

Infront-Innovation
ENGINEERING REPORT

Name of Engineer: Jose Lopez BSc ICIOB Cert CILA

Infront Innovation Reference: IFS-AVI-ROF-13-0044763

Name(s) of property Owners: Mrs Lynda Emmott

Address of Property: 10, Linda Grove, Waterlooville, Hampshire, PO8 8UX

Date of Report: 27 March 2015

1. Scope of instructions:

- 1.1. In September 2013 Cunningham Lindsey were instructed by Aviva Insurers to investigate the reported structural cracking to the property.
- 1.2. This report has been prepared in support of the Application to fell the oak tree to the rear of 10 Linda Grove, Waterlooville, Hampshire, PO8 8UX. The tree has been identified as T1 within the Arboricultural Report dated 09 December 2013, ref. SW/2111131121/JS provided by Marishall Thompson Group.
- 1.3.

2. Documents considered

The key documents considered in the report are listed below.

Table 1 – Documents considered

ID	Produced by	Description	Date
1	Cunningham Lindsey	Initial Advice	13/09/2013
2	CET Property Assurance	Site Investigation Report	02/10/2013
3	SubsNet	Site Investigation Report	17/02/2014
4	Marishall Thompson	Arboricultural Survey	09/12/2013
5	Subsnet UK	Monitoring Report	09/02/2015
6	Infront Innovation	Revisit report	13/11/2013

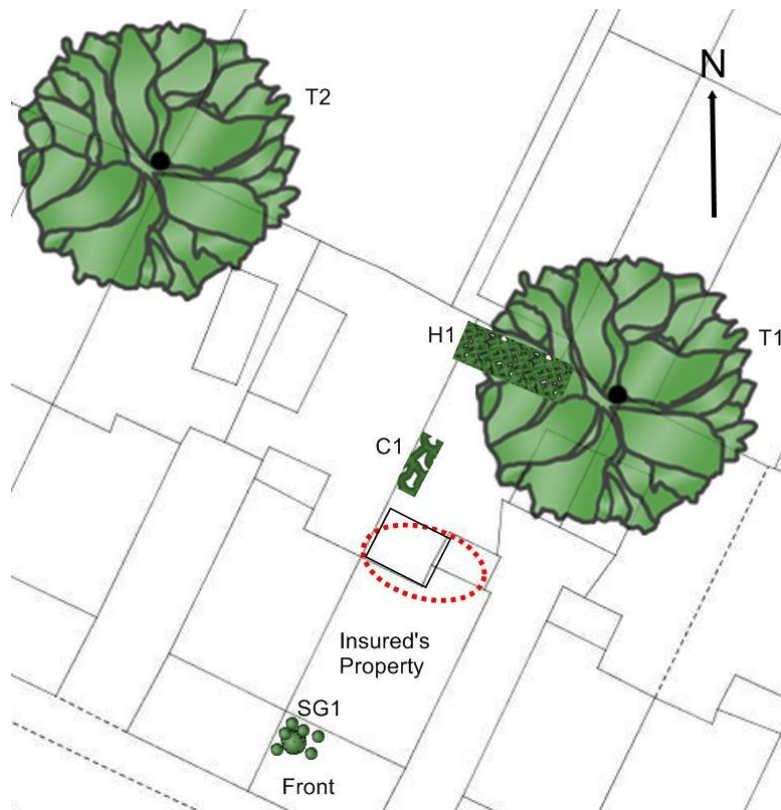


Figure 1 – Sketch taken from Marshall Thompson Group survey showing location of the principal vegetation in relation to Property

3. History and background

- 3.1. The property is a single storey, two bedroom, semi-detached bungalow of traditional construction with cavity brick walls surmounted by a hipped tile covered roof. The property is believed to have been constructed circa 1955.
- 3.2. In September 2013 large cracks were noted to the rear right hand corner of the property and appeared to progress rapidly. Fearing the damage was related to foundation movement, Insurers were consequently informed of a potential claim. Following receipt of instructions from Aviva Insurers, Cunningham Lindsay attended the property and the subsequent report confirmed the damage to be subsidence related.
- 3.3. Site investigations were carried out in September 2013 by CET Property Assurance from which it was concluded that the property had been affected by clay shrinkage subsidence. The site investigations confirmed that the underside of the foundations was found at 700mm below ground level and the soils at the underside were found to be a Firm, moist, mid brown mottled grey silty clay (fig 2 below)

