Appendix B. Ground Movement Assessment

REPORT CONTROL SHEET

115-119 Goldhurst Terrace, London NW6

Damage Category Assessment

Project number P4134

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1.0 Introduction

In connection with the proposal to construct a single-storey basement beneath Nos 115-119 Goldhurst Terrace, London NW6, Applied Geotechnical Engineering Ltd (AGE) has been instructed by Site Analytical Services Ltd (SAS), on behalf of their client, to carry out a damage category assessment on the neighbouring properties. These properties are Nos 113 and 121 Goldhurst Terrace, and a property to the rear, the address of which is unknown (referred to as the 'Rear Building' in this report). No 113 lies to the left of the site and No 121 lies to the right.

Right, left and rear are as viewed from the front of the property on Goldhurst Terrace, unless noted otherwise below.

The relative positions of these buildings are shown in Figure 1. A plan of the proposed basement of the property is given below in Figure 2.

The structural engineer for the project is ElliotWood (EW).

The exterior ground level in the general area of the site is believed to be approximately 39mOD.

It is understood that basement construction will be carried out within a combination of a bored pile wall (rear wall) and underpin walls (elsewhere) at an excavation level approximately 4m depth below ground level (34.95mOD). It is understood that the piles have not yet been designed in detail, therefore for the purposes of this analysis only, a total pile depth of 1.4 x adjacent dig depth has been adopted.

It is understood that none of the immediately adjacent properties are known to have lower ground floors or basements, but No 121 may have a small coal cellar. For the purposes of this assessment it has been assumed that no below-ground structures are present, this is potentially conservative.

It is required that a predicted damage category assessment be made on the above neighbouring properties.

2.0 Information Provided

The following relevant information has been provided for use in this assessment:-

i) SAS Borehole, Window Sampler and trial pit logs dated 14-16/3/2016.
ii) EW Drawing 2150657/SK01P2, annotations to Interlock Surveys topo drawing 150683, and sketches ref 2150657-01 and 02, giving proposed, existing, and construction loads.
iii) EW Sketches 2150657 SK/08P1, 09P1 and 11P1.
iv) KSR Architects Drawings 15033/P090(revised 10/6/16), P100, P210, P210, P212, P213, P310, P311
v) Interlock Surveys topographical survey drawings 150683 and 150683ELE.
v) Email correspondence SAS-AGE dated 1/4/16 to 21/6/16.

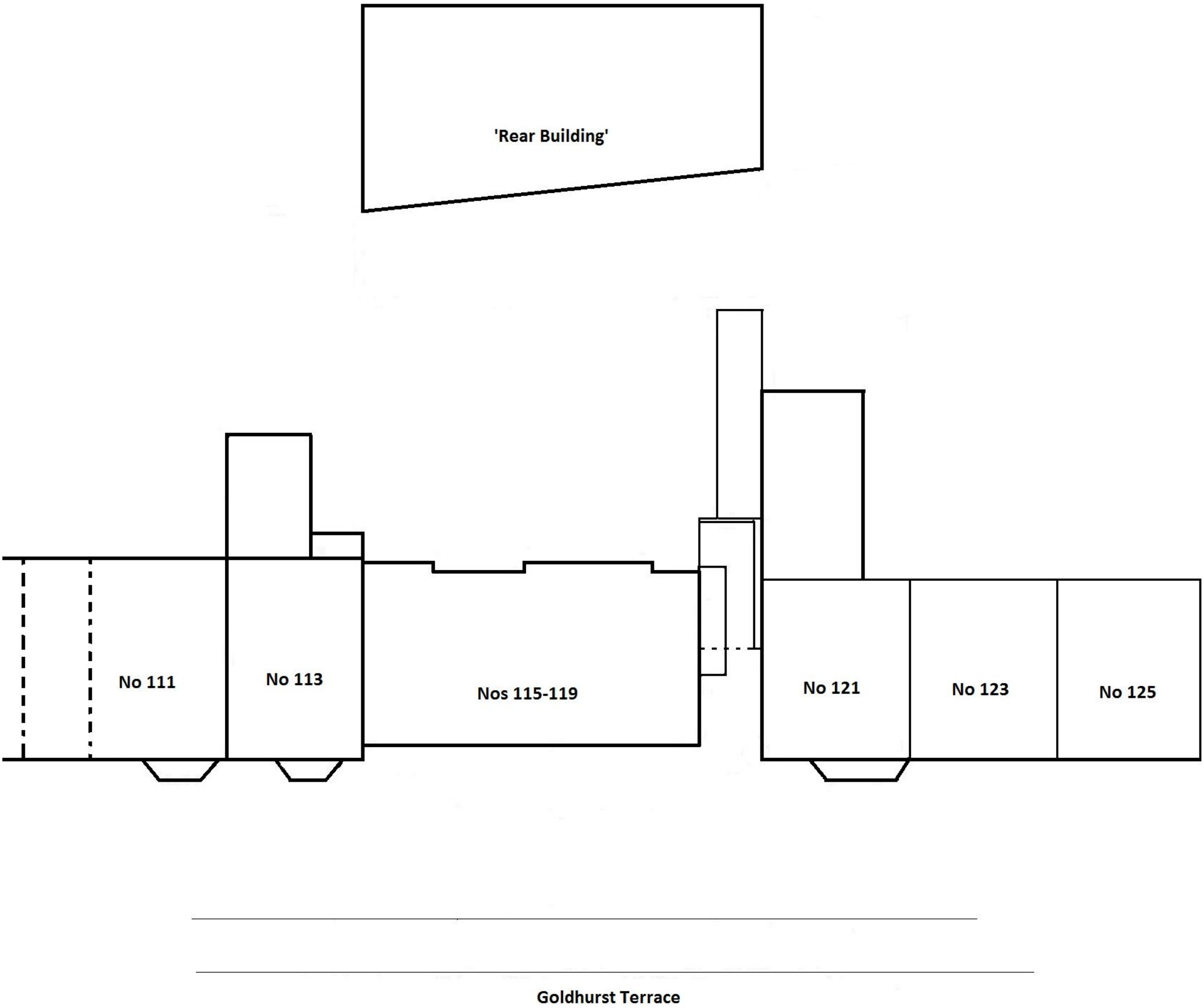


Figure 1 – Site Context

Figure 2 –Proposed Basement Plan
(Extract of KSR Drawing 15033/090)

3.0 Anticipated Ground Conditions

The external ground level in the area of the proposed basement is understood to be approximately 39mOD.

The published geological map (BGS 1:50 000 sheet 256: North London) indicates the site to lie on the London Clay. On a developed site such as this Made Ground is also anticipated.

On the basis of the published mapping, the base of the London Clay is anticipated to lie at approximately -22mOD (approx 61m bgl).

A ground investigation was undertaken at the site in March 2016 (Item 'i' in Section 2 above). This comprised a borehole (BH1) sunk to 20m depth within the front garden, and two Window Sampler boreholes (WS1 and WS2) both sunk to 5m depth in the rear garden. Additionally, ten trial pits (TP2-TP11) were excavated within the site.

Based on the available information the commencement level of the borehole is taken to be approximately 38.8mOD, while the commencement levels of the two window sampler borings are both taken to be 39.2mOD.

The borings confirmed Made Ground, generally consisting of clayey sand or sandy clay with brick and concrete rubble, to between 1.1 and 1.2m depth (taken as 38mOD). A similar Made Ground deposit was found in all the trial pits.

Beneath the Made Ground the borings revealed stiff, becoming very stiff, London Clay to the end of the boreholes.

