# 13 Holland St. : Analysis of the Problems leading to a Claim Against the Cambridge City Council and a Refutation of the Claim.


**Alexandra Gardens and the plane trees adjacent to No.13 Holland Street**

***Introduction***

The house is at the end of a terrace separated from Alexandra Gardens, a reclaimed brickpit, by Carlyle Road with a tarmac surface and two pavements. Just inside the park are a row of mature London planes 15-20 metres from the house (see above). In 2003 cracking appeared in the house and was repaired in 2006 but soon started again and further remedial work was done that year. Since then cracks were found through other parts of the house and have progressed. No further remedial work has been done. The insurers' agents decided that the adjacent trees of Alexandra Gardens were the primary cause. This is the basis of the damage claim and its proponents have never wavered. In 2008 test bore holes were made, soil samples removed and levelling data collected over a year. The soil tests did not indicate serious soil desiccation but roots of London plane were identified in some holes. Levelling data showed annual movement of the house. The Tree Officer proposed felling the nearest tree (T3) to the house and drastic pruning of two adjacent trees (T2 and T4 ), thus indicating her acceptance that the trees were probably the cause of the cracking. The public reaction to this proposal has led to a subsequent public meeting and postponement of the decision.

# Summary of the Report

***Timelines and common sense.***

The house was built in 1894 and the trees planted in 1905. The trees would have reached maturity in the 1960s as can be seen by a timeline diagram (see Report). The cracking is limited to 2003 onwards but the trees were mature 40 years previously. Common sense dictates that something in the years closer to 2003 must explain the sudden cracking of the property.

***Damage to surrounding properties.***

Our survey of the properties around the area has shown widespread settlement and cracking with a few buildings underpinned. The majority of these are not adjacent to the park or mature trees.

***Adjacent trees and roots.***

Some roots from large mature trees 15-20 m away would be expected. Examination of the three test boreholes along the house edge shows that root growth is poor. The middle borehole nearest to the tree (T3) chosen to be felled, and closest to the major damage in the house, contained no roots at all. The storage starch in the roots was only moderate when at that time (December) it should be high. These findings show that root growth under the pavement is weak and would not cause sudden cracking in 2003.

***Seeking a cause for recent cracking.***

Proceeding on the possibility that the cracking may well be due to a cause inherent in the building rather than an external one, we have analysed the data provided by the insurers' technical agents. It is clear that there is no net subsidence occurring but only the usual expected annual fall and rise of the ground. Given this movement, why has the house only recently cracked rather than half a century ago ?

***Analysis of the movements : no net subsidence but articulations.***

The movements around the wall of the building clearly show that the house is moving up and down in three articulated sections, the front house with attached conservatory, the middle extensions and the garage. The cracking is centred on the joins.

***Building work to the property – the real cause.***

In 1980-82 the back extension to the house was extended by 100% with a further section and garage added to that. These sections were built with new (concrete) foundations. The junctions are where cracking would be expected and an analysis of the cracking pattern in the house and external wall confirms this. A basic principle of building practice is that an extended structure should not be built on different foundations with differing mechanical properties.

***Conclusions.***

The cracking of the building is due to successive building works since 1980 which presumably were examined and accepted by the insurance company. They should therefore be fully responsible for any further work done to stabilize the structures. The involvement of the trees is virtually impossible due to the timeline and the weakness of the root zone at that point. The proposal to fell and drastically prune the trees came after an independent assessment of the insurer's claim that took neither independent measurements, nor conducted an analysis of the existing data with a professional degree of criticism. The final result is that the analyses and assessment has had to be done by us, the public, after struggling for weeks to obtain the data, which though still imperfect, has proved sufficient.

**Report**

***Timelines and common sense.***

The house was built in 1894 and the trees planted in 1905. The trees would have reached maturity in the 1960s as can be seen by a timeline diagram in Fig.1. The cracking is limited to 2003 onwards but the trees were mature 40 years previously. The annual soil cycle of clay shrinkage and swelling has certainly been a feature of the soil since it was formed as a deposit before Cambridge existed and is caused by summer drying followed by winter rains. The cracking to the house did start in a somewhat dry year, but after five wetter than average years (the rainfall data is from NIAB, a Met. Office registering station site on the Huntingdon Road approaching Girton College, so the data is truly local). More to the point, there were far drier years previously,

