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

Report on Investigations at Aldenham Research Site

January 2010

The Clay Research Group
www.theclayresearchgroup.org

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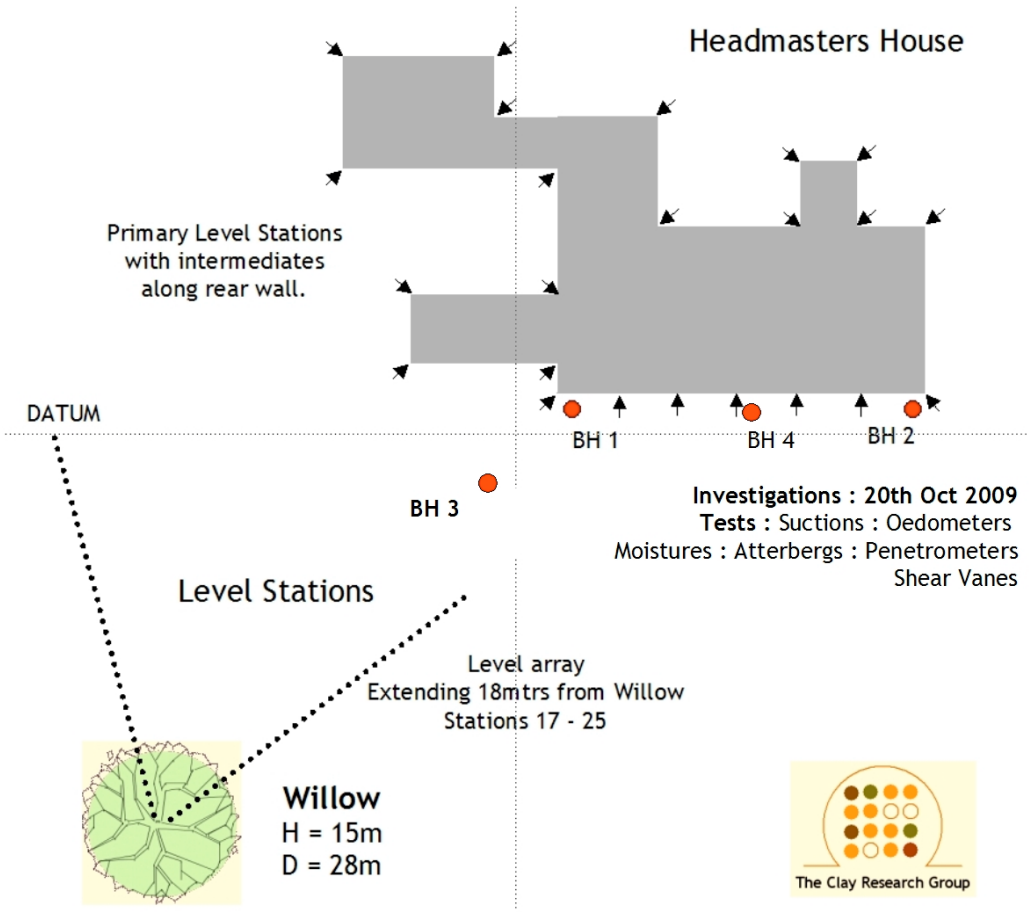
INTRODUCTION

The Aldenham Research Site has been the subject of intensive investigations since 2005 and is probably the most instrumented site in the UK, allowing us to explore the interaction between vegetation, fine-grained soils and climate.

Findings are published every month in the CRG newsletters. This special edition reviews the results of site investigations, soil testing and precise levels in the vicinity of the Headmaster's House following notification of damage in the summer of 2009.

Funding has been provided by MatLab for investigations and testing, Crawford & Company for precise levels and Innovation for meeting administration and reporting costs.

We would particularly like to thank Aldenham School for allowing access to their 100 acre site in North London and their patience in allowing regular access to undertake monitoring and to occasionally carry out extensive investigations and testing.



SITE PLAN

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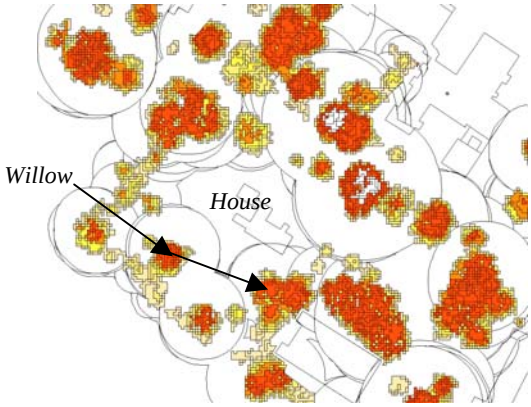
The Site

The site has been described in detail previously. Arrows on the image below indicate the relationship between the Willow and house.

To the left, arrowed, is the "Aldenham Willow", the subject of our study over the last 3 years. The right arrow indicates the Headmasters House .