Trial pit TP2 was dug adjacent to the front wall of Nos 115-119, and revealed concrete foundations to a depth in excess of 1.5m (the maximum pit depth). Trial Pit TP8 was excavated adjacent to the foundations of the left flank wall of No 121, the bottom of these foundations were not found within the dig depth of 1.5m.

For the purposes of this report only, the foundations of Nos 113 to 121 Goldhurst Terrace are taken to lie at approximately 37.5mOD. The foundations of the Rear Building are taken to lie at 38.0mOD. Small variations from these assumptions have no significant effect on the outcome of the analysis.

Groundwater was not encountered during excavation of the trial pits or the borings. Standpipes were installed in BH1 and WS1+2, with response zones from approximately 1 to 5m depth in all of the borings. Subsequent monitoring approximately 4 weeks after installation showed BH1 to be dry, and water levels of 1.09m and 1.34mbgl in WS1+2 respectively. It is suspected that minor perched water bodies may exist locally at the base of the Made Ground, but in general the ground investigation indicates that significant flows of groundwater would not be expected within proposed basement excavation depth.

For the purposes of the analysis, the soil sequence in the area of the proposed basement is taken to be:-

Ground Level 39mOD
Base of Made Ground 38mOD
Base of London Clay -22mOD).

Standard Penetration Tests (SPT) were undertaken in BH1. The results of these tests (the SPT'N' value) can be correlated with the bulk undrained strength of the London Clay (Su) using the method of Stroud (Ref 1). Based on previous experience a correlation factor, f_1, of 4.4 has been adopted and the resulting undrained strength values are plotted in Figure 3.

The trend line fitted to the data in Figure 3 (solid line) has the equation:-

Su = 50 +10z (kPa)

Where z is the depth below the top of the London Clay.

This rate of strength increase is slightly higher than that typically seen in the London Clay. In order to ensure a conservative analysis a lower strength profile has been adopted, described by:-

Su = 45 + 7z_1 (kPa) to 18mOD (20m below top of clay), then

Su = 185 + 3.5z_2 (kPa) to –22mOD (base of clay).

Where z_1 is the depth in metres below the top of the London Clay (taken to be 38mOD), and z_2 is the depth in metres below 18mOD.

The use of this bilinear profile reduces any tendency for prediction of excessive strength (and stiffness) at depth.

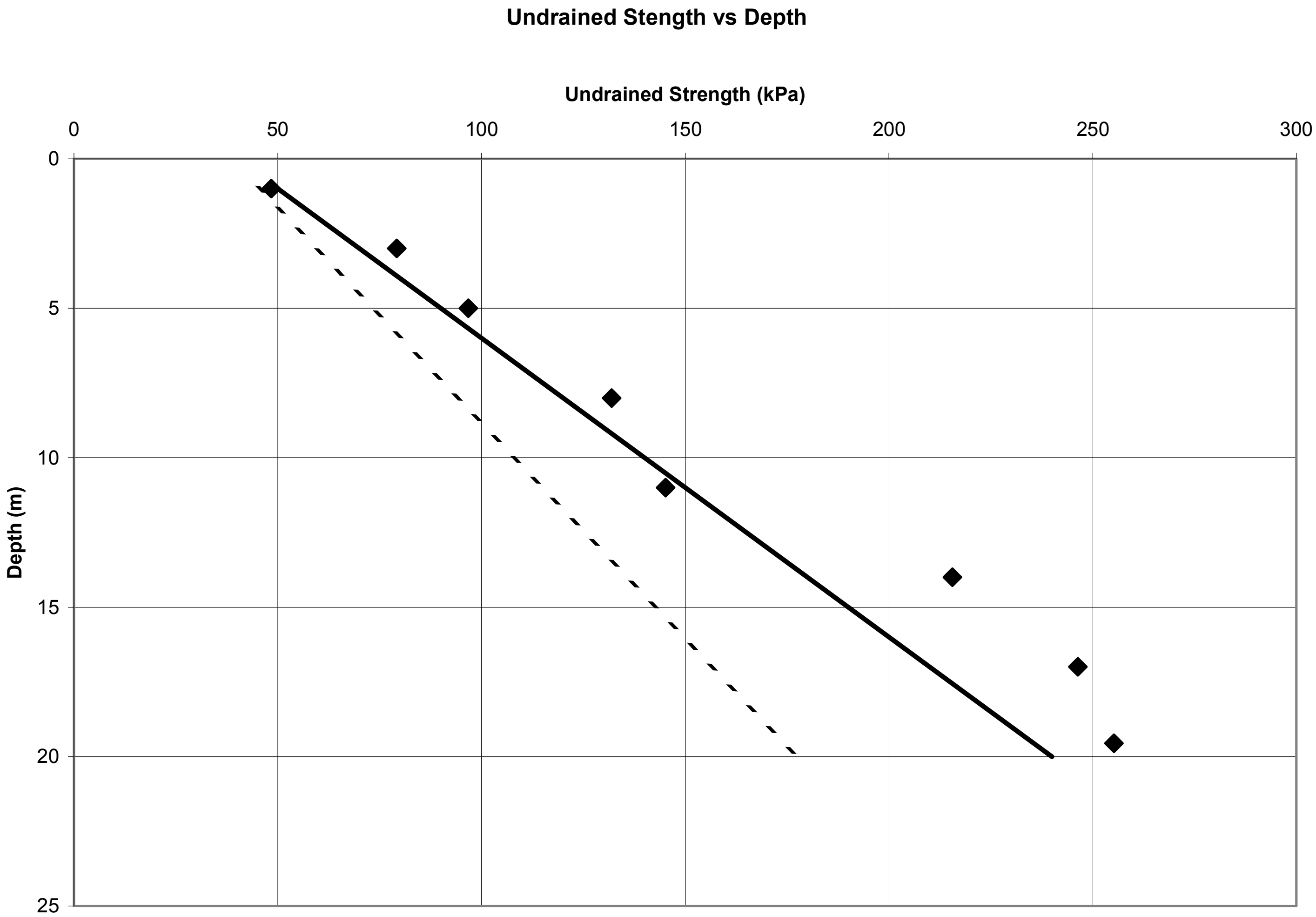


Figure 3 –Undrained strength vs depth (London Clay)

4.0 Loads

The existing and proposed basement loads have been provided by the engineer (Item ‘ii’ in Section 2 above). It is noted that substantial local loads are to be imposed along the lines of the party walls with Nos 113 and 121 Goldhurst Terrace. It is important that the structure be capable of distributing these loads along the planes of the party walls in order to minimise local distortions.

Excavation from existing ground level, to the new basement formation level, will yield a significant load reduction; a bulk unit weight of 20kN/m^3 has been adopted for the calculation of this unload.

5.0 Estimated movement

5.1 Temporary support to the basement walls.

It is assumed within the following calculations that the basement perimeter retaining walls will be stiffly and safely propped at all stages of construction in line with BS5975:2008 and current good practice. Inadequate propping is likely to result in increased ground movements, and therefore increased damage to adjacent properties, as well as increased risk of injury to personnel.

It is generally recommended that consideration be given to the preloading of temporary basement wall props, and to the monitoring of prop loads during critical stages of excavation.

5.2 Soil stiffness values

An equivalent-elastic analysis has been carried out using the program PDisp. The program takes no account of structural (building) stiffness.

The soil stiffness parameters are as given below.

The Made Ground lies above founding level and excavation level, and therefore will not influence the analysis.