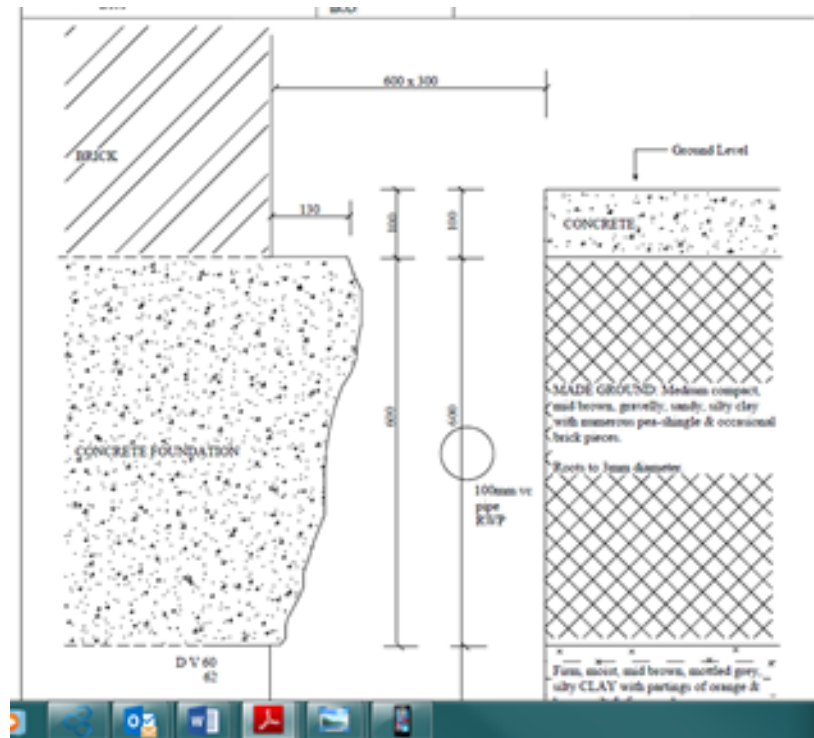


Fig 2. Foundation detail and soil description

Marshall Thompson subsequently recommended removal of the Oak tree (reference T1) at the rear of the property. Additionally, it was recommended in the same report of December 2013, that further tree management works should be undertaken to the nearby trees as a precautionary measure.

The tree roots found within the borehole sampling beneath the level of the foundation of the property were identified as *Quercus* spp (Oak). The roots were tested for identification by EPSL, and the results of the tests are contained within the CET report of September 2013.

- 3.4. Soil analysis revealed that the plasticity index of the soils to be in the range of 50%-53% which is classified as a high plasticity under the Casagrande classification. Using the Driscoll scale to identify desiccation which compares moisture content against liquid limits the ratio is 44% at the underside of the foundations and reducing to 36% at 1.5m bgl. (fig 3 below)

Laboratory Testing Results														
document for signature 155447														
Location : 10, Lads Grove, Waterlooville														
Work carried out for: Cunningham Lindsey - Solicitor														
Date Sampled: 02/10/2013														
Date Received: 05/10/2013														
Date Tested: 05/10/2013														
Date of Report: 11/10/2013														
Test No	Depth (m)	Type	Moisture Content (%) 20	Soil Plasticity - 0.425mm (%) 20	Liquid Limit (%) 20	Plastic Limit (%) 20	Plasticity Index (%) 20	Soil Class	Soil Sample Series	Soil Sample Depth (m)	Soil Sample Strength (kPa) 20	Soil Sample pH	Soil Sample Temperature (°C) 20	Class
1	0.70(1/3)	D	35	<5	78	25	53	CV	168	54	53			
	1.0	D	29	<5										
	1.5	D	27	<5	74	23	51	CV	168	241				
	2.0	D	27	<5										
	2.5	D	26	<5	74	24	50	CV	168	251				
	3.0	D	26	<5										
	3.5	D	24	<5	61	22	39	CH	168	244				
	4.0	D	21	<5										
	4.5	D	23	<5										
	5.0	D	23	<5										

Fig 3. Table showing Soils laboratory testing.

