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

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December 2014

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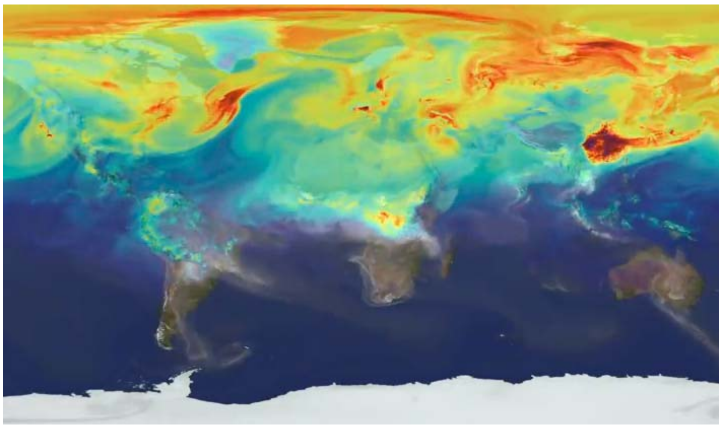
Issue 115, December 2014

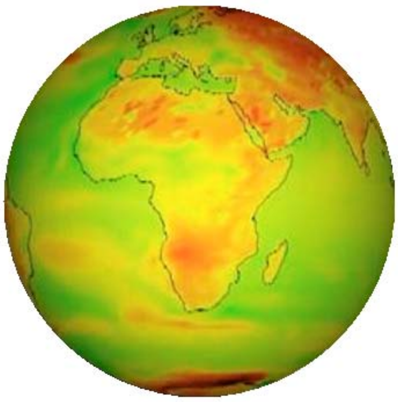
NASA CO^2 Map

"A year in the life of Earth's CO^2"



NASA have developed, "an ultra-high-resolution computer model giving scientists a stunning new look at how carbon dioxide in the atmosphere travels around the globe". A video shows how CO^2 levels reduce in the summer as plants come into leaf and increase again in the winter and models daily change through 2006.

Met Office Report



The Meteorological Office report that "preliminary figures show that 2014 is on course to be the warmest year on record, both globally and for the UK."

Aldenham Maintenance

Our thanks to ACS for carrying out essential maintenance work on the level station covers in the vicinity of the Aldenham willow. The covers were damaged by the grass mower and had become a hazard but thanks to the prompt action of ACS, the problem has been resolved.

Is it Desiccated?

Ease of use has made comparisons between the index properties of a clay soil and the moisture content popular for detecting desiccation. Just how useful are these tests? The technical issues were explored in Edition 113. In this edition we compare the output of such tests with soil suctions to understand the statistical value. Just how often are the results correct? What is the margin of error?

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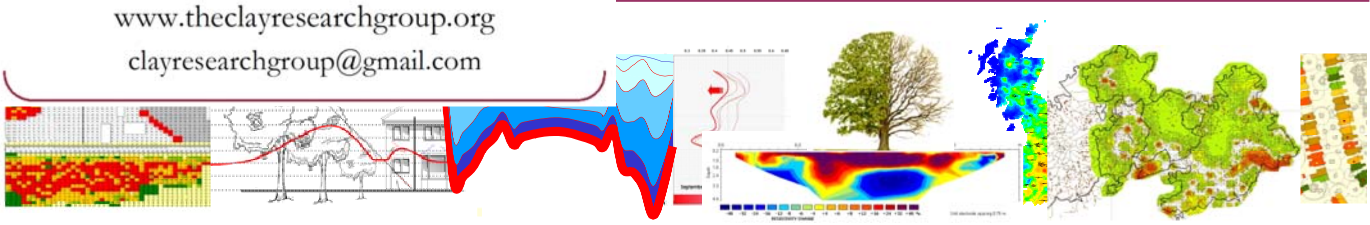

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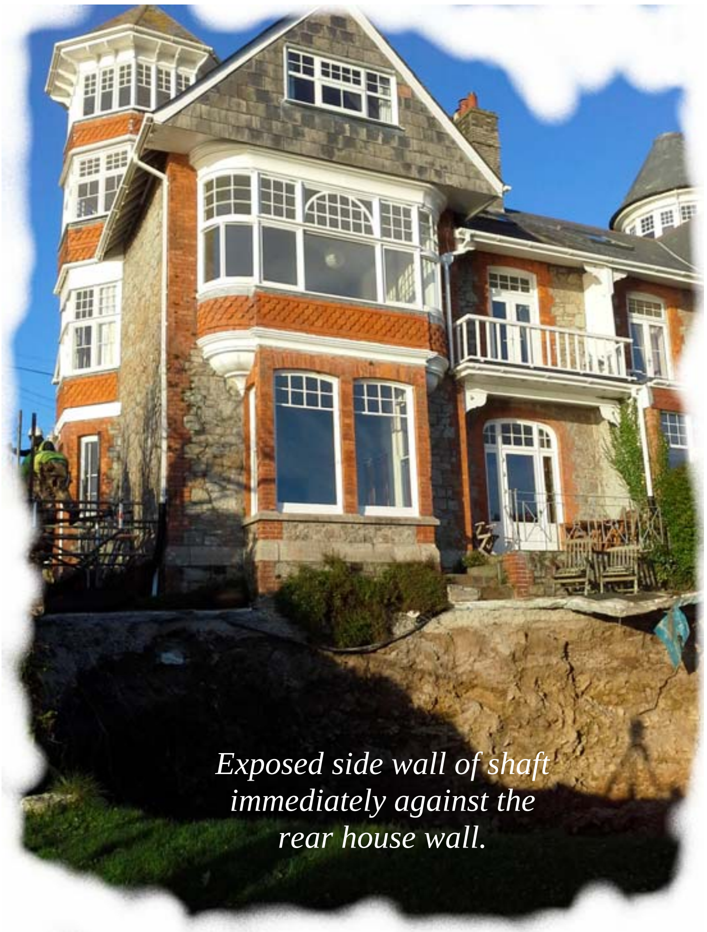
Report on Mining Collapse



Exposed side wall of shaft immediately against the rear house wall.