The London Clay has been treated as a non-linear material. The small-strain stiffness is taken as 80% of the small-strain stiffness calculated from recent high quality data (Bond Street Station). These data yielded E_{uo} = 1940Su, therefore for the purposes of the current analysis take:-

$E_{uo} = 1550 \times Su$; (Poisson's ratio = 0.5)
$E'_{o} = 1240 \times Su$; (Poisson's ratio = 0.2)

Yielding :-

$E_{uo} = 69.8 + 10.85z_1$ (MPa) to 18mOD (20m below top of clay), then
$E_{uo} = 286 + 5.4z_2$ (MPa) to -22mOD (base of clay).

and:-

$E'_{o} = 55.8 + 8.7z_1$ (MPa) to 18mOD (20m below top of clay), then
$E'_{o} = 230 + 4.3z_2$ (MPa) to –22mOD (base of clay).

Where z_1 is the depth in metres below the top of the London Clay (taken to be 38mOD), and z_2 is the depth in metres below 18mOD.

A non-linear degradation curve relating stiffness to strain, based on published data for the London Clay, has been used.

5.3 Causes of ground movement outside the excavation

The analysis considers three causes of ground movement outside the excavation, these are:-
i) Vertical ground movement due to vertical changes in load resulting from building works and excavation
ii) Vertical and horizontal movement due to installation of underpin or pile walls.
iii) Vertical and horizontal movement due to deflection of underpin or pile walls, following removal of support from in front of the wall by excavation.

The first of these causes is investigated using equivalent-elastic analysis in the program PDISP. The second and third are based upon case-history data presented in Figures 2.8, 2.9 and 2.11 in CIRIA C580 (Ref 3). These data relate to installation in stiff clays. It is currently understood that the plots presented by CIRIA in the above figures include short-term movement arising from cause 'i' above. Therefore in this report short-term movements are calculated using the CIRIA data, and subsequent long-term movement is calculated using PDISP.

The CIRIA plots relate vertical and horizontal ground movement to the depth of the wall installed (for Cause 'ii' above), or to the depth of excavation within that wall (for Cause 'iii' above) as appropriate. Data relating to the secant bored pile wall case history in Ref 3 Figure 2.8 are considered to be unreliable and have been ignored. In addition, data relating to counterfort diaphragm walls have not been taken into account in this analysis. No data are presented by CIRIA for underpinned walls, and no other data are available from other sources for underpin walls. Underpin walls are therefore, of necessity, assumed to be similar in behaviour to plane diaphragm walls and bored pile walls.

The CIRIA data indicate that:-

a) Adjacent to the underpin or bored-pile wall, vertical ground settlement resulting from wall installation can be taken to equal 0.04% of wall depth, reducing linearly to zero at a distance of 2 x wall depth from the wall (Ref 3, Figures 2.8b and 2.9b).

b) Adjacent to the underpin or bored-pile wall, vertical ground settlement resulting from wall deflection can be taken to equal 0.04% of excavation depth, increasing to 0.08% of excavation depth at a distance of 0.6 x excavation depth from the wall, then reducing approximately linearly to zero at a distance of 3 x excavation depth from the wall. (Ref 3, Figure 2.11b).

c) Adjacent to the underpin or bored-pile wall, horizontal ground movement resulting from wall installation can be taken to equal 0.04% of wall depth, reducing linearly to zero at a distance of 1.5 x wall depth from the wall (Ref 3, Figures 2.8a and 2.9a).

d) Adjacent to the underpin or bored-pile wall, horizontal ground movement resulting from wall deflection can be taken to equal 0.15% of excavation depth, reducing linearly to zero at a distance of 4 x dig depth from the wall. (Ref 3, Figure 2.11a).

The above trends rely on good workmanship and stiffly-propped, stiff walls. Temporary support of excavations should be designed to BS5975 and BS8002 and current good practice.

It will be noted that the horizontal ground movements described in 'c' and 'd' above will tend to yield consistent average ground strains; these are (0.04%/1.5 =) 0.0267% average horizontal ground strain resulting from wall installation, and (0.15%/4 =) 0.0375% average horizontal ground strain resulting from yielding of the wall due to basement excavation within. There is therefore a consistent prediction, following wall installation and basement excavation, of a total of 0.064% average total horizontal ground strain within a distance of 1.5 x wall depth from the excavation, reducing, at greater distance, to 0.0375% horizontal ground strain, out to a distance of 4 x excavation depth from the excavation. These results are used in the following sections.

CIRIA C580 is used to predict the ground movement under plane-strain conditions. Near the corners of the excavation plane-strain conditions are unlikely to develop and the buttressing effect around these corners has been taken into account in calculating the predicted (reduced) vertical ground movements, using the method of Fuentes and Devriendt (Ref 4). This method has not been sufficiently verified for the case of horizontal ground movements, and therefore is not taken into account rigorously in the analysis, however the tendency for horizontal ground movement to be reduced at excavation corners is noted where appropriate.
Note that, in all the plots of vertical movement, settlement is taken as positive and heave as negative. The CIRIA data are understood to relate to movement at, or close to, ground level.

The analysis assumes that excavation is carried out reasonably uniformly across the footprint of the basement. If this is not the case, and there are temporary substantial variations in the excavation depth, then more severe short-term wall distortions may arise than are predicted here.

5.4 Predicted movement – Nos 111+113 Goldhurst Terrace, front wall

5.4.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the front wall of Nos 111 and 113 Goldhurst Terrace have been calculated and plotted in Figure 5.

The wall is taken to be approximately 11.9m long (before a break in the wall at ground floor level) and approximately 9m high, above ground level. It lies in the position shown on the plan in Figure 5.

The analysis indicates a maximum overall tilt of approximately 3.2mm over the length of the wall. This equates to a whole-wall gradient of less than 1 in 3700. This is less than the 1:400 gradient recognised as requiring remedial action.

The maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is 1.25mm over the length of the wall. The limit on tensile strain for 'very slight' damage is 0.075% (Ref 2) therefore the ratio of deflection ratio to limiting tensile strain is 0.14. By reference to Figure 4 (Ref 2 Figure 6) a horizontal strain/limiting tensile strain ratio of 0.87 is obtained, indicating that a horizontal strain of 0.065% is acceptable for a 'very slight' category of damage. This analysis does not take account of the stiffness of the wall; the result is conservative in this respect.

5.4.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the proposed excavation at Nos115-119 is predicted to be 0.064%. This is less than the 0.065% limit for very slight damage calculated above, and is likely to be an overestimate of horizontal ground strain, as the wall abuts the excavation close to a corner, where lesser strains would be anticipated.

The predicted level of damage to this wall can therefore be taken as 'very slight'.