4. Description of Damage

- 4.1. The areas of damage are described in the Initial advice report prepared by Patrick Riddy of Cunningham Lindsey. Further detailed description of the damage is later highlighted in the Infront Innovation Re-Visit report by Spencer Caizley in November 2013. Since then it is clear from level monitoring and subsequent engineering revisit reports that the property has suffered seasonal downward movement during the drier summer months and subsequent recovery during the wetter winter months. This has impacted upon the structural integrity of the building.
- 4.2. It was noted that the cracks were predominantly to the rear right hand corner and were up to 5mm in width. The downward movement of the foundations have caused the rear right corner to drop and rotate away from the main property, creating a separation crack.
- 4.3. Subsidence is characterised by diagonal tapered cracks at the corners of window and door openings and corresponding internal and external damage. In my opinion, the relevant damage described in the Re-visit Report has the hallmarks of damage caused by subsidence. The location and nature of the internal cracking present in 2013 indicated that the rear right hand corner was mainly affected with other areas of the property suffering more minor damage.
- 4.4. Cracking in the kitchen mirrors the damage externally within the same area, and other minor cracking to other areas all point towards the oak as the principal source of the moisture extraction as it is the closest to this point.

5. Evidence of root encroachment

- 5.1. A site investigation was carried out in October 2013 by CET Property Assurance. This comprised one external trial pit / borehole: TH1 was located on the rear right hand corner. The foundation in TH1 was found to be a 150mm thick concrete strip footing, bearing on to a firm, mid brown mottled grey slightly silty CLAY at a depth of 700mm below ground level with a spread of 110mm from the face of the brickwork. The soil and roots from TH1 were tested by CET.

The borehole in TH1 was extended to a depth of 5m and root activity was recorded to a depth of 1.8m below ground level. Root samples retrieved on site from below foundation to a depth of 1.8m below ground level have been identified as *Quercus (Oak)*.
- 5.2. The only Oak tree near the area of damage to the property and therefore the tree whose roots are present below the foundations within TH1 is that denoted on the Marshall Thompson site plan above.

6. Soil Conditions

- 6.1. The soil excavated from the trial pit by the CET site investigation is described as a Firm mid brown mottled grey silty CLAY with partings of orange and brown silt and fine sand.
- 6.2. The plasticity indices were reasonably consistent with depth, such readings would place the soil at this site in the *"high shrinkage potential"* category in accordance with NHBC classification of clay soils.
- 6.3. It is universally accepted that moisture contents generally decrease with depth due to the effects of overburden pressure (the weight of soil above squashes the clay below and thus reduces its moisture content). It is expected that a soil with equilibrium moisture content will have a linear reduction in moisture content with depth. Borehole 1 shows that the moisture content reducing from 35% at the underside to 27% at 1.5m bgl.
- 6.4. Atterberg Limits Testing allows interpretation of results in the terms of Driscoll's assessment of desiccation (soil dryness). This compares the soil's actual moisture content with its liquid and plastic limits. It is acknowledged that Driscoll's theory is unreliable in isolation and is only applicable to London Clay so appears relevant in this case. It is suggested that if the moisture content exceeded 50% of its liquid limit there was no desiccation. At 50% the onset of desiccation occurred and below 40% the soil sample had attained significant desiccation. The results throughout the depth of the borehole indicate the samples to be desiccated.
- 6.5. Oedometer tests were carried out on the sample obtained. The results obtained estimates a free surface heave potential 73mm. The swell predicted is that expected of the ground if it were allowed to fully re-hydrate and come to equilibrium. No allowance has been made for the weight of the building and its anticipated damping effect on that result. In the context of level monitoring results, this also confirms the result to be reasonably accurate. (fig 4 below).

Depth (mtrs)	Recorded Strain	Layer Thickness (mm)	Layer Heave (mm)
0.25			
0.40	0.0374	150.00	2.73
0.90	0.0312	500.00	7.55
1.40	0.0417	500.00	10.175
1.90	0.0442	500.00	10.8
2.40	0.0451	500.00	11.025
2.90	0.0442	500.00	10.8
3.40	0.0417	500.00	10.175
3.90	0.0418	500.00	10.2

Predicted Total Free Surface Heave Over Depth of Borehole

73

Fig4. Oedometer Test results

- 6.6. The heave potential calculations indicating 73mm of upward movement at the front based on the soils analysis carried out in September 2013 is a strong indicator that the risk of long term heave as a result of tree removal is low.