There is a gentle slope up from the house towards the Willow. The soil is a highly shrinkable London clay with Plasticity Index in the range 45 – 55%.



LiDAR model showing scaled relationship between building and surrounding trees.

The Willow is estimated to be around 35 years old, and the house perhaps 10 years older.

Below is a picture of the rear elevation of the damaged building showing the numerous shrubs (Wisteria?) growing against the house wall.

Rear elevation of the Headmasters House. A mature Wisteria is growing to the left of the bay window.

Objectives

The Headmasters House suffered subsidence damage in the summer of 2009 and investigations were undertaken in October to diagnose the cause and advise on remedial measures.

The investigations had the following objectives:-

The damaged building is some 28mtrs distant from the 15m high "Aldenham Willow". Nearly twice the height of the tree away. Shrubs are growing along the damaged wall and there are trees elsewhere (see LiDAR image), within influencing distance.

The study would hopefully clarify which method of investigation provided the most useful information in establishing causation – soil testing or precise levels.

The results of the site investigation are being used to make comparisons between different tests, and to assess the benefit of the pocket penetrometer. Does this relatively cheap and fast method produce reliable result? Also, how does the bentonite sensor being developed by MatLab compare with the filter paper test?

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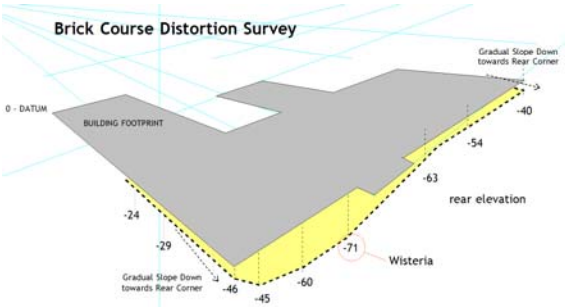
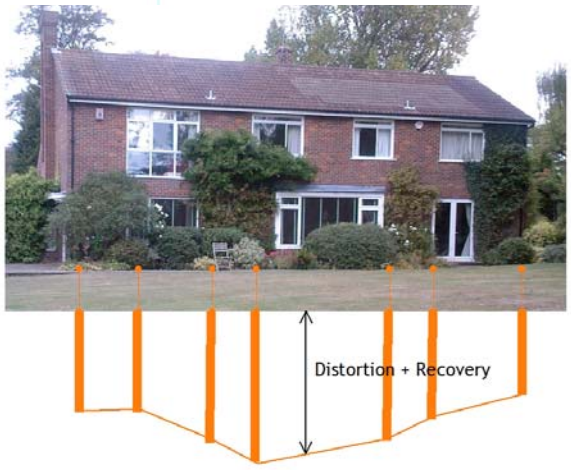
RESULTS

Precise Levels

Funded and arranged by Crawford & Company. GeoServ Limited carried out a preliminary survey on the 13th October, 2009.

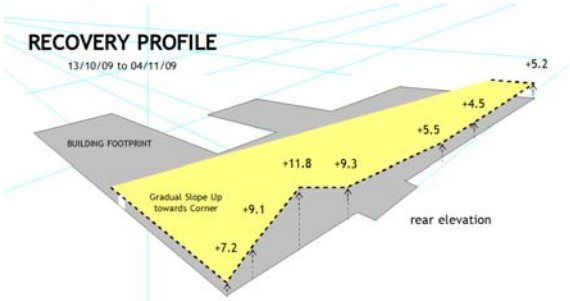
There two sets of readings. The first is a distortion survey, taken on the same bed joint and measuring 'warts and all' variations. That is, variations that may be due to initial building setting out problems or subsequent ground movement.





Both flank walls show downward slopes towards the rear corners of the house of 40 – 46mm possibly implicating the surrounding trees. The maximum distortion has the Wisteria as a focal point, one-third the way along the rear house wall.

The second readings record recovery that has taken place between 13th October and 4th November 2009. The measure of dynamic movement (i.e. recovery following leaf fall) provides some way of distinguishing 'built-in' distortions from root induced clay shrinkage.



There has been more recovery (11.8mm) in the vicinity of the Wisteria, than elsewhere as can be seen from the image below. There has also been recovery along the side walls of between 5.2 and 7.2mm. Adding the two – the initial distortion and the active movement – gives some feel for the dynamic changes associated with root activity. See graph in adjoining column, below the photograph.

It would appear that the trees have exerted an influence, but the cause of recent damage is more likely to be the shrubs along the rear house wall, and the large Wisteria in particular.

Boreholes

4 No. boreholes were sunk to a depth of 5mtrs as shown on Page 1. Three were sunk along the rear wall, and another (BH 3) at the assumed root periphery of the Willow based on level monitoring.