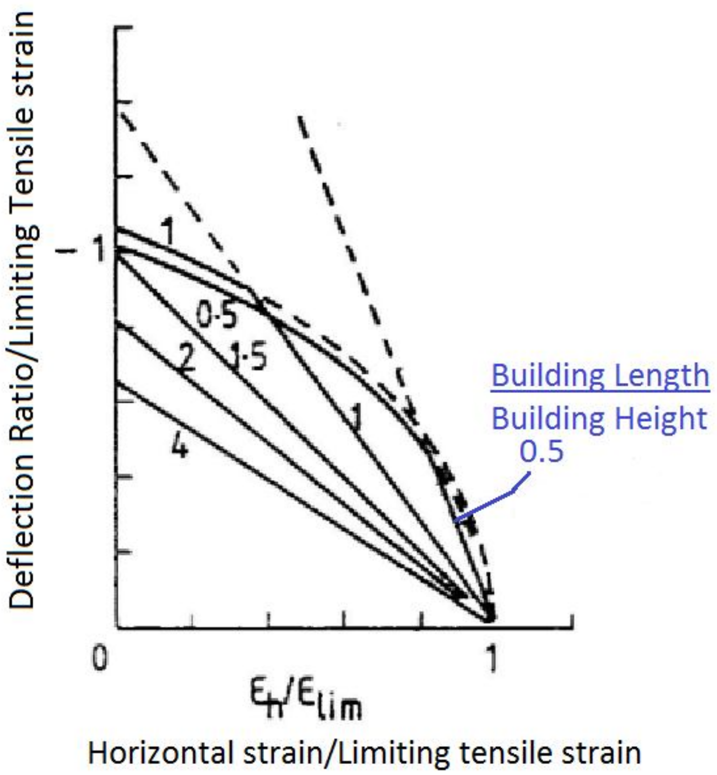


Figure 4 (from Ref 2)

5.5 Predicted movement – Nos 111+113 Goldhurst Terrace, rear wall.

5.5.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the rear wall of Nos 111 and 113 Goldhurst Terrace have been calculated and plotted in Figure 6.

The wall is taken to be approximately 11.9m long and 9m high above ground level. It lies in the position shown on the plan in Figure 6.

The analysis indicates a maximum overall tilt of 3.8mm along the length of the wall. This equates to a whole-wall gradient of less than 1 in 3100. This is less than the 1:400 gradient recognised as requiring remedial action.

The maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is) 1.65mm within the length of the wall. The limit on tensile strain for 'very slight' damage is 0.075% (Ref 2), therefore the ratio of deflection ratio to limiting tensile strain is 0.185. By reference to Figure 4 (Ref 2 Figure 6) a horizontal strain/limiting tensile strain ratio of 0.83 is obtained, indicating that a horizontal strain of 0.062% is acceptable for a 'very slight' category of damage. The analysis does not take into account the stiffness of the wall and is conservative in this respect.

5.5.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the proposed excavation at Nos 115-119 is predicted to be 0.064%. This is greater than the 0.062% limit for very slight damage calculated above, indicating that damage may lie at the lower end of the 'slight' category, which in this case extends from 0.062% to 0.137%.

However the maximum average horizontal strain is predicted only to extend 6.1m from the excavation, and beyond this distance the average horizontal strain reduces to 0.0375%. Furthermore, the analysis does not take into account the horizontal stiffness of the wall, or the fact that the predicted mode of distortion is sagging, which is less damaging than the hogging mode considered by Burland in his analysis. It is therefore considered that the predicted level of damage to this wall can be taken to lie close to the 'very slight'/'slight' boundary. Particular care in the propping of the excavation will be required at this location.

5.6 Predicted movement – Nos 113 and 115 Goldhurst Terrace, party wall.

5.6.1 Vertical movement

Profiles of short- and long-term vertical ground movement along the party wall shared by Nos 113 and 115 Goldhurst Terrace have been calculated and plotted in Figure 7.

This wall is taken to be approximately 10m long and approximately 13m high after underpinning. It lies in the position shown on the plan in Figure 7.

This wall is to be underpinned. The vertical movement of underpinned walls is not defined by the CIRIA C580 data, which apply outside the excavation. Instead the short-term settlement of this section of party wall, above ground, will be controlled by movements occurring during the underpin construction process. However, such movements depend on the condition of the existing wall, the precise underpinning technique and the quality of workmanship and so cannot reliably be predicted. Experience shows that, in most cases, such movements are minimal and may go unnoticed. However, in adverse circumstances, some millimetres of movement could be realised from this cause.

For the purposes of this report the short-term wall settlement due to underpinning has arbitrarily been assumed to be 5mm, and uniform. It is considered unlikely that this value will be exceeded, assuming good workmanship. The magnitudes of tilt and distortion of this wall will be significantly influenced by the settlement occurring during underpinning.

On the above basis the analysis indicates a negligible overall tilt along the length of this wall.

On the above basis the maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is negligible, therefore a horizontal strain of 0.075% is acceptable for a 'very slight' category of damage.

5.6.2 Lateral movement.

Due to the position of this wall in relation to the proposed works the predicted horizontal ground strain along the plane of the party wall is predicted to be negligible. On the above basis the predicted level of damage to this wall can therefore be taken as 'very slight' or less.

5.7 Predicted movement – No 113 Goldhurst Terrace, rear extension rear wall.

5.7.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the rear wall of the rear extension to No 113 Goldhurst Terrace have been calculated and plotted in Figure 8.

This wall is taken to be approximately 3.7m long and a minimum of approximately 3m high, above ground level. It lies in the position shown on the plan in Figure 8.

The analysis indicates a maximum overall tilt of approximately 2mm along the length of this wall. This equates to a whole-wall gradient of less than 1 in 1800. This is less than the 1:400 gradient recognised as requiring remedial action.

The maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is negligible, indicating that a horizontal strain of 0.075% is acceptable for a 'very slight' category of damage.

5.7.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the proposed excavation at Nos 115-119 is predicted to be 0.064%. This is less than the 0.075% limit for very slight damage calculated above.

The predicted level of damage to this wall can therefore be taken as 'very slight' or less.

5.8 Predicted movement – Nos 121 to 125 Goldhurst Terrace, front wall.

5.8.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the front wall of Nos 121 to 125 Goldhurst Terrace have been calculated and plotted in Figure 9.

This wall is taken to be approximately 18.8m long and approximately 9m high, above ground level. It lies in the position shown on the plan in Figure 9.

The analysis indicates a maximum overall tilt of approximately 3.9mm along the length of this wall. This equates to a whole-wall gradient of less than 1 in 4800. This is less than the 1:400 gradient recognised as requiring remedial action.

Two modes of distortion are evident from Figure 9; sagging close to the excavation, and hogging over a greater part of the wall. Hogging is usually the more damaging mode, but from Section 5.3 above it is noted that the maximum average horizontal strain only occurs within approximately 1.5 x wall depth of the excavation, in this case this is approximately 6.1m (to X= 23.3m in Figure 9). Therefore the local sagging is considered to be more critical.

This predicted sagging wall distortion (Delta – as defined by Burland, Ref 2) is 1.2mm within an 11.5m length of the wall. The limit on tensile strain for 'very slight' damage is 0.075% (Ref 2), therefore the ratio of deflection ratio to limiting tensile strain is 0.14. By reference to Figure 4 (Ref 2 Figure 6) a horizontal strain/limiting tensile strain ratio of 0.87 is obtained, indicating that a horizontal strain of 0.066% is acceptable for a 'very slight' category of damage.

This result does not take into account the vertical stiffness of the wall, and is conservative in this respect.

5.8.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the proposed excavation at Nos 115-119 is predicted to be 0.064%. This is less than the 0.066% limit for very slight damage calculated above, and is likely to be an overestimate of horizontal ground strain, as the wall abuts the excavation close to a corner, where lesser strains would be anticipated.

The predicted level of damage to this wall can therefore be taken as 'very slight'.

5.9 Predicted movement – Nos 121 to 125 Goldhurst Terrace, rear wall.

5.9.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the rear wall of Nos 121 to 125 Goldhurst Terrace have been calculated and plotted in Figure 10.

This wall is taken to be approximately 18.8m long and approximately 9m high, above ground level. It lies in the position shown on the plan in Figure 10.

The analysis indicates a maximum overall tilt of approximately 4.9mm along the length of this wall. This equates to a whole-wall gradient of less than 1 in 3800. This is less than the 1:400 gradient recognised as requiring remedial action.