7. Drains

- 7.1. The property appears to have separate foul and surface water drainage. The drainage system was noted to be remote from the area of damage and is not thought to be relevant to the current problems. It is noted that there is a rain water down pipe on the rear corner although there is no visible evidence of damage and the soil characteristics are not typical of a soil that has been affected by leaking drains.

8. Monitoring

- 8.1. Level monitoring involved fixing pins around the perimeter of the building from which levels were taken to determine where the external walls and hence by implication the foundations are moving and by how much.
- 8.2. Level monitoring was set up in November 2013 and readings have been taken at approximately 8 week intervals. The monitoring locations which are presented in *Figure 5* below, show that the property is affected by seasonal downward movement to the rear right corner with the maximum degree of seasonal downward movement occurring between points 4 and 6 on the rear right corner. The left hand elevation shows minimal movement which would be anticipated in a property founded upon clay and unaffected by subsidence and the rear right hand corner which is closest to the oak tree which is consistent with anticipated trends in clay shrinkage cases. The monitoring shows the affected parts of the property moving down during the summer months when the tree is in leaf, demanding larger amounts of water and rainfall is lower and the net moisture content within the clay soil below the property decreases. Recovery or upward movement is then witnessed during the winter months when the tree loses leaf, demands less moisture and the rainfall events increase, allowing the soil to rehydrate to some degree and swell, causing upward movement and consequential closing of cracks within the property.
- 8.3. The level monitoring program to date clearly indicates downward movement through June to October 2014 with recovery becoming evident with the onset of the wetter winter months. This demonstrates that the identified offending trees are the cause.
- 8.4. While climate alone can cause some small changes in the surface soil (to a depth of 500 mm or so), the foundations of the house, being some 700mm below ground level are beyond this zone and seasonal movements of the scale shown in *Figure 5* are indicative of root-induced shrinkage associated with a large tree.
- 8.5. In this instance, the only significant vegetation within influencing distance of the rear right corner of the property is the large Oak tree.

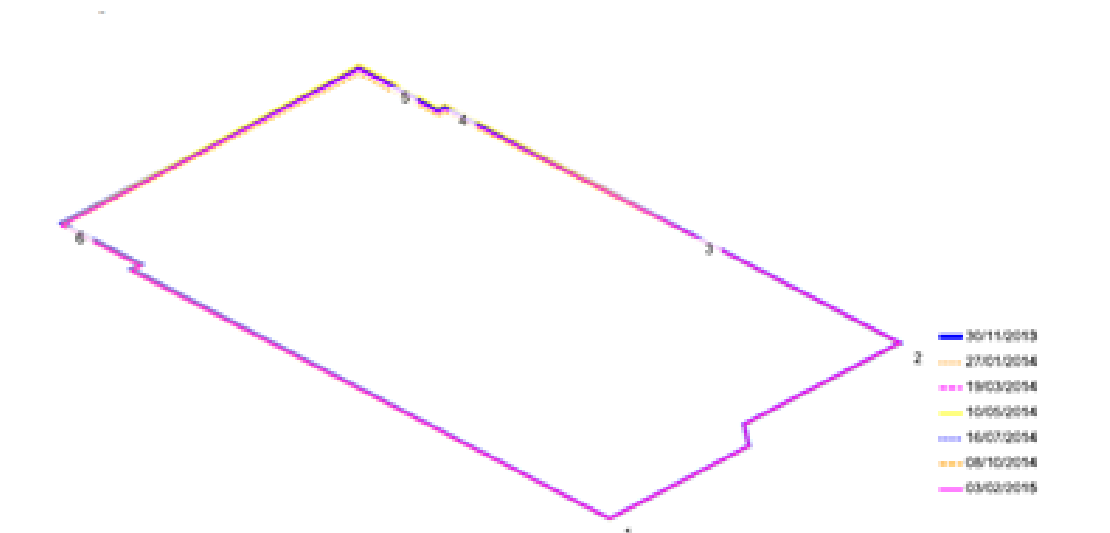


Figure 5 – Monitoring location positions

Cause of Damage

8.6. In my opinion, the evidence points conclusively towards the damage reported in 2013 having been caused by root-induced shrinkage in the subsoil. Specifically, we have:

- Damage characteristic of subsidence
- The damage is focussed on the front right hand corner (when viewed from the front)
- Evidence of root activity to 1.8m below ground level
- Presence of a clay subsoil with a high shrinkage potential
- Level monitoring showing seasonal movement (upward in winter, downward in summer).
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8.7 Given its proximity and the presence of *Quercus* roots in the subsoil, the Oak tree is the only plausible explanation for the seasonal movements recorded at the rear right of the property.

