# 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

January 2009

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## The CRG - 3 YEARS ON

The first edition of the Newsletter was issued in December 2005. A research site had been identified at Aldenham School and we reported our intention to build an academic team to investigate root induced clay shrinkage in fine grained soils.

A preliminary meeting to discuss aims and objectives was held at Birmingham University, attended by Hillary Skinner (BRE at the time), Richard Rollit (Crawford), Giles Biddle, Dr Ron Barker (Birmingham University) and Stephen Plante.

Meetings were held with Dr Jeremy Pritchard (BioSciences, Birmingham University), Dr Nigel Cassidy (GeoPhysical Sciences, Keele University), Professor Powrie (Southampton University) and his team including Dr Derek Clarke and Dr Joel Smethurst.

Dr Pritchard pointed us in the direction of Abscisic Acid, explaining its role in stomatal regulation.

Dr Derek Clarke and Joel Smethurt took neutron probe readings at sufficient intervals to build a picture of the influence of climate on moisture content profiles throughout the season.

Off site we visited Prof. Bill Davies and Dr Ian Dodd at Lancaster University for advice on Partial Root Drying, Giles Biddle for a critical review and others in both the geotechnical and arboricultural community.

We appointed BOX to build the initial telemetry units. They were tested in the field using both electrolevels and TDR moisture sensors and adopted by Crawford who operate the largest of the telemetry operations as far as we are aware.

The TDR and electrolevel sensors were calibrated against moisture change and building movement (respectively) over time. The combination of the two offered significant benefits over the more traditional 'snapshot in time' view afforded by lengthy investigations and soil testing.

MatLab installed precise level stations to monitor ground movement in the footprint of both the Oak and Willow at Aldenham. Level readings were taken every month by SPPS and then GeoServ.

At similar intervals, data was gathered from the adjacent ERT arrays. This work was carried out by Glenda Jones from Keele University as part of her PhD project and offered a visual and attractive 'change over time' view of subterranean moisture movement beneath a mature tree.

MatLab carried out both disturbed and undisturbed sampling, testing the soil using a variety of techniques including moisture, filter paper suction and the oedometer.

Paul Thompson funded the purchase of a weather station at Aldenham, meeting the cost of a solar radiation sensor a year later and has provided moral support throughout.

Several parties donated claims data. Innovation provided the bulk of the funding and their LiDAR data.

### Outcomes

MatLab are now developing a different technique for measuring soil suctions using a bentonite sensor and Clive Bennett is using this as the basis for a PhD.

Two MSc students passed through Birmingham University just prior to commencing the project, exploring the ERT/tree relationship.

Glenda Jones is currently writing up her PhD thesis at Keele University.

Southampton have a 3rd year student preparing a dissertation on the use of climate data alone to predict the SMD. She is using the Aldenham Oak neutron probe data and is building a soil-water-plant-atmosphere model based on the weather station data.

Telemetry has been adopted by SPPS Monitoring Services who have developed their own crack monitoring box.

Crawford appointed Jonathan Grey to manage their telemetry/electrolevel installations, and monitoring generally.

The work on transpiration and ABA has produced an Intervention Technique. Dr Allan Tew joined late and has been supportive, offering several sites for trials. Allan is just commencing a Doctor of Engineering degree.

Innovation now have the most advanced risk model with every tree within the M25 accurately mapped for height and location. They also have a unique geological model that allows them to assess risk on a house-by-house basis across the UK.

Software applications include Triage, DataREADER, the Disorder Model, Soils Interpreter, OSCAR (Innovation) and VISCAT (Crawford).

Current work is around the Intervention Technique and the Triage application.

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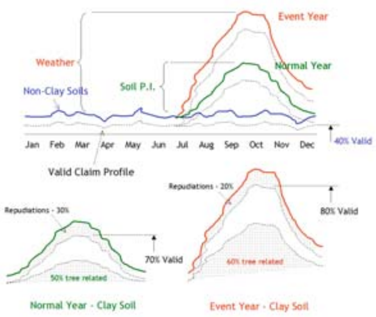
## TRIAGE

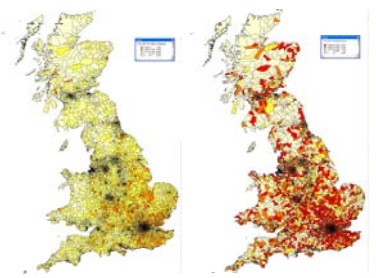
To derive a ‘probability of valid claim’ model we have used ABI figures to develop signatures for normal and event years by soil type – see below.