Two modes of distortion are evident from Figure 10; sagging close to the excavation, and hogging over a greater part of the wall. Hogging is usually the more damaging mode, but from Section 5.3 above it is noted that maximum average horizontal strain only occurs within approximately 1.5 x wall depth of the excavation, in this case this is approximately 6.1m (to X= 23.3m in Figure 9). Therefore the local sagging is considered to be more critical.

This predicted sagging wall distortion (Delta – as defined by Burland, Ref 2) is 1.6mm within a 10.4m length of the wall. The limit on tensile strain for 'very slight' damage is 0.075% (Ref 2), therefore the ratio of deflection ratio to limiting tensile strain is 0.20. By reference to Figure 4 (Ref 2 Figure 6) a horizontal strain/limiting tensile strain ratio of 0.83 is obtained, indicating that a horizontal strain of 0.062% is acceptable for a 'very slight' category of damage.

This result does not take into account the vertical stiffness of the wall, and is conservative in this respect.

5.9.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the proposed excavation at Nos 115-119 is predicted to be 0.064%. This is greater than the 0.062% limit for very slight damage calculated above, indicating that damage may lie at the lower end of the 'slight' category, which in this case extends from 0.062% to 0.137%.

However the maximum average horizontal strain is predicted only to extend 6.1m from the excavation, and beyond this distance the average horizontal strain reduces to 0.0375%. Furthermore, the analysis does not take into account the horizontal stiffness of the wall, or the fact that the predicted mode of distortion is sagging, which is less damaging than the hogging mode considered by Burland in his analysis. It is therefore considered that the predicted level of damage to this wall can be taken to lie close to the 'very slight'/'slight' boundary. Particular care in the propping of the excavation will be required at this location.

5.10 Predicted movement – Nos 119 and 121 Goldhurst Terrace, party wall.

The left flank wall of No 121 Goldhurst Terrace is to be underpinned under the proposals, and will form a party wall between the two buildings in the future.

5.10.1 Vertical movement

Profiles of short- and long-term vertical ground movement along the party wall shared by Nos 119 and 121 have been calculated and plotted in Figure 11.

This wall is taken to be approximately 16.2m long. Its height is understood to be variable along its length, and has been taken here to be approximately 9m high after underpinning. It lies in the position shown on the plan in Figure 11.

This wall is to be underpinned. The vertical movement of underpinned walls is not defined by the CIRIA C580 data, which apply outside the excavation. Instead the short-term settlement of this section of party wall, above ground, will be controlled by movements occurring during the underpin construction process. However, such movements depend on the condition of the existing wall, the precise underpinning technique and the quality of workmanship and so cannot reliably be predicted. Experience shows that, in most cases, such movements are minimal and may go unnoticed. However, in adverse circumstances, some millimetres of movement could be realised from this cause.

For the purposes of this report the short-term wall settlement due to underpinning has arbitrarily been assumed to be 5mm, and uniform. It is considered unlikely that this value will be exceeded, assuming good workmanship. The magnitudes of tilt and distortion of this wall are significantly influenced by the settlement occurring during underpinning.

On the above basis the analysis indicates an overall tilt of approximately 1mm along the length of this wall, this is negligible.

On the basis of the above, the maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is 2mm within an 11.1m length of the wall. The limit on tensile strain for 'very slight' damage is 0.075% (Ref 2), therefore the ratio of deflection ratio to limiting tensile strain is 0.24. By reference to Figure 4 (Ref 2 Figure 6) a horizontal strain/limiting tensile strain ratio of 0.79 is obtained, indicating that a horizontal strain of 0.059% is acceptable for a 'very slight' category of damage.

This result does not take into account the vertical stiffness of the wall, and is conservative in this respect.

5.10.2 Lateral movement.

Due to the position of this wall in relation to the proposed works the predicted horizontal ground strain along the plane of the party wall is predicted to be negligible. On the above basis the predicted level of damage to the flank wall can therefore be taken as 'very slight'.

5.11 Predicted movement – No 121 Goldhurst Terrace, rear extension rear wall.

5.11.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the rear wall of the rear extension to No 121 Goldhurst Terrace have been calculated and plotted in Figure 12.

This wall is taken to be approximately 4.3m long and is understood to be approximately 6m high, above ground level. It lies in the position shown on the plan in Figure 12.

The analysis indicates a maximum overall tilt of approximately 2.5mm along the length of this wall. This equates to a whole-wall gradient of less than 1 in 1700. This is less than the 1:400 gradient recognised as requiring remedial action.

The maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is 0.9mm within the length of the wall. The limit on tensile strain for 'very slight' damage is 0.075% (Ref 2), therefore the ratio of deflection ratio to limiting tensile strain is 0.28. By reference to Figure 4 (Ref 2 Figure 6) a horizontal strain/limiting tensile strain ratio of 0.87 is obtained, indicating that a horizontal strain of 0.065% is acceptable for a 'very slight' category of damage.

This result does not take into account the vertical stiffness of the wall, and is conservative in this respect.

5.11.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the proposed excavation at Nos 115-119 is predicted to be 0.064%. This is less than the 0.065% limit for very slight damage calculated above.

The predicted level of damage to this wall can therefore be taken as 'very slight'.

5.12 Predicted movement – 'Rear Building' front wall.

5.12.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the front wall of the building behind Nos 115-119 Goldhurst Terrace (the 'Rear Building') have been calculated and plotted in Figure 13.

This wall is taken to be approximately 17.3m long and approximately 6m high. It lies in the position shown on the plan in Figure 13. The wall lies oblique to the co-ordinate axes, but locations along the wall are adequately represented by the X co-ordinate (see Figure 13).

The analysis indicates an overall tilt of approximately 0.7mm along the length of this wall, this is negligible.

The maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is 1.5mm within the length of the wall. The limit on tensile strain for 'very slight' damage is 0.075% (Ref 2), therefore the ratio of deflection ratio to limiting tensile strain is 0.12. By reference to Figure 4 (Ref 2 Figure 6) a horizontal strain/limiting tensile strain ratio of 0.84 is obtained, indicating that a horizontal strain of 0.063% is acceptable for a 'very slight' category of damage.

This result does not take into account the vertical stiffness of the wall, and is conservative in this respect.

5.12.2 Lateral movement.

Due to the position of this wall in relation to the proposed works the predicted horizontal ground strain along the plane of the wall is predicted to be negligible.

The predicted level of damage to this wall can be taken as 'very slight' or less.

5.13 Predicted movement – 'Rear Building' left flank wall.

The left flank wall of the Rear Building is longer than the right flank, and closer to the proposed works. Assuming the two walls are of a similar height the left flank is more susceptible to damage, by inspection.

5.13.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the left flank wall of the Rear Building have been calculated and plotted in Figure 14.

This wall is taken to be approximately 8.8m long. Its height is taken to be 6m. The wall lies in the position shown on the plan in Figure 14.

The analysis indicates a maximum overall tilt of approximately 3mm along the length of this wall. This equates to a whole-wall gradient of less than 1 in 2900. This is less than the 1:400 gradient recognised as requiring remedial action.

The maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is negligible, indicating that a horizontal strain of 0.075% is acceptable for a 'very slight' category of damage.

5.13.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the proposed excavation at Nos 115-119 Goldhurst Terrace is predicted to be 0.064%. This is less than the 0.075% limit for very slight damage calculated above, and is likely to be a significant over-estimate of horizontal strain in this location.

The predicted level of damage to this wall can therefore be taken as 'very slight' or less.