8.8 There is no reason to suspect that drainage defects have contributed materially to the damage under consideration and there are no other credible explanations for the evident foundation movement at the rear.

8.9 The monitoring results clearly indicate a scale of seasonal foundation movement at the front right of the property and this has now been confirmed by the subsequent monitoring results.

Where a tree is causing movement to an entire elevation (in this case the front and right hand elevations) it is common for the effects to be transmitted throughout the superstructure and for cracks to appear at weak points, such as the junctions of walls and ceilings or the ends of lintels. In my opinion, the seasonal movement associated with the Oak and Lime are the only plausible explanation for the movement at the front of the property.

8 Remedial options

- 8.7 Although the damage is relatively minor in structural terms, it will be expensive to rectify because of the size of the rooms and the extensive decorations that will be required.
- 8.8 Even if there were some doubt as to the extent of the damage that can be reasonably attributed to the influence of the Oak, the current recorded seasonal foundation movements are unacceptable. If the influence of the implicated trees are not eliminated, an engineering solution will be needed to stabilise the property.
- 8.9 A range of underpinning solutions is available depending on the area that requires stabilisation and the depth required. Traditional, mass concrete, underpinning is generally the most economical solution where the required depth is relatively shallow. It has the added advantage that the underpinning also acts as a root barrier. However, it tends to become uneconomical, and the Health & Safety considerations become increasingly onerous, where the required depth exceeds 2.5 m. Most underpinning is extended to a metre below the last discovered root and this is 2.8 m making this an unacceptable risk from a health and safety perspective and should be discounted.
- 8.10 Pile-based underpinning solutions tend to be more economical where (i) the required depth exceeds 2.5 m and (ii) it is necessary to stabilise internal walls as well as external walls. A common variant is the piled-raft which consists of a reinforced concrete slab under the entire footprint of the property supported on driven or bored piles.
- 8.11 It is very difficult to partially underpin a property with a piled raft as the transition between stabilised and un-stabilised parts of the property is very vulnerable to cracking as a consequence of the minor seasonal fluctuations which might be expected in the traditionally founded part relative to the very stable piled section.
- 8.12 In this instance, I would have some reservations about the use of traditional underpinning because of the depth of the root activity indicated in the CET report. In addition, the potential benefits of the barrier provided by the traditional underpinning are likely to be outweighed by the advantages that a piled raft offers in providing a long term solution particularly if all of the property was stabilised although there is no technical justification beyond the avoidance of differential movement.
- 8.13 I have considered whether the implicated trees could be controlled by regular pruning. However, recent research indicates that even heavy canopy reduction is likely to be effective for no more than one growing season. Annual management, in any case, would destroy most of the amenity value of the tree which appears to be the only impediment to its removal. It would also leave the property susceptible to damage in an exceptional summer such as 2003 when even recently pruned trees can cause significant soil shrinkage.

9 Summary of Conclusions

- 9.7 The nature and distribution of the cracking first reported in 2013 is indicative of subsidence with the focal point of the movement at the rear right hand corner.
- 9.8 Root samples recovered from below foundation level and identified as *Quercus* indicate that roots from the Oak have encroached into the soil underlying 10 Lynda Grove, Waterloooville.
- 9.9 There was no evidence to suggest that water escaping into the soil from defective drainage or other sources caused any significant movement to the foundations or otherwise contributed materially to the reported damage.
- 9.10 The level monitoring confirmed that the foundations were moving seasonally and with greater movement at the front elevation.
- 9.11 The submitted evidence therefore points conclusively towards the Oak tree being the substantial and effective cause of the damage that appeared in 2013. It also indicated the scale of the movement associated with the tree to be unacceptable.
- 9.12 If the implicated tree is not removed, it will be necessary to underpin the property to prevent a recurrence of the damage. The most cost effective scheme is likely to be a piled raft scheme which is anticipated to cost in the region of £70,000.
- 9.13 The cost of superstructure repairs in the region of £4000.00 but exclusive of professional fees is considered reasonable.