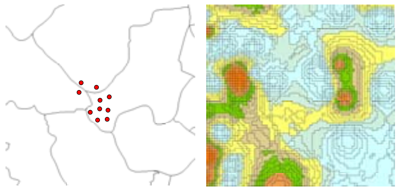

They have been superimposed onto a ‘valid-repudiated’ sample of claims covering a six year period (including one event year) to understand distribution.

| P(rep) | P(valid) |
|---|---|
| 0.5 | 0.5 |
| 0.333 | 0.667 |
| 0.167 | 0.833 |
| 0.1 | 0.9 |
| 0.25 | 0.75 |
| 0.2 | 0.8 |

Triage doesn’t rely on annual averages, but ‘time of damage’ and the model allows a user to derive a dynamic probability that changes by month, taking account of seasons and event years.



Above we can see the differences at sector level, with risk changing both with climate and geology.



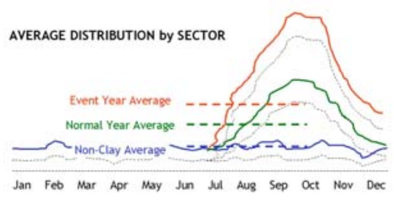
Unfortunately Post Office sector outlines (above, left) have no relationship to risk and often provide misleading information.

A group of claims (red dots) in a corner of the polygon increases the risk for all houses within the sector, even though some may present a very low risk.

Our model overcomes this by using cluster analysis against a unique 250m grid. Above, right.

Below we see how the industry figures (average shown as black dotted line) are distributed to fit weather patterns, claim notifications and the soil type.

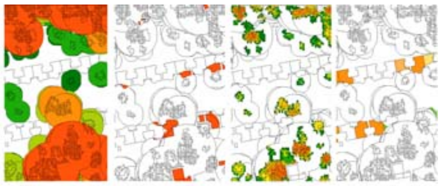

Each peril for every location in every weather pattern is then accounted for – see below. Non-cohesive soils (blue line) will not exhibit seasonal changes and the probability of a valid claim increases sharply in the summer when a property is on a clay soil.




Finally the Triage application has to take account of trees on clay soils.

Aerial photographs are good in terms of setting the context provided they are linked to some form of location intelligence. Finding “13 Acacia Avenue, Bromley” isn’t easy without a GIS and OS AddressPoint.

In addition, we need some idea of tree height and distance from the building to be effective.



This is where the digital LiDAR data proves invaluable. Our work on root zones and a study of several hundred claims has delivered a benefit.

If trees are implicated in say 70% of claims in dry years, and valid claims are running at say 80%, the number involving trees for Triage purposes will be 0.56 – provided the house is on a clay soil of course.

The final piece of the jigsaw, and perhaps the most important when handling repudiations, is conversation management.

Providing reassurance to the homeowner that we understand the problem from the very first telephone call, and then directing resources more efficiently, is the objective.

Next month we see how this has developed.

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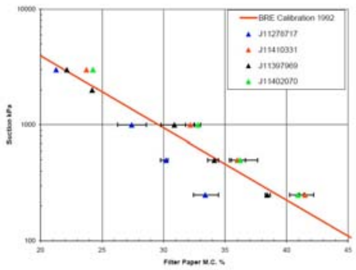
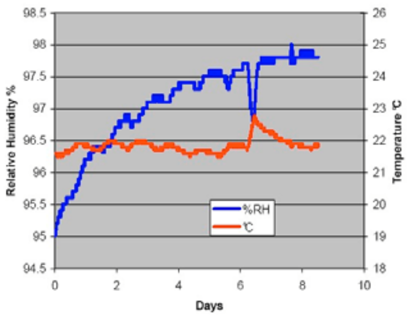
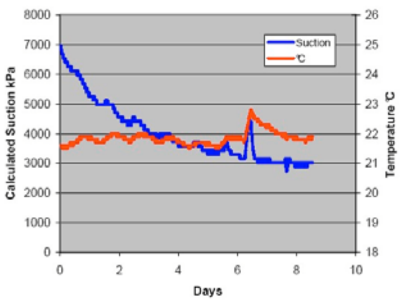
## FILTER PAPER TEST

Clive Bennett from MatLab has been carrying out further research into the variations they have previously observed using Whatman's filter papers and a membrane extractor set at pressures of 250, 500 and 1,000kPa.




As a result they have identified a batch of filter papers that match the results of the original BRE calibration curve and hope to avoid or reduce the inconsistencies that we sometime see.