A previously capped shaft has collapsed above some old mineworkings, creating a large hole some 10mtrs across and at least 12mtrs deep immediately against the rear wall of the property, shown left.

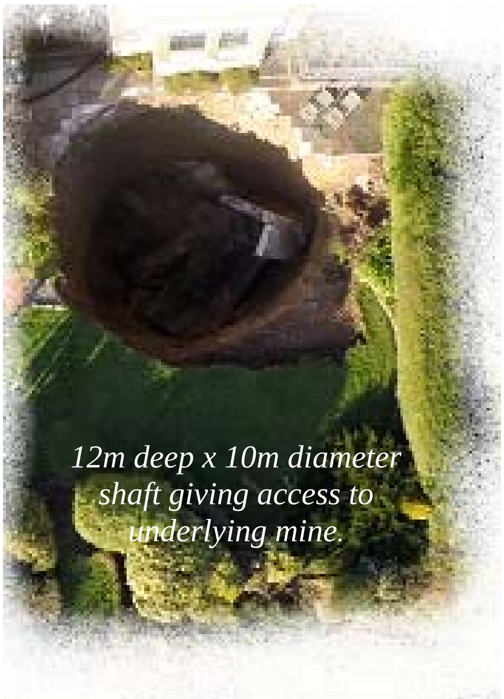
Teams are on site at the moment liaising with Health & Safety, erecting safety barriers and arranging concrete deliveries.

Everything is being done to save the property and plans are underway to fill the void and stabilise the structure.

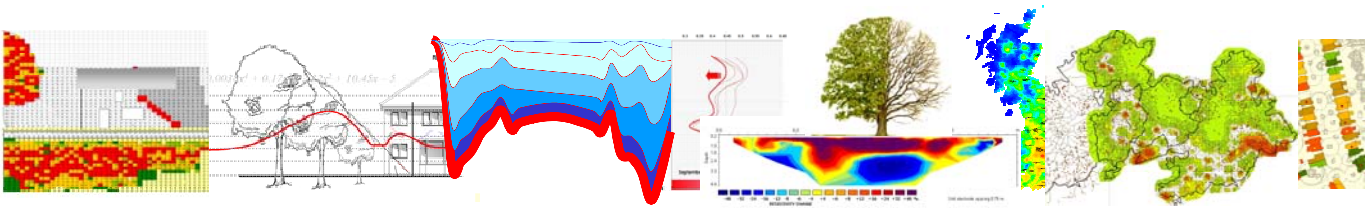
A drone has been used to gather data, allowing the survey team to estimate the depth and width of the crater, the conditions of the side walls and any funnels giving access to the underlying mine shafts.

The proposal is to fill the shaft as quickly as possible, and hopefully before the wet weather returns.

If you have any interesting projects that you would be willing to share, please provide pictures and an outline of the problem.



12m deep x 10m diameter shaft giving access to underlying mine.



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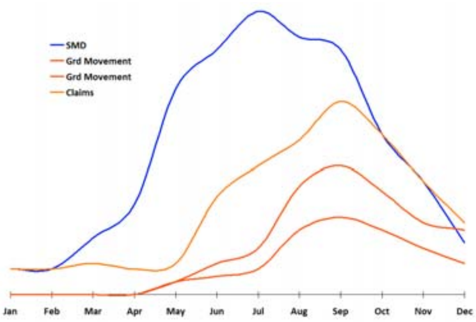
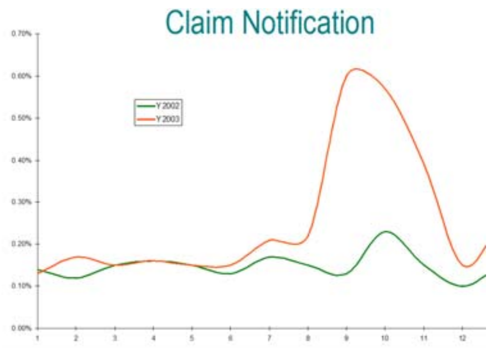
Periodic Signatures

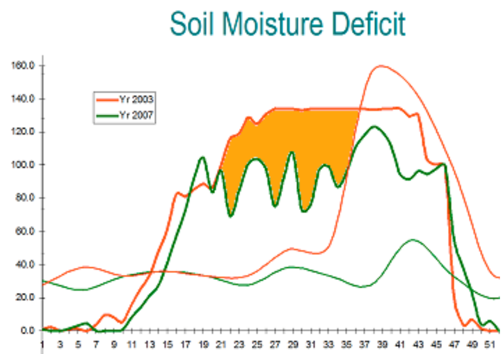
Linking SMD, Claims and Ground Movement



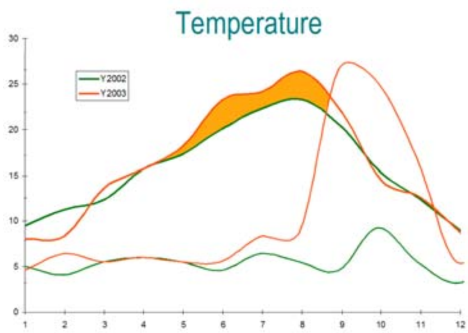
The chart, left, is a generic plot showing the relationship between the soil moisture deficit (Met Office), claim notifications (ABI) and ground movement (Aldenham willow) for a 'normal' year in terms of subsidence numbers.