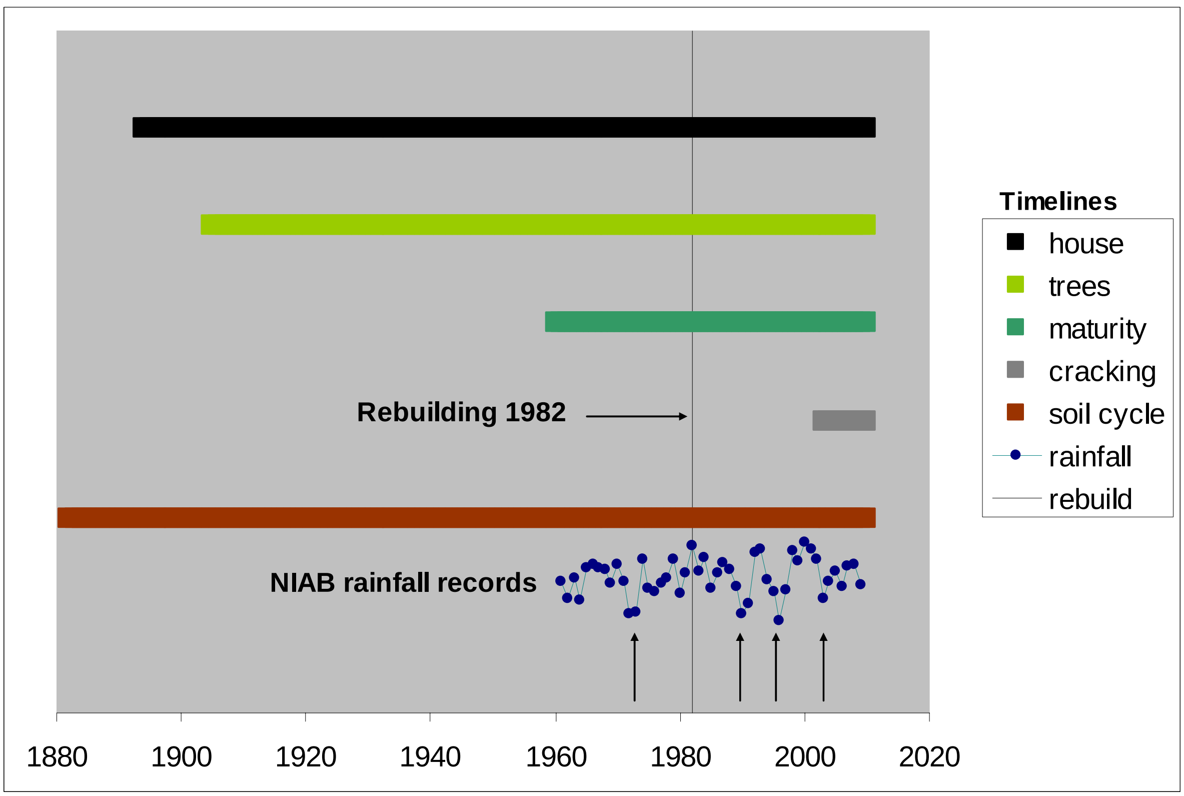



**Figure 1**

in 1972-73, 1990 and 1996 (see arrows), which produced no evident cracking. We shall argue below that the damage is cumulative strain subsequent to changes in the structure of the house after rebuilding from 1980 onwards, perhaps accelerated by drying in 2003. Common sense dictates that something in the years closer to 2003 must explain the relatively sudden cracking of the property[1].

***Damage to surrounding properties.***

Our survey of the properties around the area (the park and several nearby streets) has shown widespread settlement and cracking with a few buildings underpinned – the majority of the latter are not near the park or thought to be caused by adjacent mature trees (Fig.2) . Clay soil does move annually whether near trees or not, responding to the summer-winter cycle.

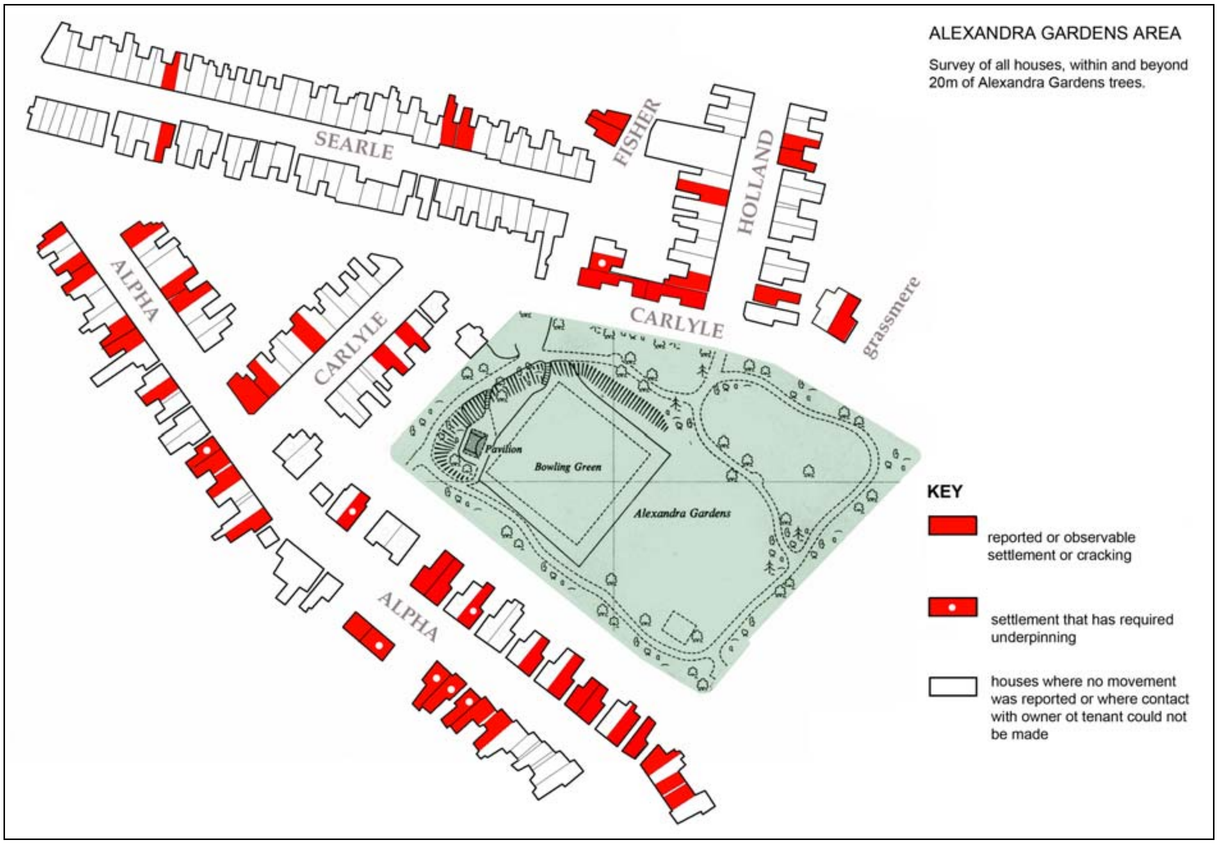



**Figure 2**

The distribution clearly shows that there is little correlation with proximity to trees. Many of the properties, built in the late 19$^{th}$ – early 20$^{th}$ century, have had extensions added to their backs over the years. The relevance of this latter finding will be evident from our analysis below.

***Adjacent trees and roots.***

Finding roots 15-20 m from large mature trees would not be unexpected after 100 years. However, the extent and strength of root growth is strongly influenced by the local conditions[2]. The trees are situated at a junction between two widely different substrata : (1) the park which is an open green space with open access to air and water extending far beyond the normal root zone of such mature trees; (2) the pavements, tarmac and built-over infrastructures with restricted area and most of the rainfall conducted away by drains. It should also be borne in mind that any roots growing across the road would have to contend with services, especially the sewers of which there are three in parallel. From all that is known about root development one would expect that the root zone would be well developed under the park and poorly developed under Carlyle Rd.[3]