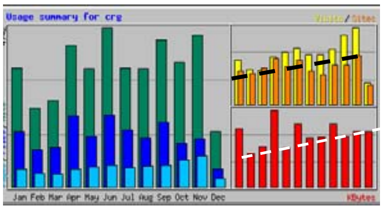



Above, the relationships between suctions and relative humidity over time – the blip is apparently due to a power cut with the air conditioning - Clive lives in Costa Rica.

## CRG WEBSITE

The CRG web site received 42,241 'hits' in 2008 and interest has grown steadily over the last twelve months with more people accessing more pages.

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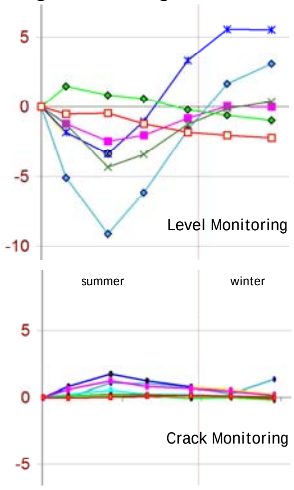
This was unexpected given the rather specialilsed nature of the topic.

## PRECISE LEVELS

Another example taken from a GeoServ survey illustrating the benefit of precise levelling. Although both pictures tell the same story, seasonal movement is clearly demonstrated using the former, and often ambiguous using the latter.




As a rule of thumb only, the 'signal' produced by precise levels is amplified by a factor of between 5 and 10.

## TRIAGE PAPER

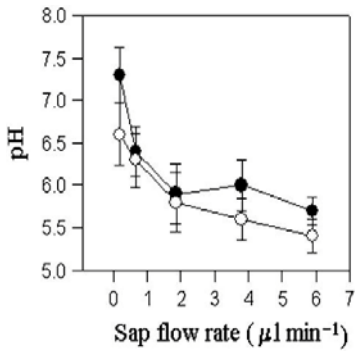
We were commissioned by InFront Innovation to produce the paper on Triage, which was completed recently. The extract (following page) has been included with their permission.

We reviewed available data, put together a 'pre-inspection' report, undertook blind trials where the inspecting engineer was not aware of the initial analysis, and added conversation management – handling the initial call – as well as on site recording for audit purposes.

### "Modification of Leaf Apoplastic pH in Relation to Stomatal Sensitivity to Root-Sourced Abscisic Acid Signals"

Wensuo Jia and William John Davies

**Plant Physiol. 2007 January; 143(1): 68-77.**




Graph showing the relationship between pH and xylem sap flow rates. As the pH rises, so the flow rates drop.

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## TRIAGE - NW1 9

Our ‘raw data’ for NW1 9 is as follows:.

- Soil - P.I. 42% - High
- Likely Cause - Clay Shrinkage
- Claims Experience - Very High
- Likelihood Valid Claim = 68%
- Likelihood Repudiation = 32%

**Initial call note ...** *“Policyholder had a previous claim for subsidence in 2005 - cracking has reappeared in the same areas as before mainly in laundry room and front door both internally and externally.”* The probability of a valid claim decreases in the winter months.

### Tree Data

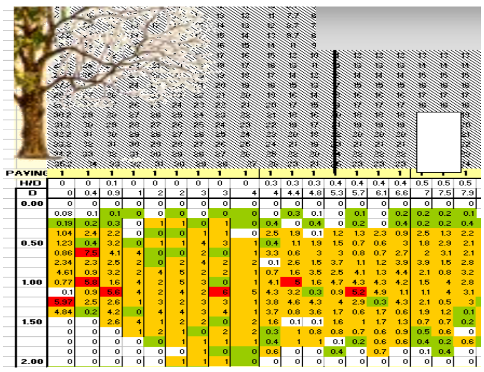
LiDAR data (flown in 2005) recorded a pavement tree, 9mtrs tall. The tree was measured on site as being between 8 – 10mtrs tall. The location was accurately plotted. See plan.

### Sum Insured

Ordnance Survey Footprint = 64 $m^2$
Actual = 64 $m^2$
Ordnance Survey Master Map accurately predicted the building footprint in this instance, but has been variable elsewhere.

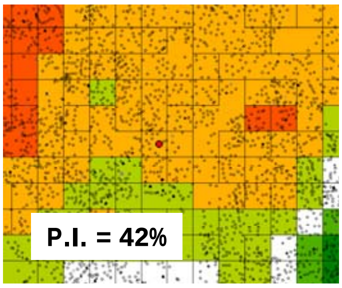
### Disorder Modelling

Damage was estimated to be cracking between 1 – 2mm wide based on a modelled 15mm of vertical movement. See screen print below.