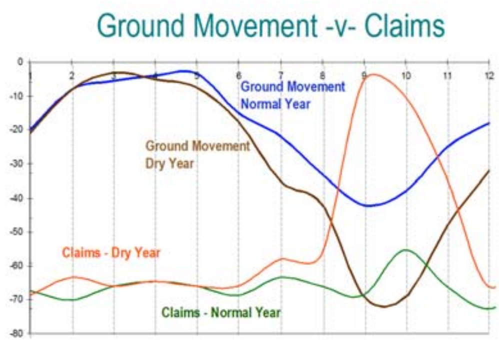


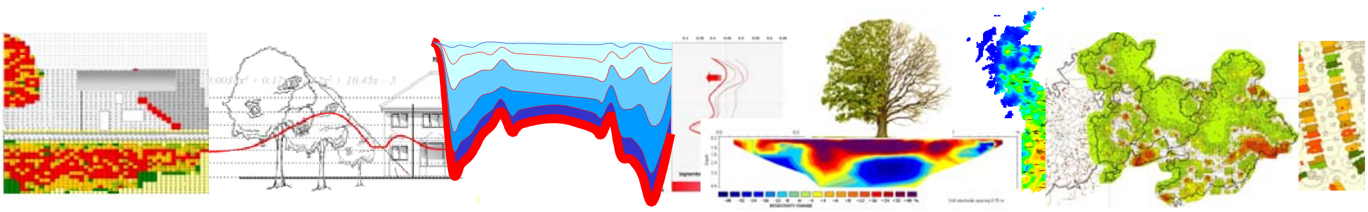
How do event years differ from normal years? Are there any obvious triggers and if so, is the timing relevant? Right, comparing claim notification for an event year (2003 - red) to a normal year (2007 - green).



Left, the SMD for 2003 was far higher and more consistent than the plot for 2007. Temperature is a component of the SMD data and as we would expect, June, July and August were higher in 2003 than 2007. Ground movement (see below) commenced around June and peaked in September/October.







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Estimating the Burning Rate at Postcode Sector Level

Using our sample of claims and working backwards from the ABI tables on annual spend, modified by the geological series, a burning rate for every postcode sector have been derived across the UK.

That is, the total spend on subsidence per sector, divided by the number of houses. This is a re-visit of our earlier exercise calculating an average burning rate per policy across the UK.

Not surprisingly the rate varies considerably and even in this small extract the lowest is just over £5 and the highest exceeds £38.

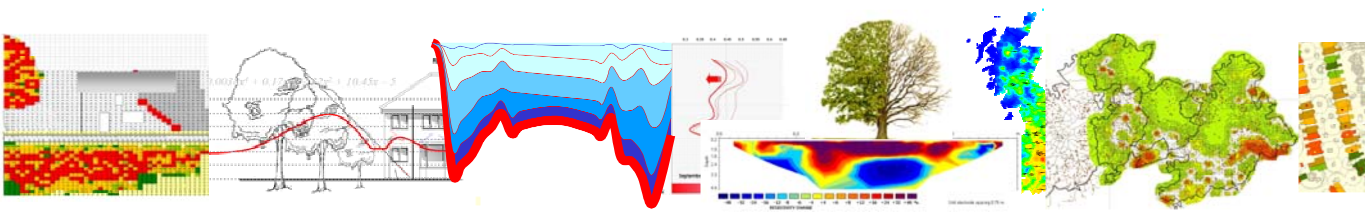
Postcode	Subs (per house)
EH32 0	7.030128726
TN26 2	31.14060164
NE2 2	9.91784394
CM8 3	38.64014236
E14 0	21.65226792
LE9 9	7.547933057
SA12 7	5.176502126
SO15 5	5.731613054
SL6 3	7.798813231

Hortlink II and London Borough Data

In his recent review Dr. Neil Hipps suggested that one way of determining whether tree maintenance was an effective means of reducing risk was to ask the London Boroughs. Did those that had a policy in place of regular tree reduction benefit in terms of fewer claims?

In 'Branching Out', published in 2011, the London Government reported that where Borough's undertake regular, pro-active management they saw a reduction in the number of claims received amounting to 18.5%.

The 27 Boroughs that undertook pro-active pruning received 2,364 claims over a 5 year term (average 272 claims per Borough), whereas two Boroughs managing claims following notification of a claim received 666 claims (333 each). The means of analysis is unclear and we don't know for example tree frequency and past claims experience but that aside, an open discussion should provide the answer. Comparing the form of crown reduction between boroughs that undertake maintenance would tell us which method was the most effective.



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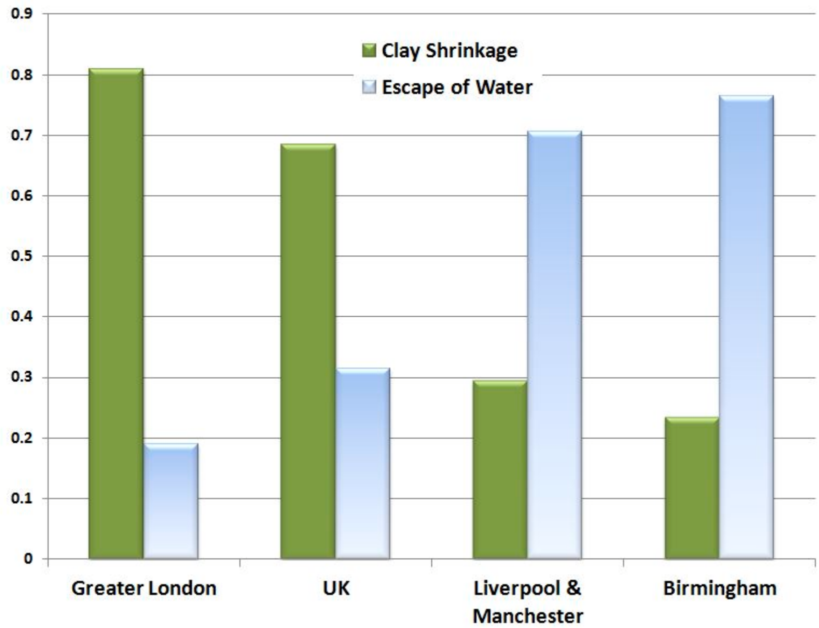
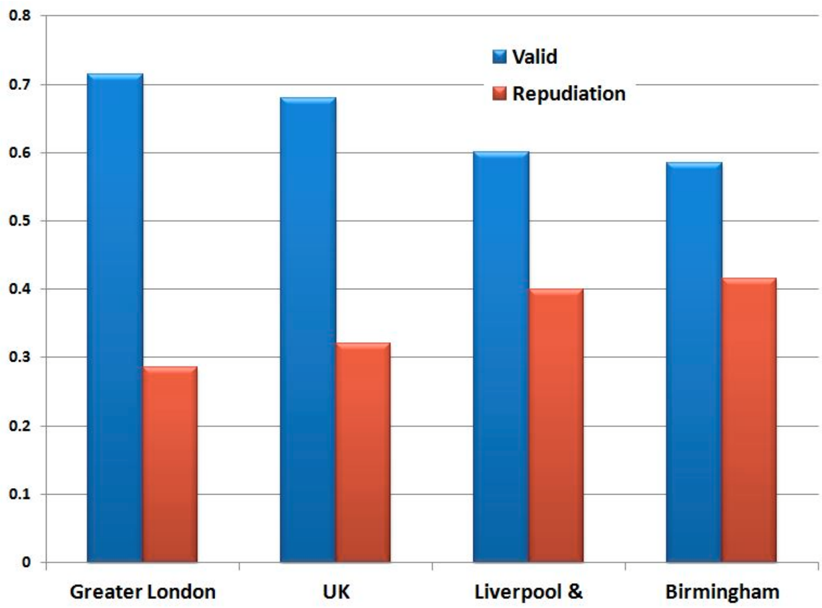
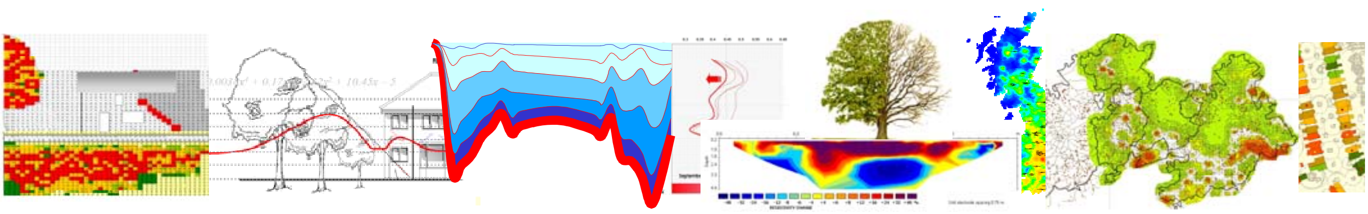
Frequency Risk by Location