5.14 Predicted damage summary

On the basis of the above, it is considered that the category of damage to Nos 111, 113 and 121-125 Goldhurst Terrace and to the building behind Nos 115-119, arising from the proposed works at Nos 115-119, can be limited to 'very slight' or less, as defined in Ref 2.

This conclusion assumes a high standard of workmanship and stiff propping of the basement excavation at all stages. Particular care is required when working adjacent to the rear walls of Nos 113 and 121 Goldhurst Terrace (Sections 5.5 and 5.9 above).

The analysis does not take into account the potential for relative movement between walls that are to be underpinned, and connected walls that are not. It is essential that great care is taken in the underpin process to ensure that any such relative movement is minimised.

It is noted that there are mature trees present in the front gardens of the site and some of the neighbouring properties, it is considered likely that seasonal ground movements due to these trees may exceed the movements predicted above, especially for the front walls.

A plot of the calculated short-term settlement contours is presented in Figure 15 below. The figure shows a maximum of 3mm predicted short-term settlement to the footpath and road pavement outside the site. Given the typically flexible nature of these areas, this is unlikely to be noticeable, and in any event, is likely to be dwarfed by seasonal movements caused by the trees noted above.

6.0 Groundwater

It is proposed to excavate to a depth of approximately 4.05m (to 34.95mOD) through Made Ground into a thick deposit of London Clay. Readings from three standpipe piezometers installed to depths of 5m (33mOD) indicated the likely presence of perched water at the base of the Made Ground, but significant groundwater flows are not expected in this geological setting.

On the basis of the ground investigation results there is unlikely to be significant groundwater flow within the proposed basement depth, and therefore the development will not affect the local groundwater regime.

7.0 Conclusions and Recommendations

From the above, it is concluded that, given good workmanship, the basement to Nos 115-119 Goldhurst Terrace can be constructed without imposing more than 'very slight' damage on the adjoining properties.

The development is unlikely to significantly affect the local groundwater regime.

References:

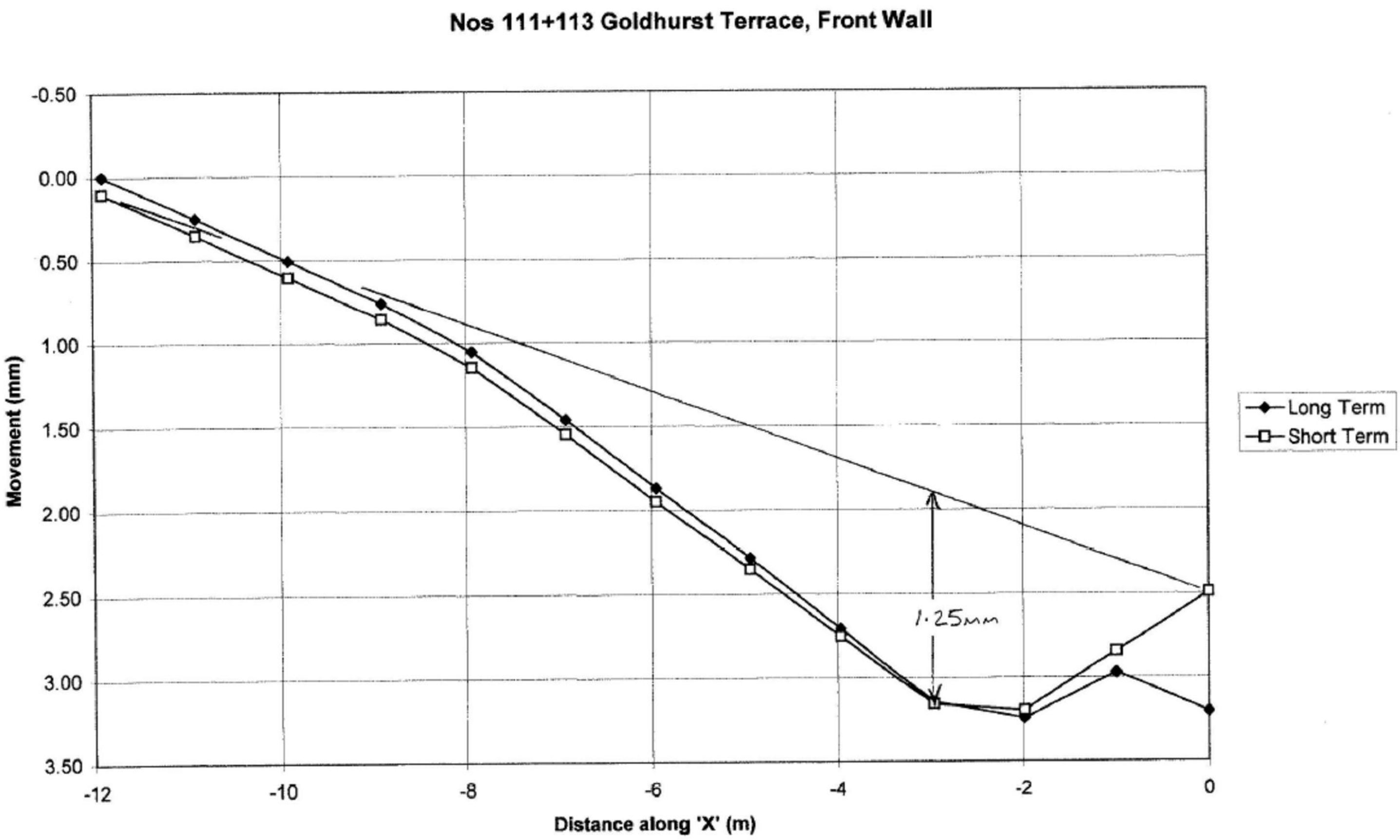
1 Stroud M A (1989) ‘The standard penetration test – its application and interpretation’. In ‘Penetration testing in the UK’, Thomas Telford pub.

2 Burland JB (1997). ‘Assessment of risk of damage to buildings due to tunnelling and excavation’. In ‘Earthquake Geotechnical engineering’ Ishihara (Ed). Balkema pub.

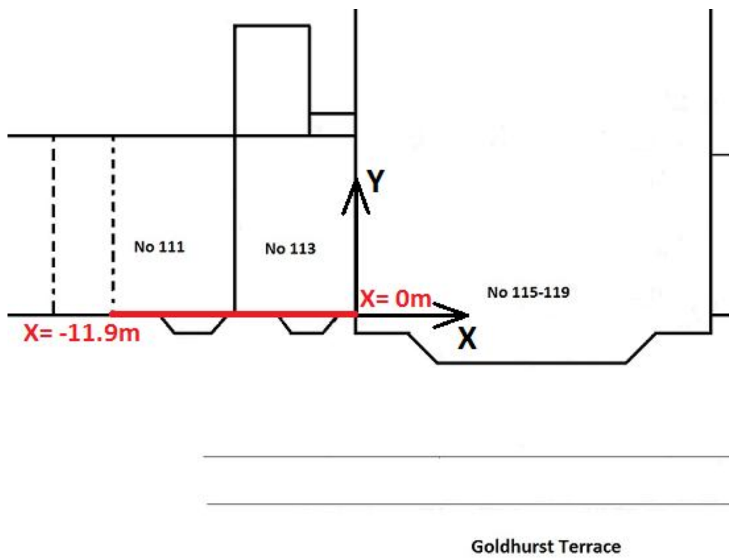
3 Gaba A R, Simpson B, Powrie W, Beadman D R (2003) Embedded retaining walls - guidance for economic design, CIRIA Report C580, London. ISBN: 978-0-86017-580-3.