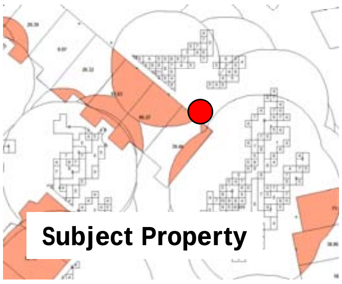


### TRIAGE OUTPUT

### FINDINGS


P.I. = 42%


Subject Property


Subject Property


Google Extract


Diagonal Crack above Door

## DISCUSSION

OS MasterMap plan provides a scaled image and both the building footprint and tree locations were accurately plotted in this example, although the OS floor area has varied on other claims.

Damage was sensibly predicted as being to the front or flank wall, and this was verified on site.

Historic claims data suggested a high probability of this being a valid claim, and the model indicated a coincidence between the reported area of damage and the root footptint (above, green tile) – front and flank walls. Further, the Disorder Model (previous edition) identified that the damage would be minor with cracking correctly predicted at between 1 – 2mm.

More work is being carried out on the topic of the building footprint and ‘off clay’ claims

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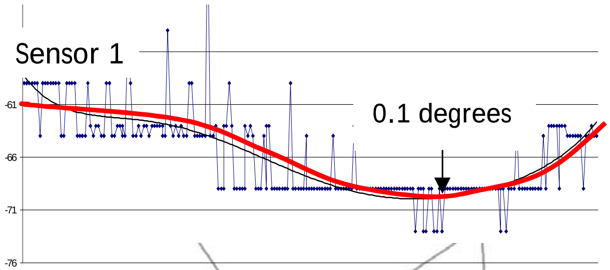
## TELEMETRY

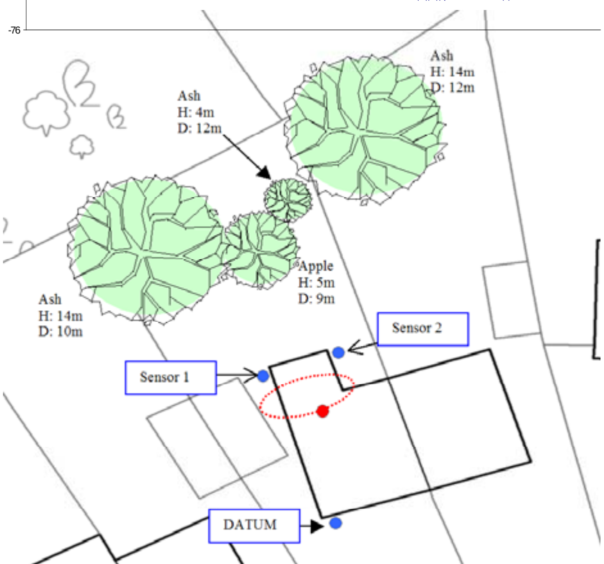
Crawford are the largest users of electrolevel telemetry in the investigation of domestic subsidence claims. Below we reproduce an example provided by Richard Rollit and Jonathan Gray relating damage to a single storey extension within influencing distance of a group of trees – predominantly Ash – see below.

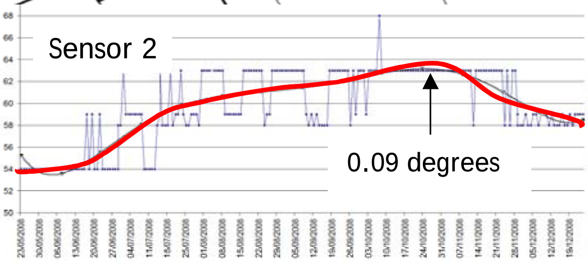
The date range is from 22nd May to the 23rd December, 2008.

Sensors measure rotation in degrees and one has been fixed either side of the extension. There is a datum remote from any trees.

The 'y' values represent digital output which is then converted to degrees.

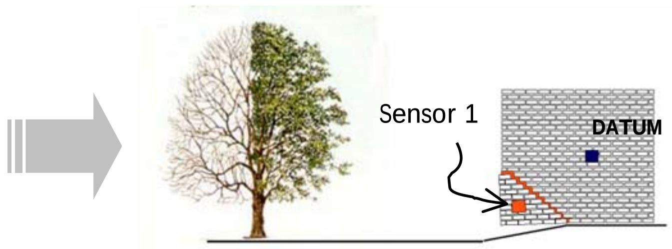



Because the movement is angular, and because building flex when subsiding and we have no way of establishing accurately the fulcrum, there is no simple method of deriving vertical movement using electrolevels. Engineers will need guidelines on the degree of rotation that might be regarded as significant in relation to the length of wall etc., but essentially the sensors provide evidence (or the absence) of root induced clay shrinkage. By matching the periodic signature against a datum a probability can be estimated.