Above, a chart showing the 'risk by peril' for valid claims in the cities noted, compared with the average for the UK. Below, the probability of a valid claim (variable by year and season). For example, in London the most likely cause is clay shrinkage, and the chance of a claim being valid is far higher than say Birmingham, where the most likely peril would be subsidence due to escape of water.





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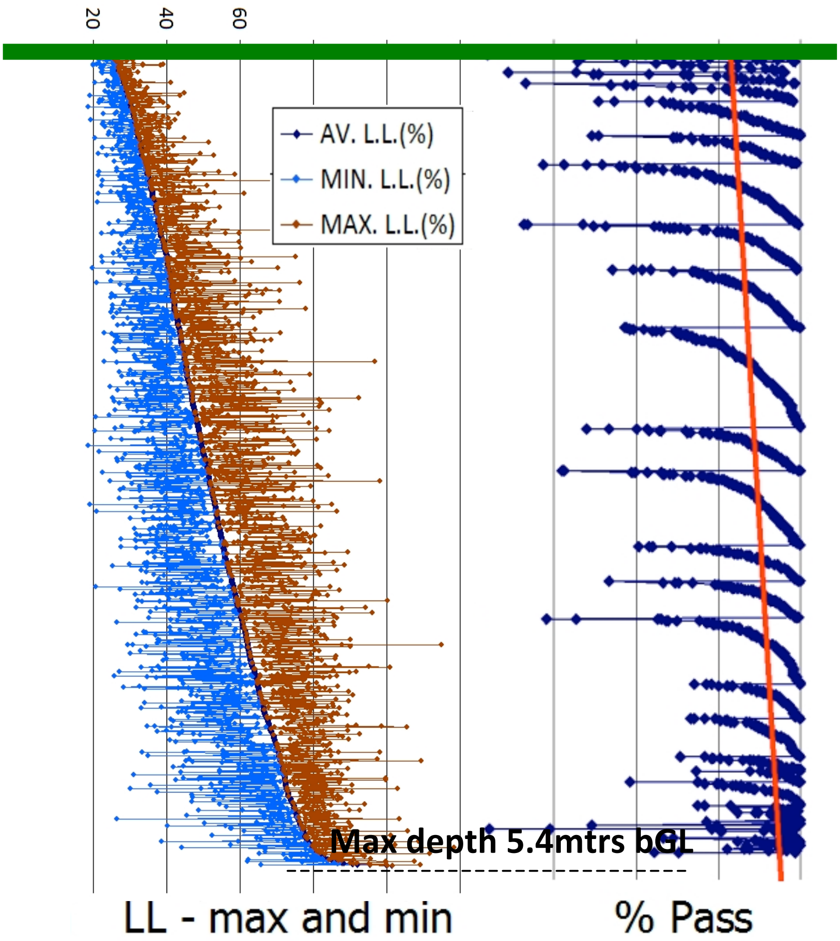
Soil Properties – Variation over Depth

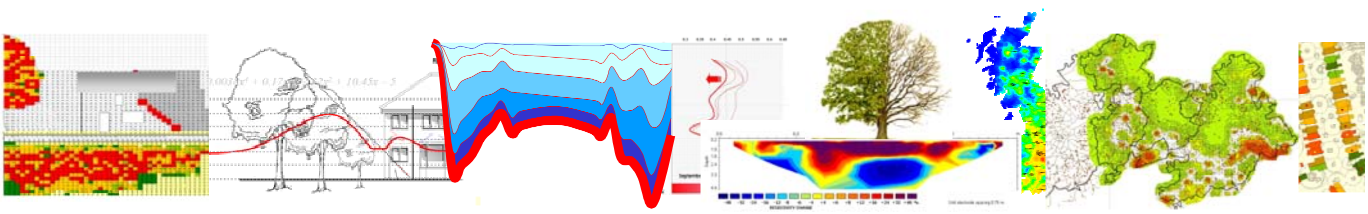


Above, the Liquid Limit and “% passing” plotted against depth from a sample of 1,826 test results. Trendline analysis shows that both increase over depth although with considerable spread. Maximum depth = 5.4mtrs.