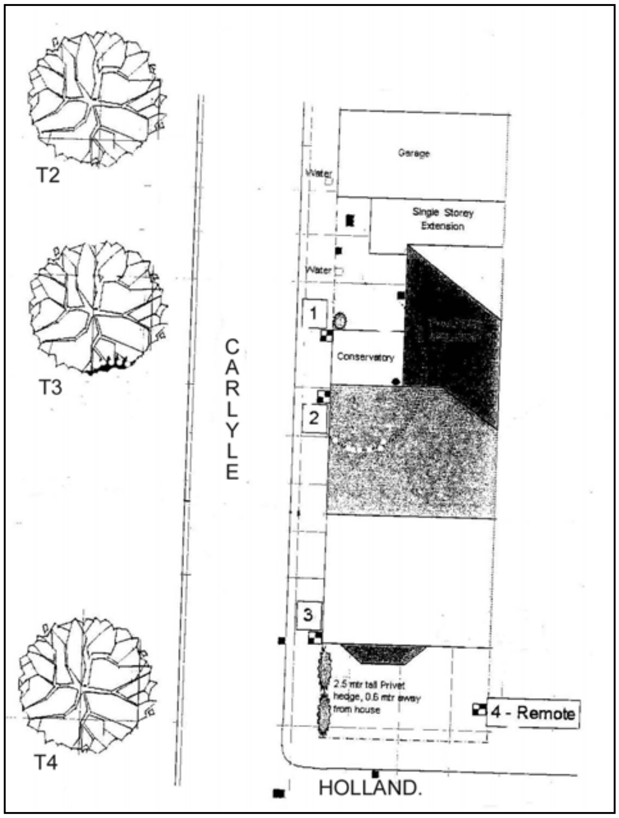



**Figure 3**

Examination of the three test boreholes (marked 1-3 in Fig.3) along the outer line of the house show two things with respect to the small roots found. First, the roots are weakly present. The middle borehole 2 adjacent to the nearest tree to the house chosen to be felled (T3) contained no roots at all. If there were an extensive root mat under the house such sporadic results would not be found. Second, the starch content of the roots, where found, was only moderate when at that sampling time (December) it should be high[4]. Trees store 80% or more of their carbohydrate reserves in root parenchyma and if healthy and vigorous would be expected to have a high starch titre. Furthermore, three boreholes sunk around an adjacent house backing on to this one, with a common street wall, have shown even weaker root growth, no detectable starch and root diameters too small for identification.[5]

These facts show that root growth under the pavement running along the house side nearest the trees is weak[6] and could not possibly be responsible for sudden cracking in 2003. The root zone would have been fully developed in these mature trees for *at least* 40 years.

***Seeking a cause for recent cracking.***

Proceeding on the possibility that the cracking may well be due to a cause inherent in the building rather than an external one, we have analysed the data from ‘precise level monitoring’ provided by the insurers’ technical agents. This involved monitoring of the height of 22 set points around the outer house wall at periodic intervals, compared to a ‘datum’ or reference point. This is usually done at two-monthly intervals. After starting in June 2008 measurements were taken in August, October and December and the results presented as indication of fall in building height.[7]

The agents did not offer a complete or proper analysis of their own data but rested with presenting initial data showing the shrinkage in the annual cycle as evidence of lowering. When the data for the whole year, released 2010,[8] is plotted in Fig.4 it is clear that there is no net subsidence but the usual expected annual fall and rise of the ground.

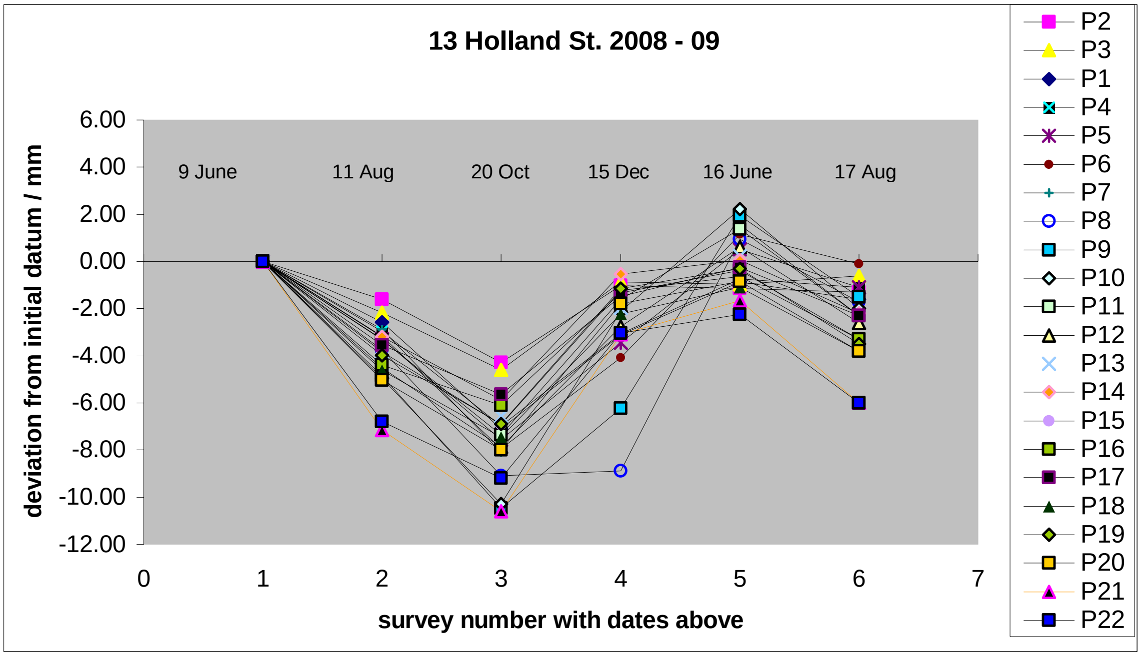



**Figure 4. Plot of all the data points for the whole year Jun08 – Jun09**

The data shows no initial deviation at zero time (by definition) but it can be seen that the fall of level during the drying phase of the year is reversed during the wetter half. When the points at each date are averaged, as in Fig.5 below, it can be seen that the house as a whole returns to the same level. Given this movement, which most houses in the area have to cope with, why has the house only recently cracked rather than half a century ago ?