A 3mm diameter Willow root was retrieved from BH 3 at a depth of between 1.15 and 1.5mtrs bGL. Roots of Leguminosae (Wisteria?) were found in BH's 1 & 4 at a similar depth.

The soils were tested using filter paper suctions, bentonite suctions, moistures, Atterbergs, oedometers and bearing pressure using the pocket penetrometer.

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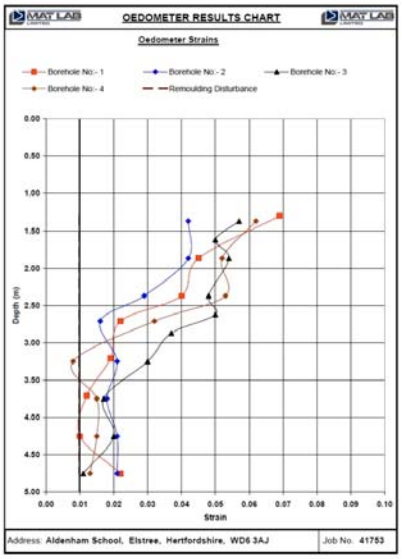
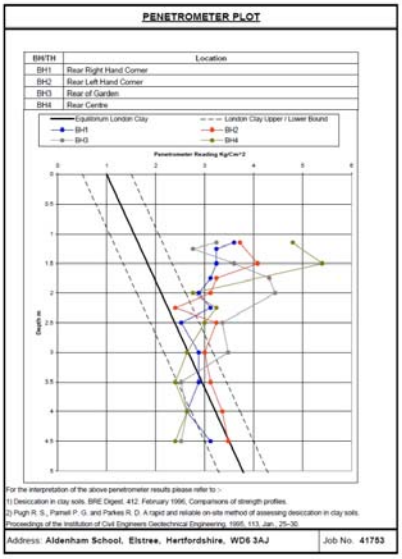
Oedometer



Penetrometer



Similar profiles from both tests, with desiccation evident in all bores to a depth of around 3mtrs bGL in the range 0.4 - 0.6 (strains) and 3 - 5Kg/cm² (penetrometer)

A total of four boreholes were sunk on site and samples tested using the penetrometer, oedometer, filter paper suction test, the new bentonite sensor as well as moistures and Atterbergs.

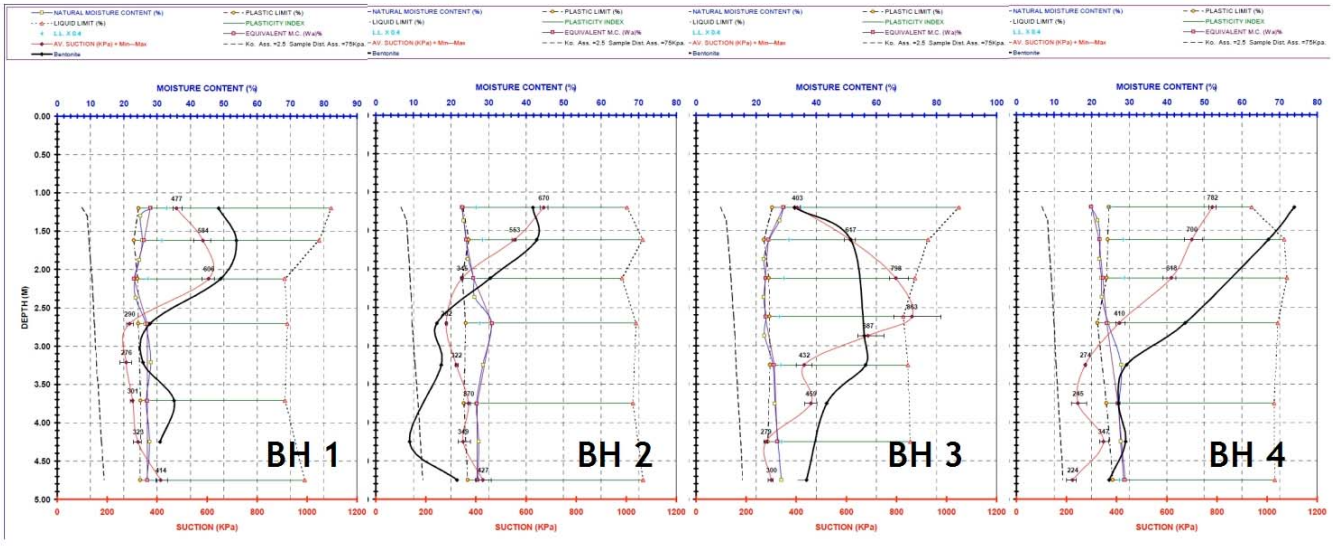
The results from the recent (October 2009) investigations are interesting because all bores record desiccation, by whatever test used, which provides an opportunity of comparing them under what appear to be very similar conditions.