The following pages consider the results of a larger sample (3,740 tests) and compare the index properties with measured soil suctions. The liquidity index (LI) is also considered and has been derived using the formula LI=(W-PL)/(LL-PL).

Abbreviations.

Mc = moisture content. LL = liquid limit. PL = plastic limit. PI = Plasticity Index, LI = liquidity index.



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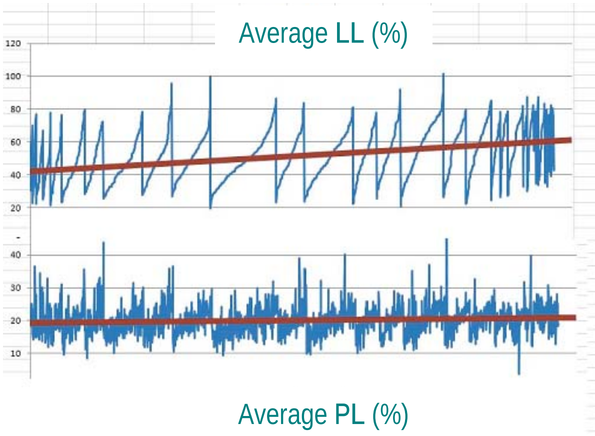
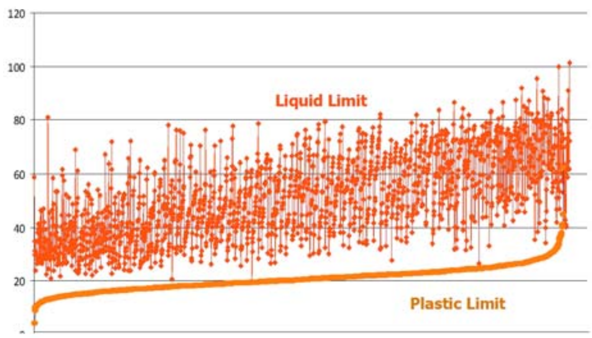
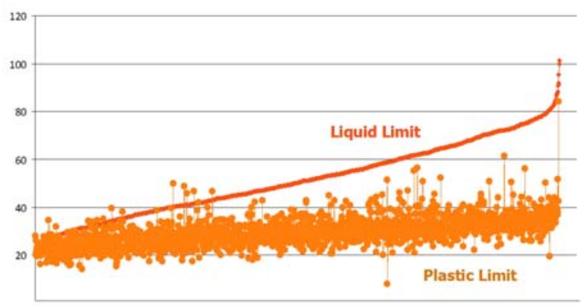


Averages – LL plotted in relation to rank ordered PL



Averages – PL plotted in relation to rank ordered LL



Index Properties

The plasticity index of clay soils is central to much of the subsidence practitioner's work and yet we rarely see the distribution of values of a large sample. What is the variance and which of the properties are the most reliable for assessing desiccation?

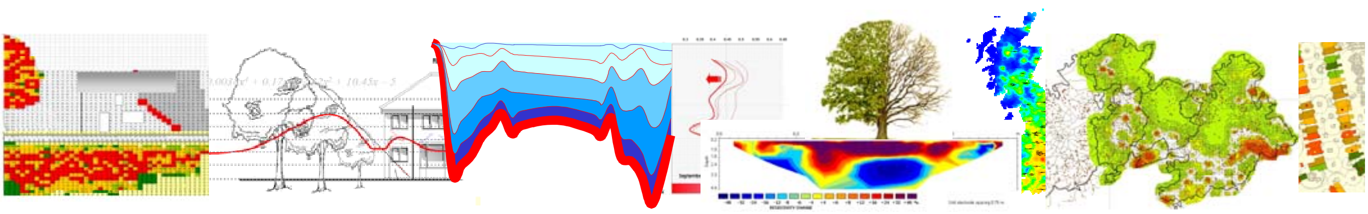
In this brief review we have analysed 3,740 test results and compared them with suction measurements. The exercise is predicated on the suctions being correct of course, which is not always the case but it does in itself raise the issue of reliability and consistency when assessing desiccation.

Top of the page, the average Liquid and Plastic Limits from our sample.

There is less variance in the PL, which averages 20%. In contrast, the average LL starts at around 40%, rising to 60% with a wide spread.

The bottom graph shows the wide distribution in values of the LL, in the range 20 – 100%. The data include mixed drift deposits.

In contrast, the PL values are closer to the 20% average with less variance over the same scale – both plots in this graph have 'y' values in the range 0 – 120.



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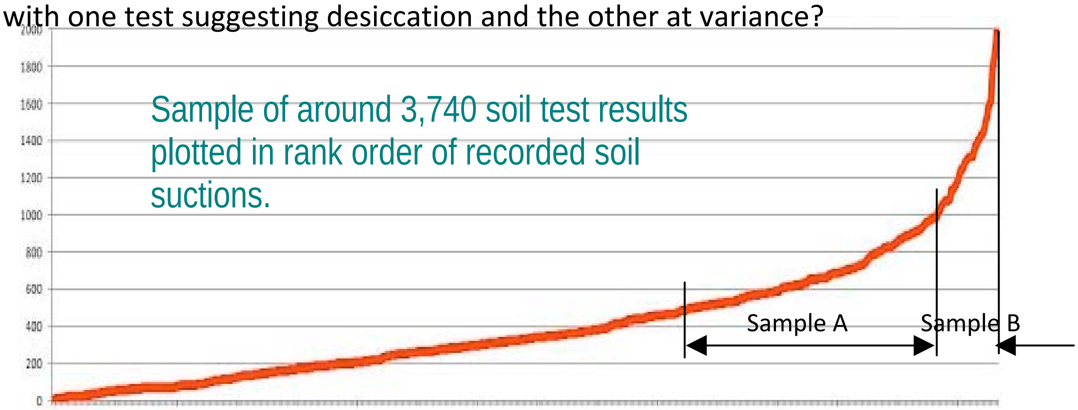
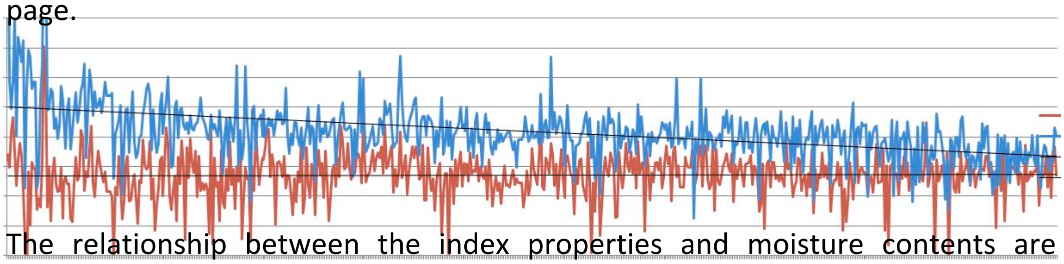
Using Index Properties to Detect Desiccation