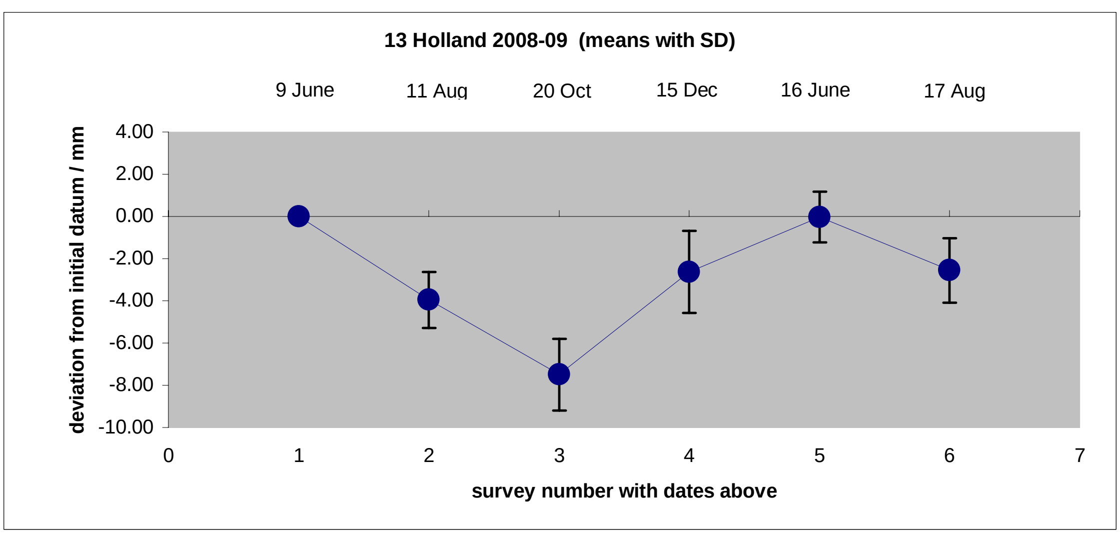
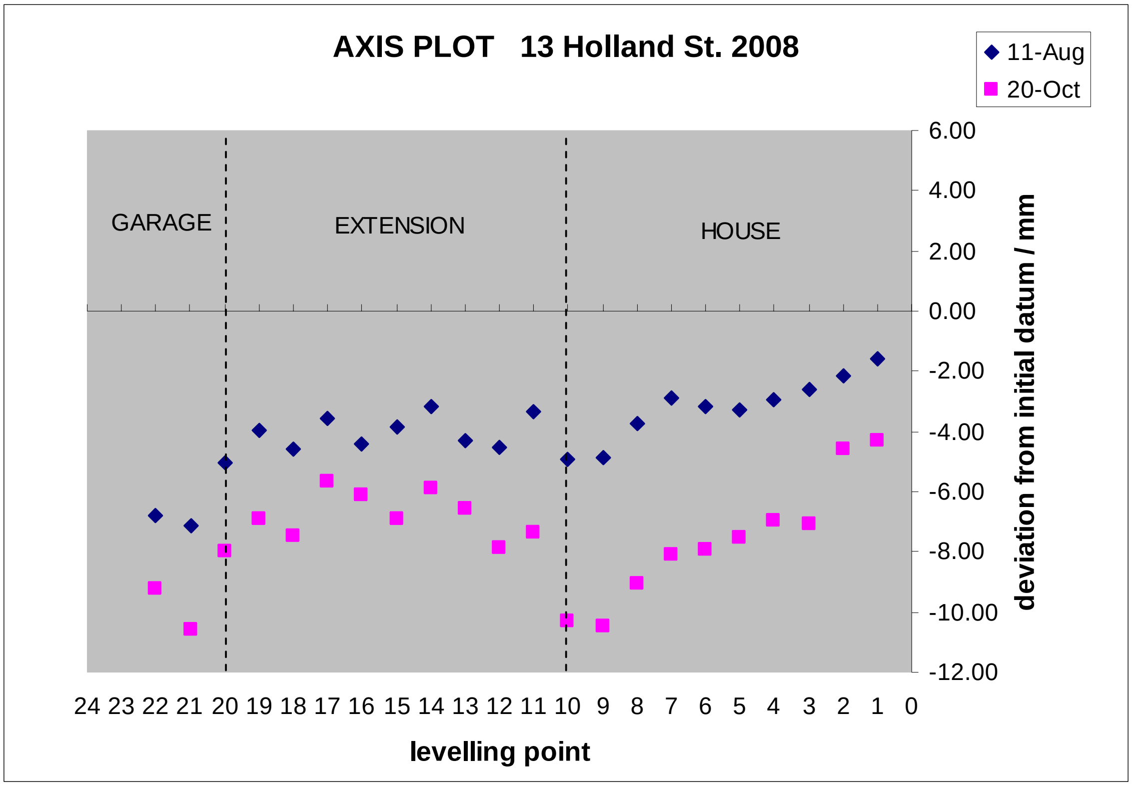



**Figure 5. Averages of all points at different dates.**

***Analysis of the movements: no net subsidence but articulations.***

What is really required is a plot showing the movements at different times *as a function of position.* This is shown in Fig.6 below and from this one can deduce the relative movements of parts of a building. When this is done at two dates, 11 August and 20 October 2008, i.e. the two sets of measurements showing a fall in level of the structures, the following picture emerges :




this can be correlated with the position of the levelling points on the building :

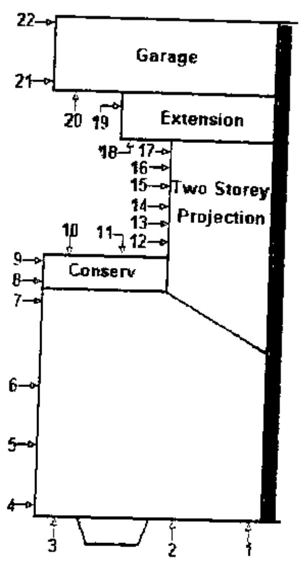



**Figure 7**

The movements around the wall of the building of clearly show that it is moving up and down in three articulated sections, the house, the middle extended section and the garage. (1) At the points 1-10 the house is flexing downwards to its lowest point on the corner; (2) the middle section from points 11-19 abruptly shows less fall spanning the middle section, and finally (3) from 19 onwards the garage plunges again. The conservatory, a small separate building, is straddling two of the sections and is cracking as a result.

