information sheds new light on the problem by accounting for the time factor.