The issue around the reliability and accuracy of comparing moistures with soil index properties to determine desiccation has been dealt with in BRE Digest 412 and by Driscoll and Skinner in their publication "Subsidence Damage to Domestic Buildings", BRE Trust, 2007 and is well understood. This study seeks to quantify the margin of error. Does the test produce results that are 'near enough', 'close', or no better than the toss of a coin? Do results using the LL and PL always agree? If not, how many times are they at odds with one another, with one test suggesting desiccation and the other at variance?

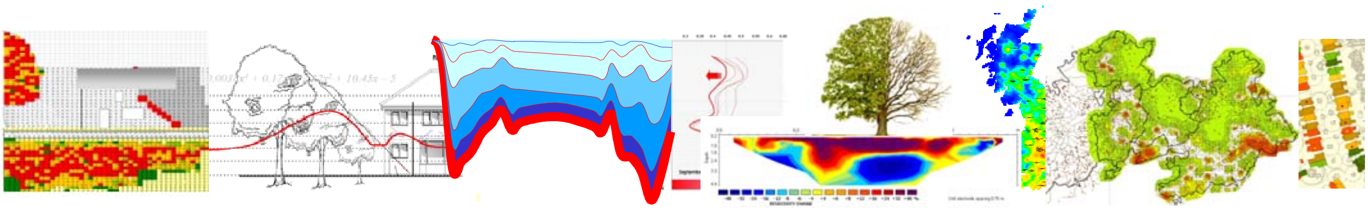


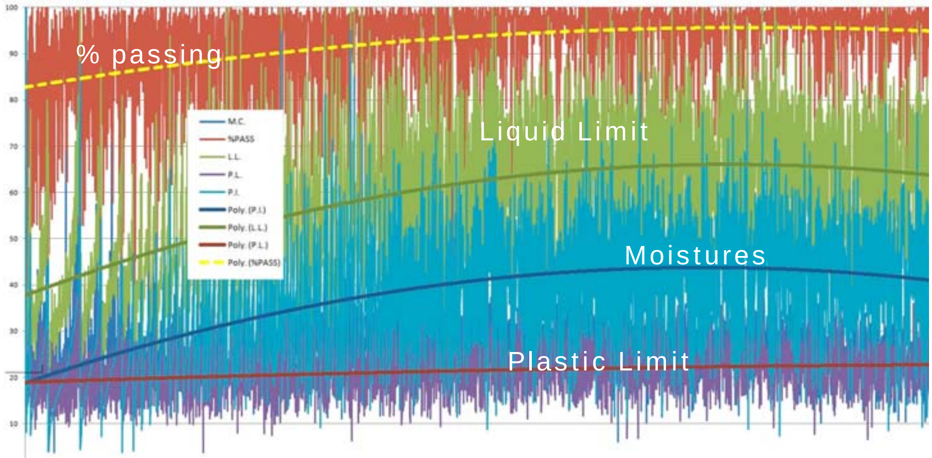
A sample of 3,740 soil suction results, plotted in rank order. Comparisons with index properties has been undertaken on samples with suctions > 500kPa.

All charts and analysis are ordered on the increasing value of soil suctions, shown above (red line) and in the range 0 – 2,000kPa. Below, the Plastic Limit (PL) and moisture content (Mc) of the soils are plotted in order of increasing suctions. For ease of viewing, this graph is an abstract of 630 soil results with a Plasticity Index ranging from 50 – 59%. The full range is shown on the following page.

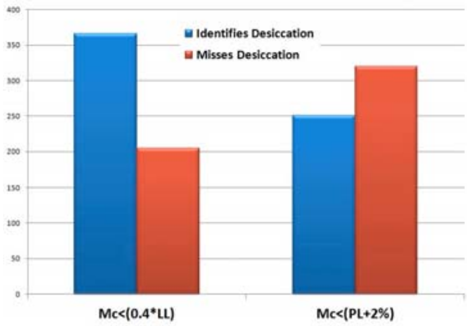


The relationship between the index properties and moisture contents are plotted along with linear trend lines. In very broad terms, and as one might expect, these trend lines show convergence of the Mc and PL as the suctions increase (to the right of the graphs), although the relationship between the individual values reveals significant spread.

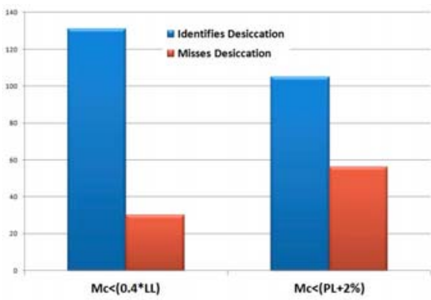




Above, the scatter of index properties, moistures and "% passing" from a total of 3,740 results obtained from valid claims reveals the nature of the problem when using any sort of comparison method to determine whether a soil is desiccated or not.