In Fig.8 below we analyse the level changes in the middle section (11-19) a further important fact emerges :

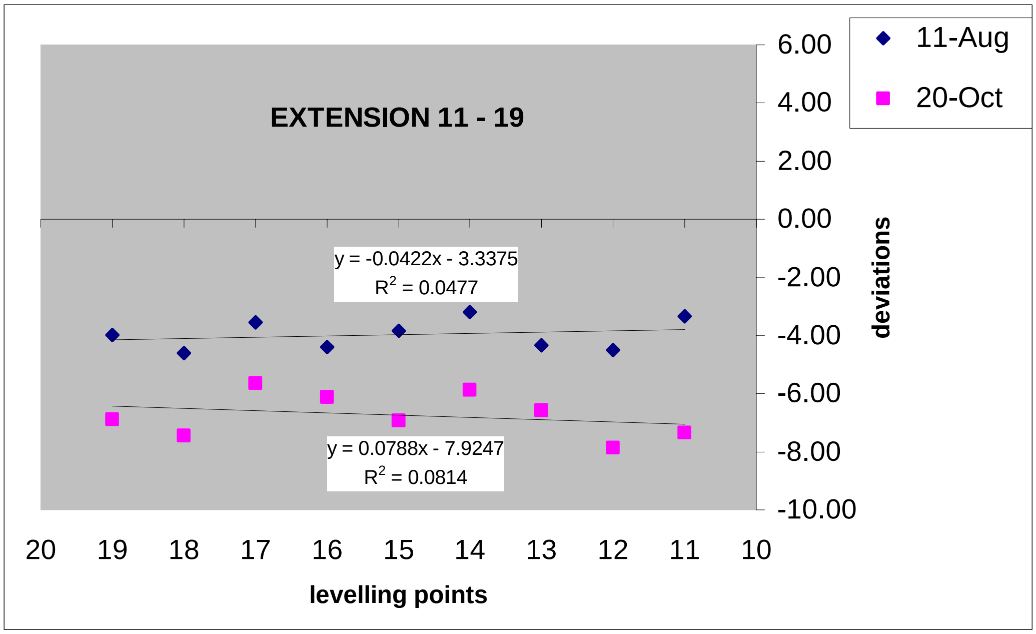



**Figure 8**

the linear regressions show that the slopes at the two different dates are 0.0422 and 0.0788 mm/point. As the points are roughly a metre apart along the walls this is less than 1/10th mm per metre. The extension is moving vertically like a flat horizontal plate. This is because the central extension section has foundations that are rigid over some considerable area and is probably locked in, horizontally by its brickwork, to the old back projection from which it was extended.

***Building work to the property – the real cause.***

In 1980-82 the back projection P to the house (see below, presumably built with it in 1895) was extended by 100% with a further section added to that also, a single storey structure E2 adjoining the garage. These sections were built with new (concrete) foundations by a builder (unknown to us) who took over after the architect of the upper section E1 was dismissed[9]. We have no knowledge of how far the new foundations were extended back into the old projection P. A conservatory was also built and to the end of the range a garage has also been built, presumably with shallow concrete foundations – if they are foundations in the proper sense of the word. There is no garden now, that being replaced by a collection of buildings on different foundations, all initially coupled together.


**Figure 9**

Shown in Figure 9 above is a picture of the house which should be compared with the levelling points diagram in Figure 7. The sections are labelled : H (end of house wall, rear left), C (conservatory), P (back projection to original house), E1 (new extension to projection), E2 (new single storey extension) and G (garage). The junction between G and E2 occurs between the levelling points 19–20, whilst the two rightmost sections C and H span the points 7–10. The middle section which appears rigid represents the points 11–19.

Consequently the old house with back projection, which was adapting to the annual soil cycle for 100 years by gently flexing, has now found itself coupled to a rigid central section and can no longer flex. The poor conservatory wall is obviously being pulled apart between the old back projection and the gable wall. Cracking may also be taking place in the garage, where there is movement between it and the rigid central section but we have no data on this and the coupling between it and the extension E2 may be less tight and consequently it can move independently.

A cardinal point is the apparent angular distortion to which the brickwork has been subjected. Assuming the levelling points are spaced about a metre apart this is as great as 4mm i.e. 1/250, a value that exceeds the accepted tolerance for brickwork and plaster[10]. This stress is occurring in the building where the damage is greatest (see below).

The result demonstrates a basic principle of building – that an extended structure should not be built on different foundations with differing mechanical properties unless separated by a full height movement joint. We emphasize that this is almost certainly the real and recent cause of the cracking in the house. The cracking pattern outside and within the house amply confirms this analysis. We show below in Figure 10 the distribution of 11 crackings (which may not be individual cracks but groups, referred to as ‘cracking’) either shown by the owner or described in a letter to insurers’ agents[11]. They fall into three groups: (i) those located near the rear wall and the adjacent back projection (marked P in Figure 9 and the wall between P and H with the conservatory, C); (ii) the corner of the house and adjacent gable wall (H); and (iii) elsewhere, being apparently confined to the hall, an area which also runs to connect with the back. We would expect the major cracking area to be along the walls P to H, including the conservatory, and this is seen to be the case; (i) and (ii) combined account for 91% of the damage. This is to be expected if the building is made of structures on different foundations joined together by interlocking brickwork.