4 Fuentes, R. and Devriendt, M (2010). ‘Ground movements around the corners of excavations: empirical calculation method’. Journal of geotechnical and geoenvironmental engineering, ASCE v136 Issue 10 pp1414-1424.

(Figures 5 - 15 follow below)

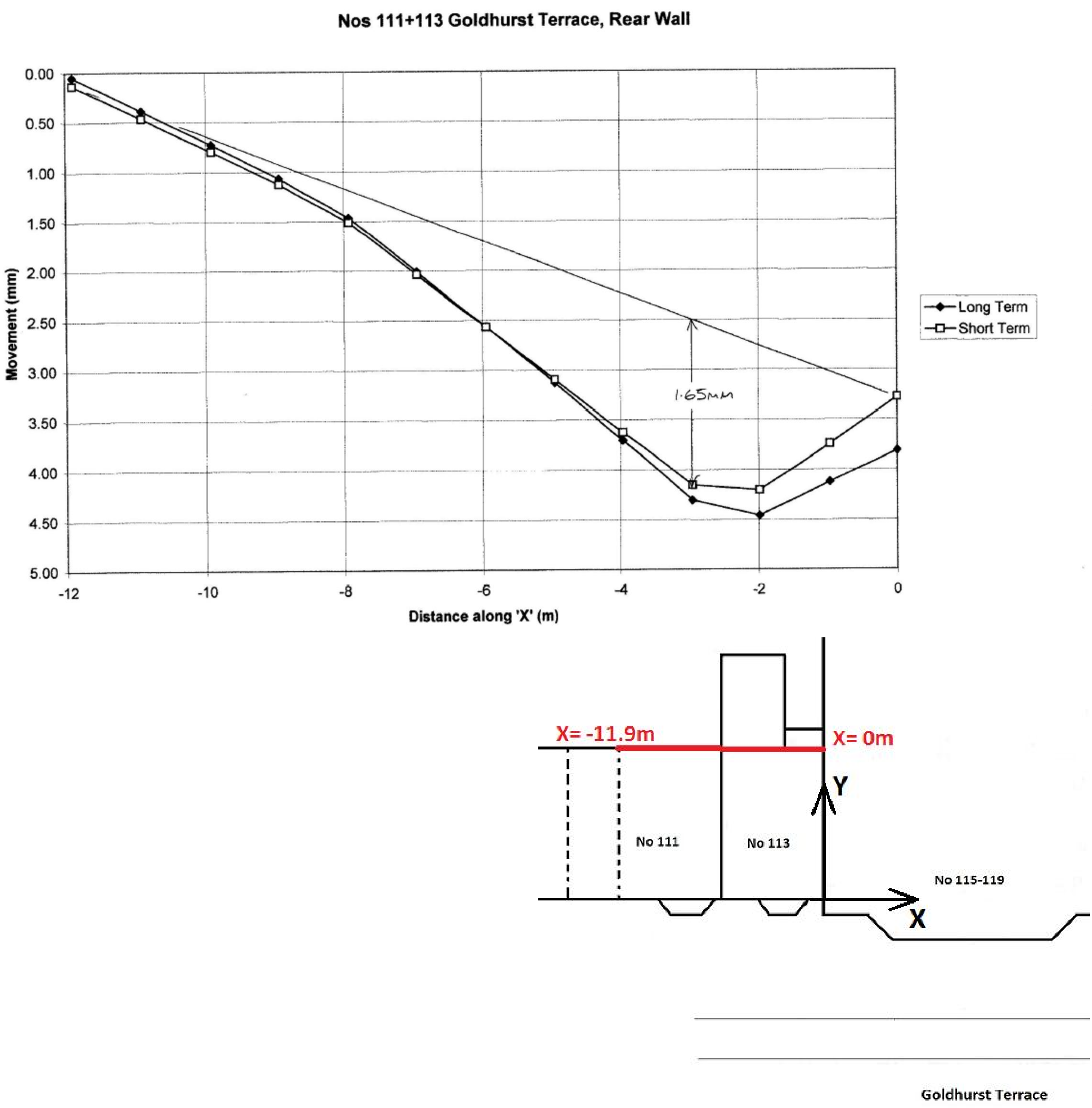


Nos 111+113 Goldhurst Terrace, Front Wall
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Movement (mm)
-12
-10
-8
-6
-4
-2
0
Distance along 'X' (m)
Long Term
Short Term
1.25mm



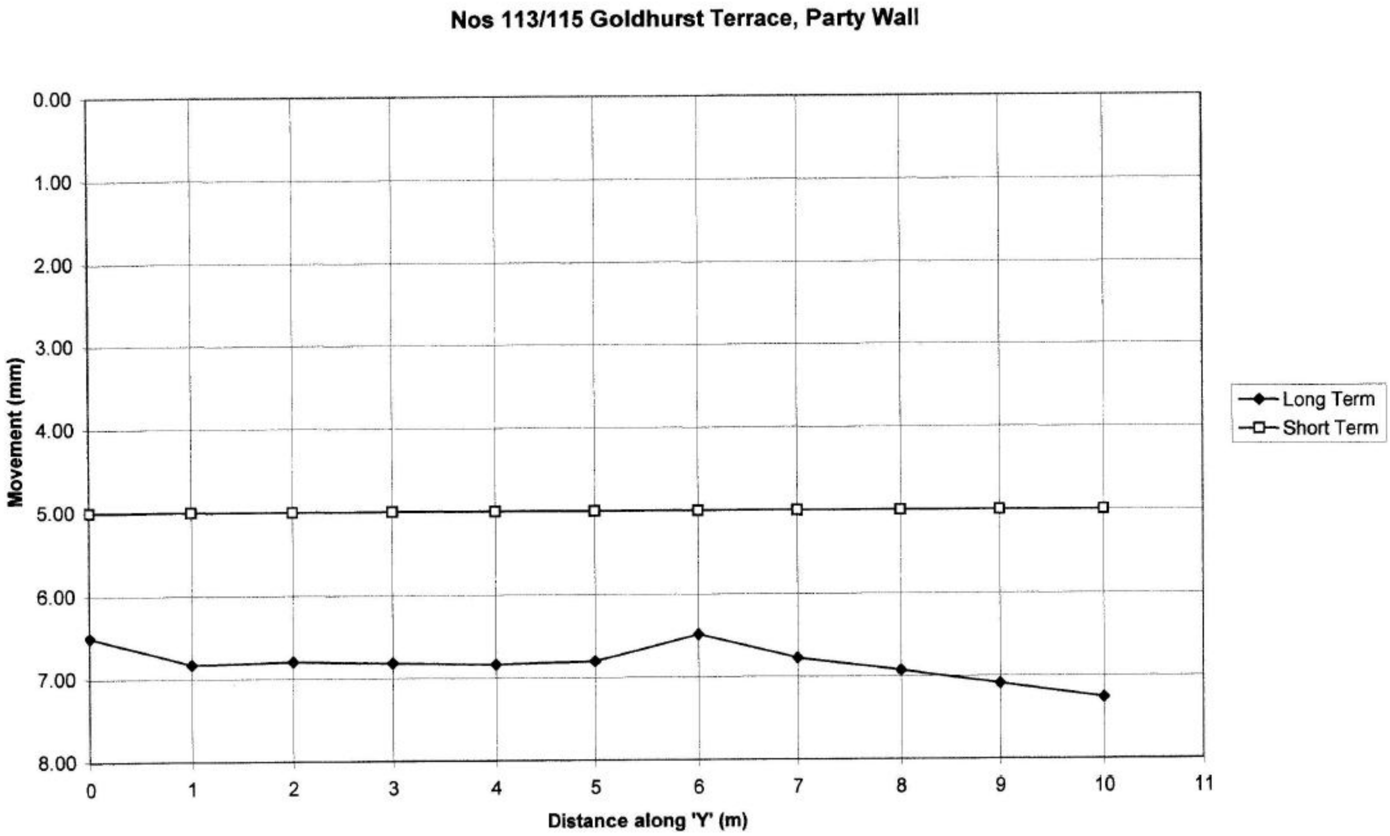
Y
No 111
No 113
No 115-119
X= 0m
X
X= -11.9m
Goldhurst Terrace