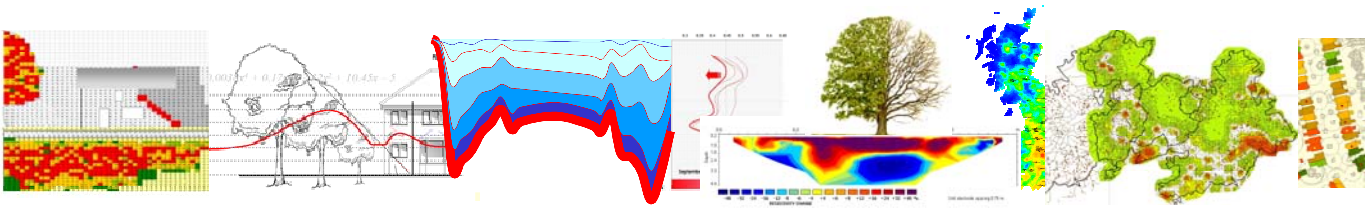
Suctions in range 500 - 1,000kPa. Sample A.



Suctions exceeding 1,000kPa Sample B

Above, graphs of results showing how successful or otherwise comparison methods are for detecting desiccation when plotted against the suction graph on the previous page. Above, left, the number of results that would have detected desiccation (blue) with suctions in the range 500 – 1,000kPa and right, values exceeding 1,000kPa.

As might be expected, the success increases with the higher (i.e. greater than 1,000kPa) suctions and in both cases the LL delivers better results than the PL, with a success rate of around 80%. Using the same criteria this drops to 64% for the lower range (500 – 1,000kPa) of suctions.



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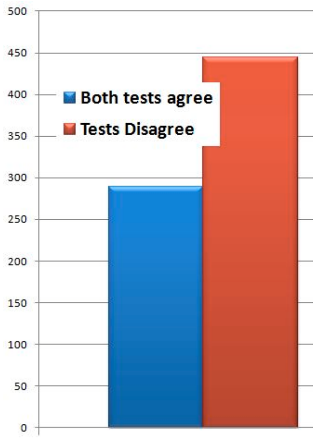
Comparing the output using the PL criteria, the test detects desiccation in 62% of cases in the higher suctions range, falling to 44% using the lower suctions.

In summary, the LL delivers a 20% improvement on the PL in both instances, and is the more reliable of the two tests in terms of methodology. However, in Digest 412 the Building Research Establishment report sending three identical samples to 40 reputable laboratories to determine the LL using the BS cone penetrometer test. The results varied with a LL between 64% and 78% which adds a further degree of inconsistency.

The problem then arises that when assessing desiccation using both criteria, how many times are they in agreement? What happens if one test indicates desiccation and the other does not?

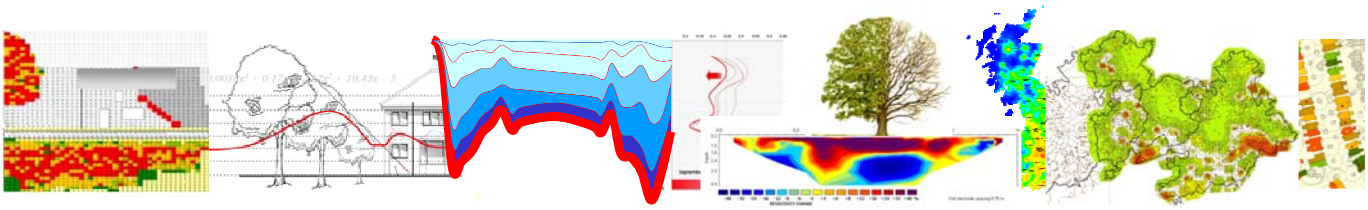
To better understand the extent of the problem, the data sample was analysed and given the above findings, the suggestion was it would make the detection of desiccation more difficult.



Left there were 289 cases where both tests were in agreement (blue) and detected desiccation. In 444 cases desiccation was detected using one criteria, but not the other.

Although the LL delivers better results, the case proving desiccation can be confounded if the alternative test (PL) does not support the findings. The odds of them being in agreement were low - around 40%.

The findings are of concern bearing in mind that the majority of claims involving the detection of desiccation are based on suctions in the mid-range. Less than 10% of the sample had recorded suctions exceeding 1,000kPa. In fact, 50% of the sample had suctions less than 400kPa. The onset of desiccation was taken as a suction > 200kPa.



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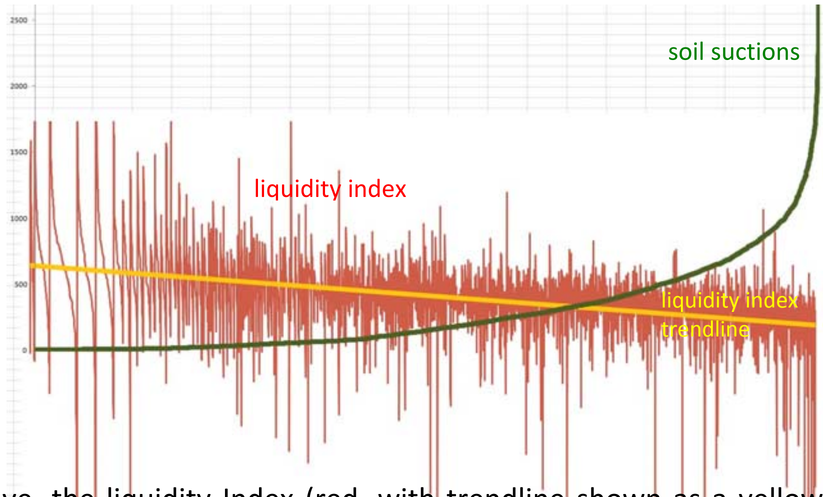
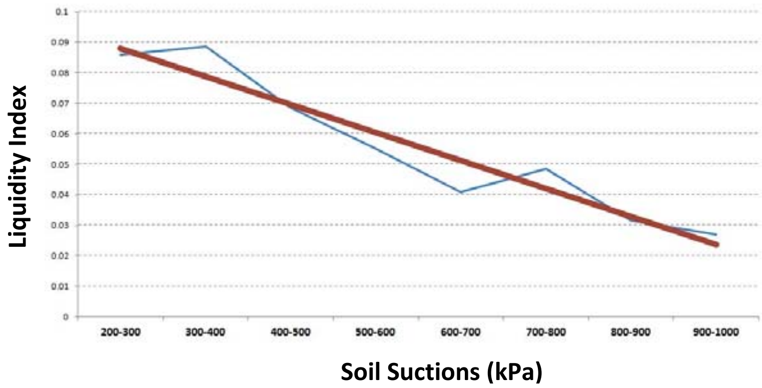
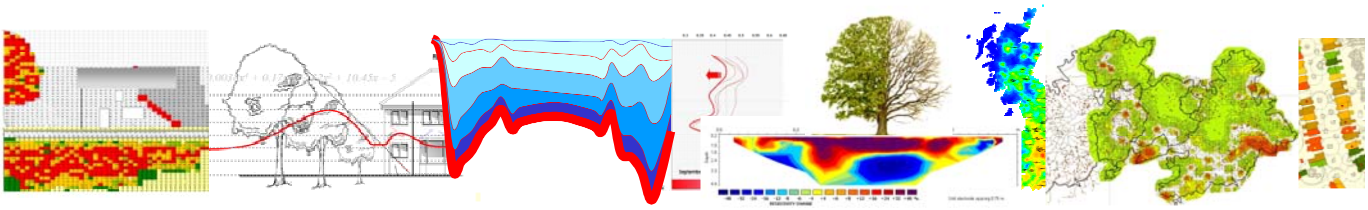