In this example, we can estimate vertical movement of between say 8 and 10mm. Precise levels are preferable when distortion data or absolute values are required.

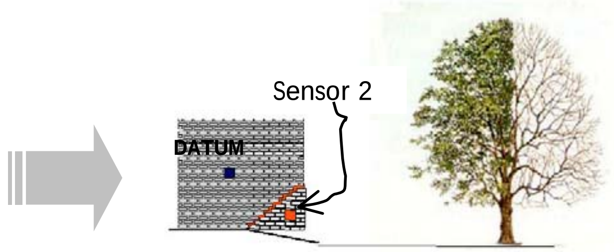



**Sensor 1 (above)**
Electrolevel rotates anti-clockwise in the summer, and in influencing distance of tree roots.

**Change Date**
The date of contraflexure was the same for both sensors - the 19th and 20th of October, 2008.

This is the period when downward movement changes to recovery and couldn't sensibly be gathered – almost to the day and site specific - by any other form of monitoring.

**Sensor 2 (below)**
Clockwise rotation in the summer, followed by recovery.



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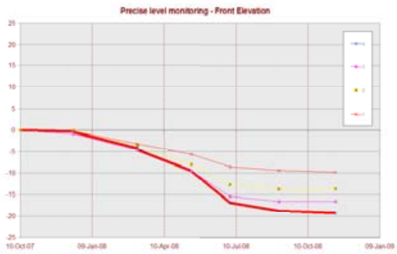
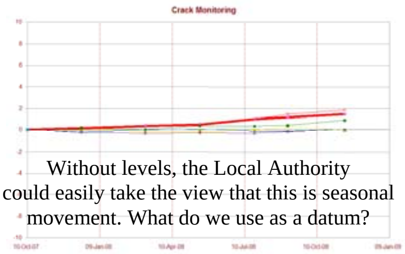
## CRACK -v- LEVEL MONITORING

Another example below illustrating the advantage of precise levels over crack monitoring.



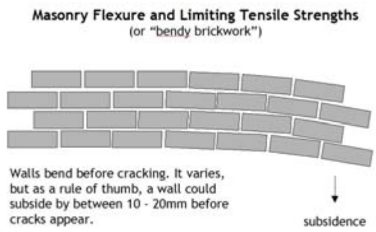

Without levels, the Local Authority could easily take the view that this is seasonal movement. What do we use as a datum?

The advantages are as follows:-

Levels deliver a signal that is typically 5 – 10 times greater than crack monitoring. Flexure takes place well before cracks appear which means we may measure say 10mm of movement with levels, and only 1mm using crack monitoring.

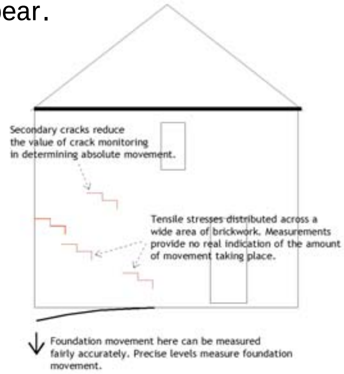
Levels provide a direct measure of foundation movement at the point of occurrence. Cracks are merely symptoms that appear (or not as the case may be) elsewhere, remote from the area of movement.

Crack monitoring can be a wasted effort if secondary cracking appears elsewhere. If there are several cracks aligned with one another, which one will move? Using precise levels we see immediately where foundation movement is taking place.




As seen on Page 3, the signal of building movement is far clearer when using levels and above we see why.

Below the distribution of stress through the masonry renders crack monitoring less effective and particularly so when there is a release of tension elsewhere that causes secondary cracks to appear.




A great deal of research by Burland and Wroth, Skempton and others confirms that masonry panels flex prior to cracking and we have undertaken tests at the MatLab yard to demonstrate this.

As a final note, the experts in our world all prefer level monitoring. Giles Biddle, Mike Crilly and Tim Freeman.

In the picture above we can see that the top three brick courses have flexed, but without cracking. Levels would have detected movement.

Patterns of movement can be complex as we see below. Precise level data has been plotted on the building plan, revealing both flexure and hogging over time.