Left, the oedometer and penetrometer have similar profiles with desiccation extending to similar depths.

There is very little to choose between them.

Below are the suctions results using filter paper and bentonite sensors. Again, reasonable agreement between the various profiles in terms of amplitude and depth.

Suctions - Filter Paper and Bentonite Sensor



Desiccation evident in all bores to a depth of around 3mtrs bGL with peak suctions of around 600 - 700kPa in BH's 1 & 2, and in the range 600 - 800kPa (BH3) and 700 - 1,100kPa.

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Soil Testing

OEDOMETER

Results using the oedometer on disturbed samples record desiccated soils in every borehole. All bores have similar profiles with peak strains averaging 0.05 and the depth of desiccation extending to between 3 – 3.5mtrs bGL. All show increasing strains as they near the surface, in contrast to other tests, some of which exhibit a closing profile as they approach ground level.

SUCTIONS

As with the oedometer test, all of the bores exhibited evidence of desiccation. Maximum suctions of 860kPa were recorded in BH 3, peaking at a depth of 2.5mtrs and extending down to 4mtrs bGL.

Even though care has been taken by the laboratory in calibrating the filter papers (as described in earlier editions), the suction profile is sometimes displaced to the right of the notional Ko line (see BH's 1 & 2), leading to possible over-estimates of desiccation – both amplitude and depth.

MOISTURES

In all cases, moistures dip below the PL in broad agreement with the values of other tests although the difference between the desiccated and non-desiccated state is a few percentage points, and one of the reasons for their use being limited where the moisture deficit is small.

PENETROMETER

The penetrometer detected desiccation corresponding to the oedometer results, but also other tests in every borehole.

The equilibrium line proposed by Pugh *et al* was proven to be replicable when compared with the results of the oedometer and suction test.

The main benefit of the penetrometer is speed of collecting results, relative cheapness and published support.

BENTONITE SENSOR

The use of an alternative sensor material to replace the filter paper is being researched by MatLab, and the results follow the profiles of calibrated filter papers.

The benefits would be, (a) the time taken to reach equilibrium is much faster – typically 48 hours instead of a few weeks, (b) the material is readily available (c) it measures suctions directly and finally (d) the test is not sophisticated and requires minimal laboratory time.

We understand the sensor would by inserted into the sample immediately on retrieval and the test would not involve laboratory time other than its final weighing.

Estimates of Swell

Estimates of heave from the suction and oedometer results provided the following estimates of swell on rehydration. They are in broad agreement with the distortions measured by the precise levels although this may be subject to amendment as we gather more data.

	BH 1	BH 2	BH 3	BH 4
Oedometer	46	34	53	47
Suctions	49	44	61	48
Amended Suction (Ko)	25	22	55	45

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Objectives Resolved

1. The cause of damage to the Headmasters House is root induced clay shrinkage. The zone of desiccation is widespread with moisture deficits evident in all four boreholes by whatever test used. The initial distortion survey suggests the shrubs growing against the wall may have contributed significantly and our recommendation is that they be removed whilst precise levelling continues over the next twelve months to determine if nearby trees are also making a contribution.

2. The study suggests that whilst soil testing has provided evidence of desiccation and causation (root induced clay shrinkage), this would not have been sufficient to identify which tree/shrub caused the damage. Precise levels are superior in determining the culprit when several items of vegetation are implicated. Also, subsequent precise levels will provide evidence of desiccation (and hence causation) on measurement of recovery over the winter months.

3. Both the penetrometer and new sensor are going to be useful additional tools for the practitioner. Both provide quick, cheap and apparently reliable results that are unlikely to over-estimate the moisture deficit. The major benefits are the ability to produce information quickly, which is essential when handling subsidence claims at times of surge. Delays in reporting in 2003 and 2006 slowed down the claims process by months, and a development that delivers reliable testing on site is to be welcomed.

SUMMARY

Precise levels offer the most direct method for detecting building movement, and identifying which trees and/or shrubs are involved when there are several possible contributors.

Recovery confirms the presence of a clay soil and there is little added benefit in measuring the PI, as this gives an indication of potential rather than realised movement. The initial level readings provide useful guidance, and one or two additional visits will usually suffice to resolve the case as we hope to demonstrate in this instance.

As reported previously, suctions have problems that are largely overcome with careful calibration of the filter papers. Care is needed when considering the location of the Ko line.

The hand help pocket penetrometer provides useful evidence, which can be gathered quickly and cheaply without loss of accuracy. Method as described by Pugh *et al* , BRE Digest 412 and elsewhere.

Estimates of heave are notoriously unreliable but comparing levels with estimates of swell based on suction and oedometer tests (page 5) suggests that they can be useful when testing is of a high standard.

Trees situated to the rear left hand corner of the building in the foreground, and the 'Aldenham Willow' just visible in the distance, arrowed.