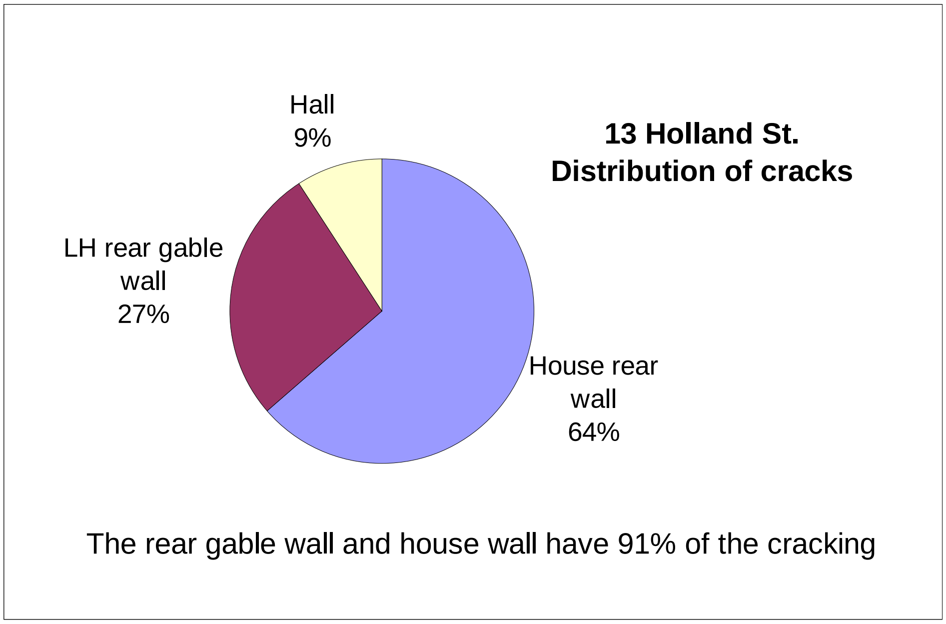



**Figure 10 Analysis of the cracking**

Cracks take time to develop. Lime mortar is a composite material of two phases, a hard granular one and a more fibrous one. Under cyclic loading, as occurs here annually, micro-cracks first develop and as the process repeats these are recruited along stress lines to ever larger cracks which finally appear[12]. In addition, when a crack has started small loose granules, particularly below ground, can fill parts of the crack and prevent its re-closure after rehydration of the soil – a ratchet effect. The process rarely happens immediately but is time-dependent[13]. This would explain the delay between the rebuilding and the cracks first being noticed. In a dryer summer as occurred locally in 2003 (see Figure 1) the annual excursions of the subsoil would have been greater than normal and would certainly have accelerated the cracking.

***Conclusions.***

The cracking of the building is due to successive building works since 1980 which (presumably) were examined and accepted by the insurance company. They should therefore be fully responsible for any further work done to stabilize the structures. The involvement of the trees is utterly peripheral due to the timeline and the weakness of the root zone at that point.

An independent assessment of the situation by Peter Dann Ltd. resulted in a recommendation to accept the felling demands after an inspection of the data and an on-site visit;

they did little more than rubber-stamp the assumptions of the group acting for the owner's insurers and were lax by the standards of the LTOA[14]. They took neither independent measurements nor conducted an analysis of the data with a professional degree of criticism[15]. The final result is that the analyses and assessment has had to be done by members of the public, after struggling for weeks to obtain the primary cracking data – and the details of cracking used here have been obtained privately.

What of the work and analysis by the insurers' agents ? The analysis made by us, pinpointing the problem, could have been made by their competent engineers but was not. It was not in their financial interest to do so, but a decision was made to shift the blame to nearby trees and demand the destruction of a public amenity. We consider such behaviour as nothing less than acting against the public interest.

Could the damage have been avoided ? The problems arising from the attachment of building extensions on modern foundations to old houses have been known for many years and is widespread. When the extensions were added, the original building had shown no signs of cracking and it would have taken knowledge and foresight of this problem by a local builder, to avoid this potential damage. It is worth noting that modern lime mortar is now manufactured for use in just such cases[16], and flexible joins are used for extensions[17], and may be a better alternative to underpinning which in this case would have to be extensive, disruptive and very expensive.

***Contributors***

This report is the collective work of several people who have come together to pool their expertise and judgement together with input and advice from many others who represent a group of concerned residents united by their opposition to fell London planes in the park.

David Brown DipLD MA PhD MIHort FArborA
Andy Davey
Liz Fenton
Joanna Gordon-Clark
Adrian Hill
Trevor McCann
Bruria Shachar-Hill
Peter Sparks
Cassie Sparks

**Addendum : Report from an independent arboricultural expert Dr. P.G. Biddle OBE commissioned by GAB Robins UK Ltd. loss adjusters (received 22 November 2010).**

Recently Dr. Biddle has been asked to look at the problem. He did not visit the site before he wrote a management plan as his report but he then came to see the site and for a meeting with Council officers in which we were represented (5th Jan 2011).

He has suggested a management protocol which should be followed on the basis of his analysis of levelling movements. He has chosen to concentrate on two comparable series of levelling movements (June-August 2008 and 2009) which are both periods representing the initial onset of Summer drying. In March 2009 the trees were pruned by 30% and so he compares the levelling data before and after pruning to determine its effect on the property. On the basis of his conclusions he suggest radical pruning of the adjacent trees with ongoing levelling monitoring for several years, if necessary, to determine the effects – in short, to conduct an experiment with the Alexandra trees and the house. The trees would be reduced to pollarded main branches and kept that way. This is considered better than outright felling. Underpinning the property is mentioned as an avoidable option and this raises the question as to what his brief was. If no mention was made of the rebuilding, which has effectively been responsible for the damage to the property, then his recommendations have limited value and merely support the insurers demand for drastic tree reduction. It is therefore important to examine his conclusions on pruning revealed by the data he uses.

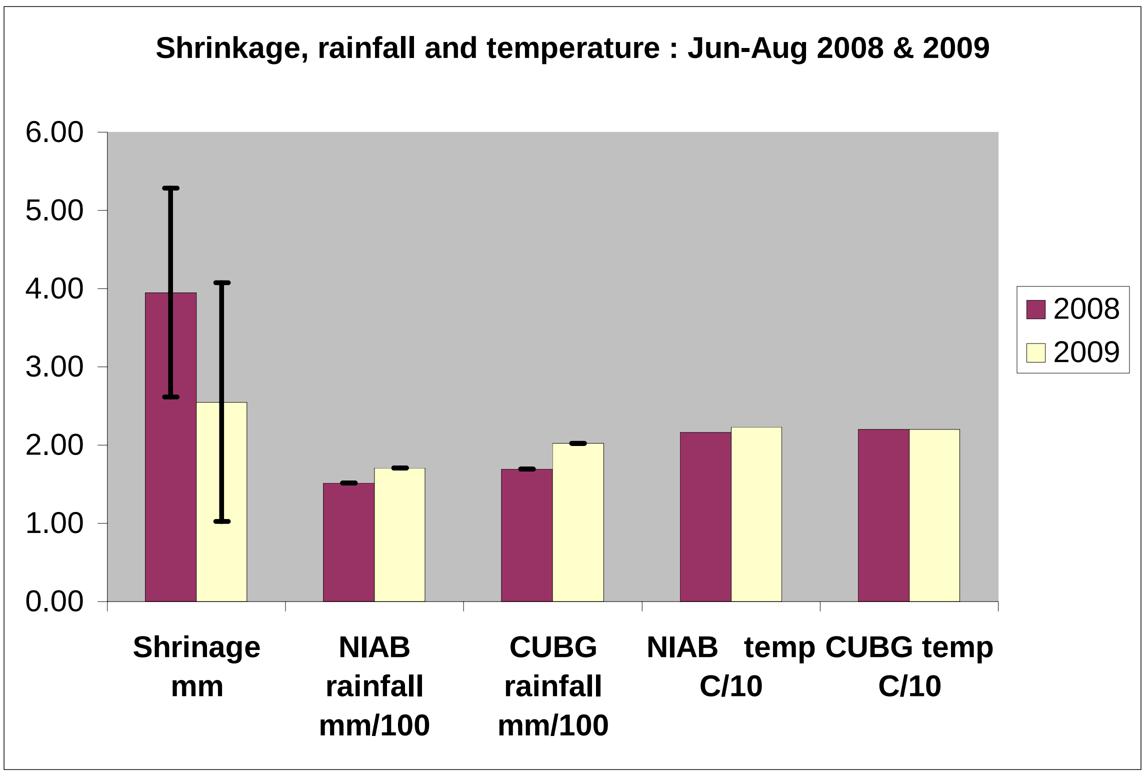
It can be seen from Figs.4 & 5 of the main report that the average fall in level from June (fully hydrated soil) to August (moderately dried after Summer) is less in 2009 than 2008. This may show that the pruning has had an effect, but we have to consider the weather. He comments that 2009 was a drier year and thus if it had been as wet as 2008 the level fall would have been even less; thus pruning had a marked effect and should be pursued (to a greater extent than 30% with ongoing monitoring).