Above, the liquidity Index (red, with trendline shown as a yellow line) has been superimposed onto the suction graph (green line) to see if there is a correlation. Although the trendline agrees broadly with the suctions, with increasing moisture deficits recorded to the right of both graphs, the spread using the raw data reveals similar problems with the liquidity index.



Above, the average Liquidity Index (LI) for the suction ranges shown reveals a linear relationship with a value for LI of 0.09 for low suctions (200-300kPa) and decreasing to 0.03 for suctions of 900-1,000kPa.

Detecting desiccation using small differences in the LI, combined with the added problems around the test procedure (described in BRE 412) and interpretation of the results presents problems. From a practical point of view it does detect differences on the normalised scale between the PL and the LL over the depth of the bore and is a useful comparison test bearing in mind the above limitations.



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Index Properties – Summary Conclusions

None of our findings will come as a surprise to experienced geotechnical engineers who are used to dealing with variability in soil mechanics but the study may be useful to the less experienced practitioner who may believe desiccation can be determined using comparison values.

There is also a bias in our analysis. The assessment of whether using index properties is a reliable way of detecting desiccation itself uses comparisons with absolute values ((Mc<(0.4xLL)) for example), whereas in reality the engineer will be looking at samples taken over the depth of the bore and using their experience to decide.

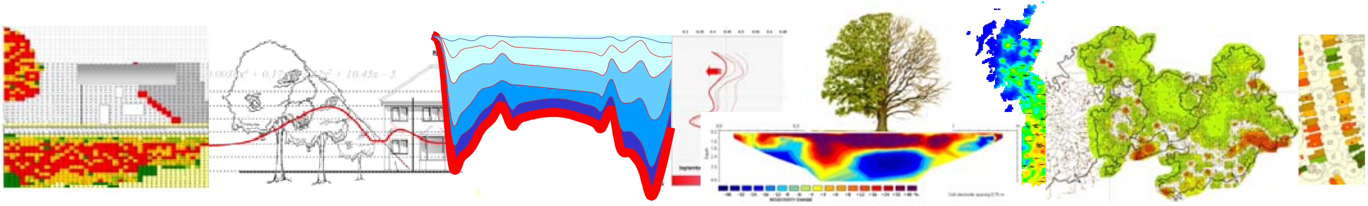
This may typically involve comparing the results of around 6 samples taken at various depths and the engineer will be looking for relative values between each, rather than a comparison with any formula. Spotting that one particular sample is drier than another, and at a depth where root activity could be expected, is a more common approach.

The problem is compounded when we add issues with the test method discussed in the report and with sample retrieval – disturbed or undisturbed samples can deliver widely differing results as we have seen in earlier studies undertaken at Aldenham and elsewhere.

Where this study might help is in quantifying the uncertainties. The LL appears to be a more reliable test than the PL, and by a figure of 20%. The LL itself may not be perfect, but delivers a correlation of 80% in the higher suction range and 64% in the mid-range.

It seems likely that the value of using index property comparisons would drop still further with suctions less than 500kPa and yet this is the most commonly encountered value according to the dataset.

The study has assumed that the suction test results are a reliable detector of desiccation. Had we approached this by comparing suctions with rank ordered LL results, the findings would have been very different, which illustrates the nature of the problem.



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"Geoengineering our climate is not a 'quick fix'"

University of Leeds. As reported in ScienceDaily
25 November 2014

We were relieved to read that scientists are considering the dangers of geo-engineering to combat climate change. Dr Matthew Watson, a reader in natural hazards from the University of Bristol, and principal investigator for the SPICE project, said: *"Whilst it is clear that temperatures could be reduced during deployment, the potential for mis-step is considerable. By identifying risks, we hope to contribute to the evidence base around geo-engineering that will determine whether deployment, in the face of the threat of climate change, has the capacity to do more good than harm."*

Professor Steve Rayner, the James Martin Professor of Science and Civilisation at the University of Oxford, and principal investigator for the CGG project, concludes: *"Take everything you hear both for and against geo-engineering with a large grain of salt. Mostly it is too soon to know what any of these technology ideas would look like in practice or what would be their true cost and benefit. But it's almost certain that geo-engineering will be neither a magic bullet nor Pandora's Box."*

Some welcome recognition from scientists exploring geo-engineering that there are dangers in taking premature action without a better understanding of the potential consequences.

Bayesian Identification of Soil Strata in London clay

Geotechnique Vol 64, Issue 3, January 2014

The following is an abbreviated abstract taken from the Geotechnique web site:

"To assist geotechnical engineers in identifying the soil strata in LCF, this paper aims to develop Bayesian approaches to identification of soil strata in LCF using water content data. Equations are derived for the proposed Bayesian approaches, and illustrated using a water content profile at St James's Park, London. In addition, a sensitivity study is performed to explore the effect of data quantity (i.e. both the measurement interval and number of measurements at the same depth) in a water content profile and provide guidance on the water content measurements during site investigation for optimising usage of the proposed Bayesian approaches."