First, the data for shrinkage. The average falls for June-August shown in Fig.5 of the main report are different, but not statistically significant, having huge standard deviations.

Second, annual records do indicate a drier 2009 in Cambridge but <u>not</u> for the period June-August. We are fortunate in having two Meteorological Recording stations here: NIAB ( National Institute of Agricultural Botany CB3 0LE, 2 miles North of Alexandra Gardens) and CUBG (the Cambridge Botanic Garden CB2 1JE, 1.6 miles to the South) so we are closely spanned by these two. The rainfall was higher in both stations for the period in question in 2009 *v.* 2008 (NIAB: 170/151 mm, CUBG: 202/169 mm) a difference of 13 – 20% for those three months.

Third, the temperatures, an important input to the dryness of any period, were virtually identical (22$^{o}$C). Thus evapotranspiration, the major input to the soil drying, could not have increased in the period either. This collected data is shown in the Figure below.

Dr. Biddle's reasoning cannot therefore be sustained. As a demonstration of the efficacy of pruning it obviously cannot be used, based on such slender data, to pollard these mature trees even if there were no other data indicating the obvious cause of recent damage.




It is important to look into what Dr. Biddle recommends in his widely-cited reference book on trees and buildings (o*p.cit.* Reference 1). At the end of Vol.1 (The Choice of Actions pg.295) he gives a very useful flow chart for dealing with a tree-related damage problem which sums up a great deal of what has been discussed throughout the work. This is reproduced below together with a route map through the chart that we supply as an aid to applying it to the present problem as simply and directly as possible. It is evident that his advice to the Council must have been within the constraints of 'tree management' i.e. for the cheapest option. But his overall view, as can be seen from his book, would be to underpin the property and not to prune the plane trees.

Is there existing damage?  YES.
Is there foundation movement? YES.
Is a tree involved?  YES.
Are movements due to seasonal deficit?  YES.   [there is no persistent deficit under the house]
Are existing movements tolerable?  NO.
Would existing foundations be adequate in the absence of the trees? YES.
**Is the tree so valuable as to make felling or pruning unacceptable?** YES.
**UNDERPIN**.

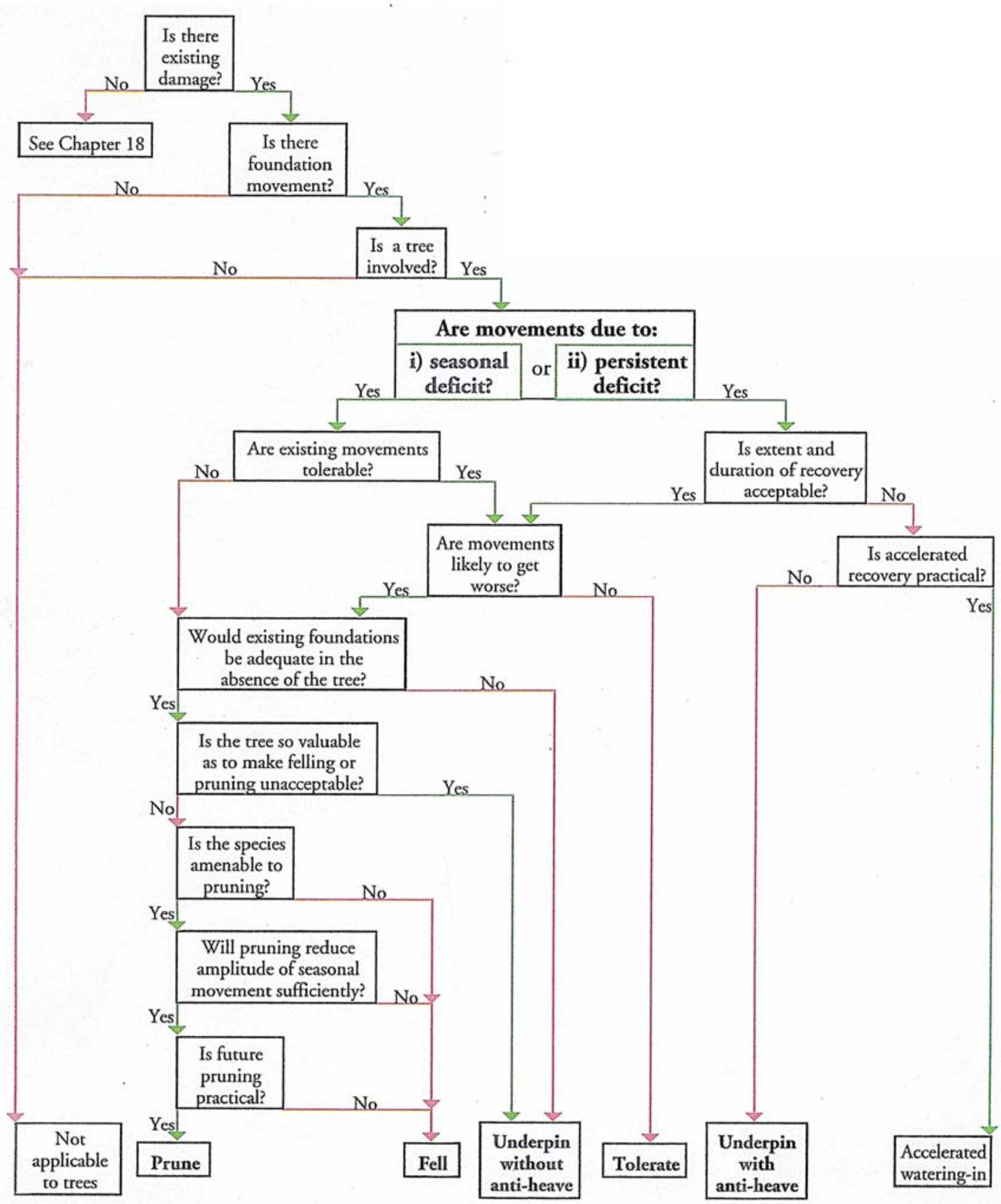



*Figure 17.14*
*Decision flowchart for remedial works*

***References***

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[1] This point is considered as so obvious in a standard work on tree damage to buildings : Biddle, P.G. (1998) *Tree Root Damage to Buildings: Vol.1*. (Willowmead, Wantage) that it is not really discussed. Instead, methods for determining the rate of tree growth as indicative of the *recent changes* in water use are detailed (Chap.14). For mature trees, therefore, the recent changes would be zero.

By way of guidance on the probability of damage from a plane tree, the Kew Root Study is the basis of NHBC Chapter 4.2 for foundation design and of the guidance for new tree planting found in BRE Digest 298. The distance within which 90% of the damage occurred in that study where Plane trees were implicated is 10 metres. The distances reported for the nearest trees to the property are T4 – 16m, T3 – 14.5m, T2 – 18m. All the trees are significantly beyond the likely zone of influence. Recent research (reported in The Clay Research Group Letter 56) shows that the highest risk of damage arises from trees less than ten metres height at closer than their height distance from the damage. This statistically confirms what has been known by arboriculturalists for many years – actively expanding young and maturing trees planted close to houses on clay soils are the highest risk by far. The trees in this case are fully mature specimens at greater than ten metres distance.

[2] " It must be emphasised that even the presence of live fine roots within a clay soil does not prove that they are causing drying and shrinkage of the clay." Biddle *op.cit.* pg.221.

[3] Personal communication from Prof. Oliver Rackham OBE after site inspection.

[4] Biddle *op.cit.* pg.31; Y. Haddad, Y., Clair-Maczulajtys, D. and Bory, G. (1995) *Effects of curtain-like pruning on distribution and seasonal patterns of carbohydrate reserves in plane (Platanus acerifolia Wild) trees*. Tree Physiology 15, 135-140.

[5] Root presence in three boreholes around 3 Fisher St., adjacent to 13 Holland St. and backing onto it, were obtained during a similar damages claim earlier in this decade. The claim was abandoned because the root data were so weak. No roots > 0.5 mm were found, no starch, and the roots in the lower boreholes where the clay concentration increases were dead. These boreholes were close to those sunk at 13 Holland St. along the street. Full results of the examination can be seen in Cambridge City Council FoI release No.1203 19th November 2010, *et seq.* (Additional Information).

[6] Clay that is dense and poorly aerated can be a very hostile growth medium for roots; see Biddle *op.cit.* pg.75.

[7] Report by Geo-Serve to InFront Innovation 7 Jan 2009.

[8] Report by Geo-Serve to InFront Innovation 26 Jul 2010.

[9] Personal communication (emails) from Mr Andrew Smith the designer, October 2010.

[10] See Biddle *op.cit.* pg.112; BRE Digest 63 quotes 1/300 as the angular distortion associated with the onset of brickwork and plaster cracking, a value lower than that observed here.

[11] Personal letter from local resident (2010) and from the owner to Crawford & Co., 2006.

[12] Crack progression is a huge and highly technical field. For a recent paper setting out some of the essentials see: Narasaiah, N. & Ray, K.K. (2008) *Initiation and growth of micro-cracks under cyclic loading.* Materials Science and Engineering: A. Vol. 474, 48-59.

[13] It might be argued that a permanent water deficit (PMD) was slowly developing leading to damage. Not only does the soil analysis show absolutely no indication of this but it is impossible that it should take a half-century ! Low SMD is confirmed in the Laboratory Report from Steve Brown Engineer for Mat Lab 29/01/09 where heave potential is too low to be estimated because of low suction potential in 3 out of the 4 boreholes and in the remaining one as '0 to 2 cm' (no Standard Deviation). Furthermore, damage would be apparent long before the full development of a PMD : Biddle *op.cit.* pg. 111.

[14] London Tree Officers Association: *Risk Limitation Strategy for Tree Root Claims.* 3rd edition revised May 2008. 6. Levels of Evidence. " Increasingly, due to the Freedom Of Information Act, tree officers are required to justify their decisions for tree removal in much more detail and to a greater level of accountability. This essentially means that tree officers require appropriate evidence that corroborates the view that the tree is the material cause of the problem and that other factors have been eliminated as potential influences."

They go on to specify: "Insufficient foundation design for structures that are ancillary to the main super structure of the property, resulting in differential movement between the two e.g. garages, conservatories, late addition extensions, porch, steps and bay structures." (4th from a list of 14).

[15] Peter Dann Ltd. does not accurately assess the data obtained, making imprecise statements about them, all in the direction of implicating the trees. Letter to Council 07/05/2010 : " Boreholes were excavated on the south side of the property to obtain soil and root samples…Root samples were found to a depth of approximately 2.75m … and the samples were identified as belonging to plane trees." This neglects to mention that *no* roots were found in borehole 2 nearest to T3, considered as the main tree to be felled. (Letter to Council 21/05/2010) : " The movements recorded are not solely to an extension but occur to the whole of the gable wall, the rear wall of the property and the side wall of the original rear projection. The movements are reasonably consistent along the length of the gable wall and the side wall of the rear projection.." This movement is far from consistent and a proper plot would have revealed what is happening to the building. What is said about "rotation of the building towards the trees" neglects to mention that the house is at the end of a terrace and so it could *only* dip down at the end nearest the park, in response to the annual soil cycle.

[16] Peter Ellis, *The Analysis of Mortar: The Past 20 Years* *h*ttp://www.buildingconservation.com/articles/mortar/mortar.htm

[17] There is a plethora of flexi-joins now available and also many technical treatises such as *Expansion Joints in Buildings*: Technical Report No. 65 National Academy of Sciences.