Figure 5

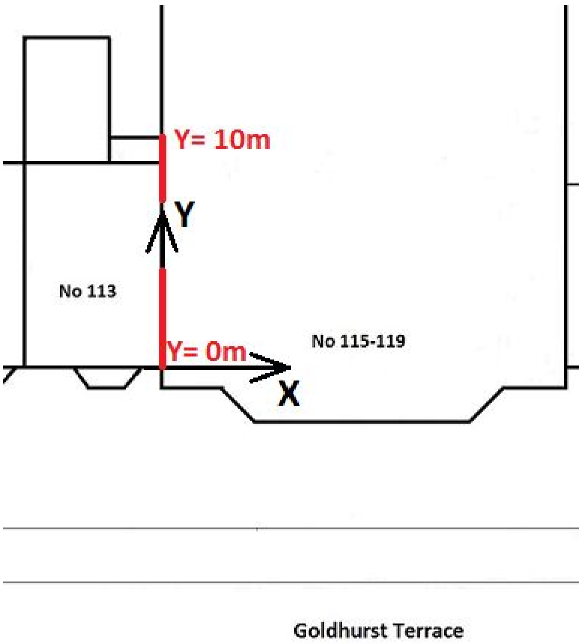


Nos 111+113 Goldhurst Terrace, Rear Wall
Movement (mm)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
-12
-10
-8
-6
-4
-2
0
Distance along 'X' (m)
Long Term
Short Term
1.65mm
X= -11.9m
X= 0m
Y
X
No 111
No 113
No 115-119
Goldhurst Terrace

Figure 6

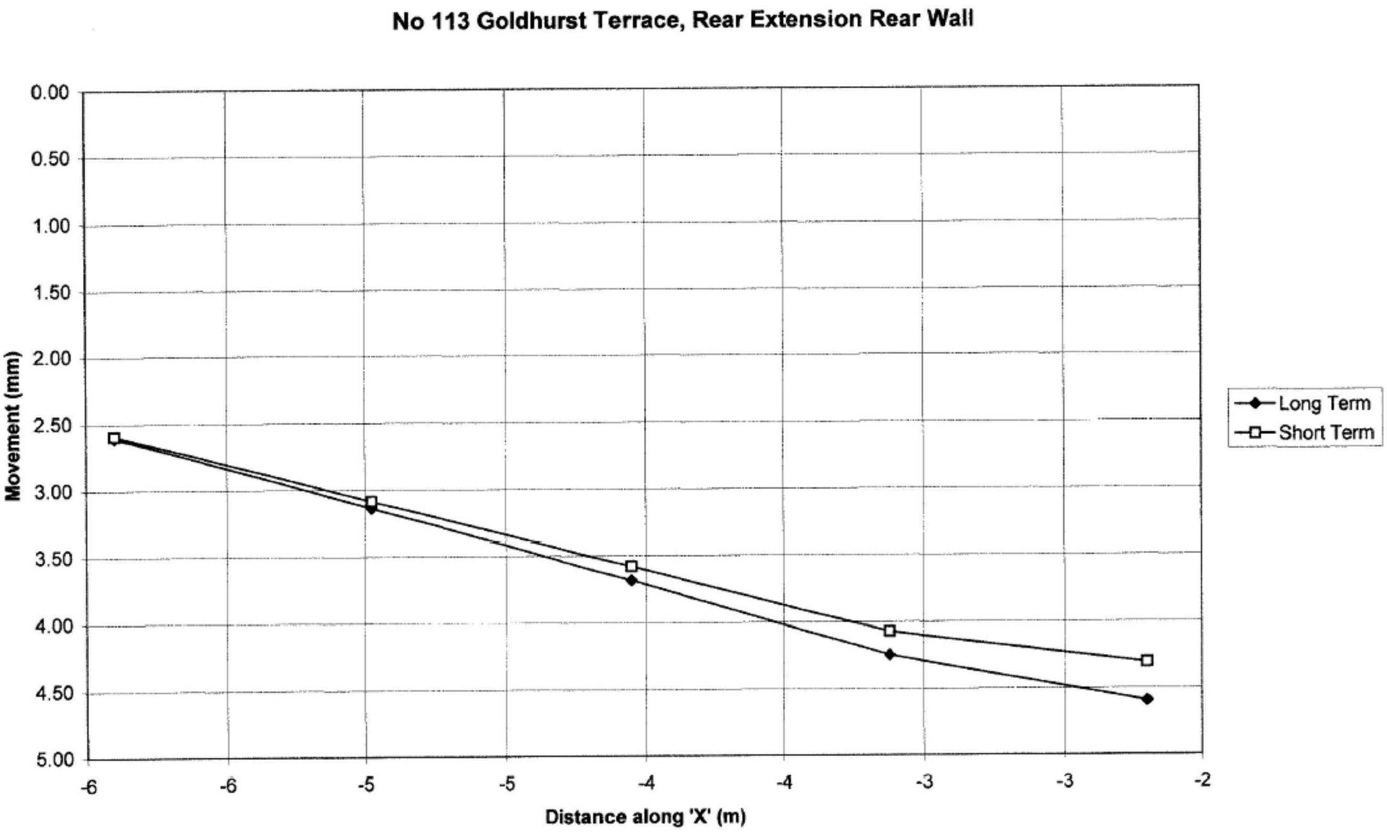


Nos 113/115 Goldhurst Terrace, Party Wall
Movement (mm)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
0
1
2
3
4
5
6
7
8
9
10
11
Distance along 'Y' (m)
Long Term
Short Term

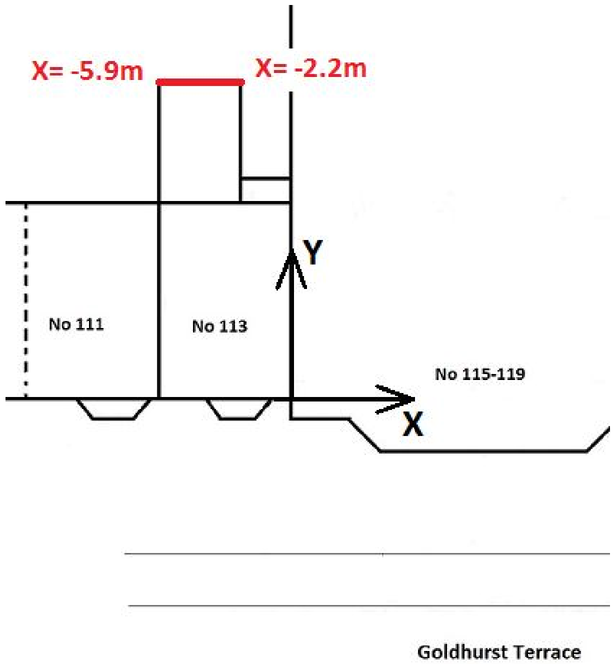


Y= 10m
Y
No 113
Y= 0m
No 115-119
X
Goldhurst Terrace

Figure 7

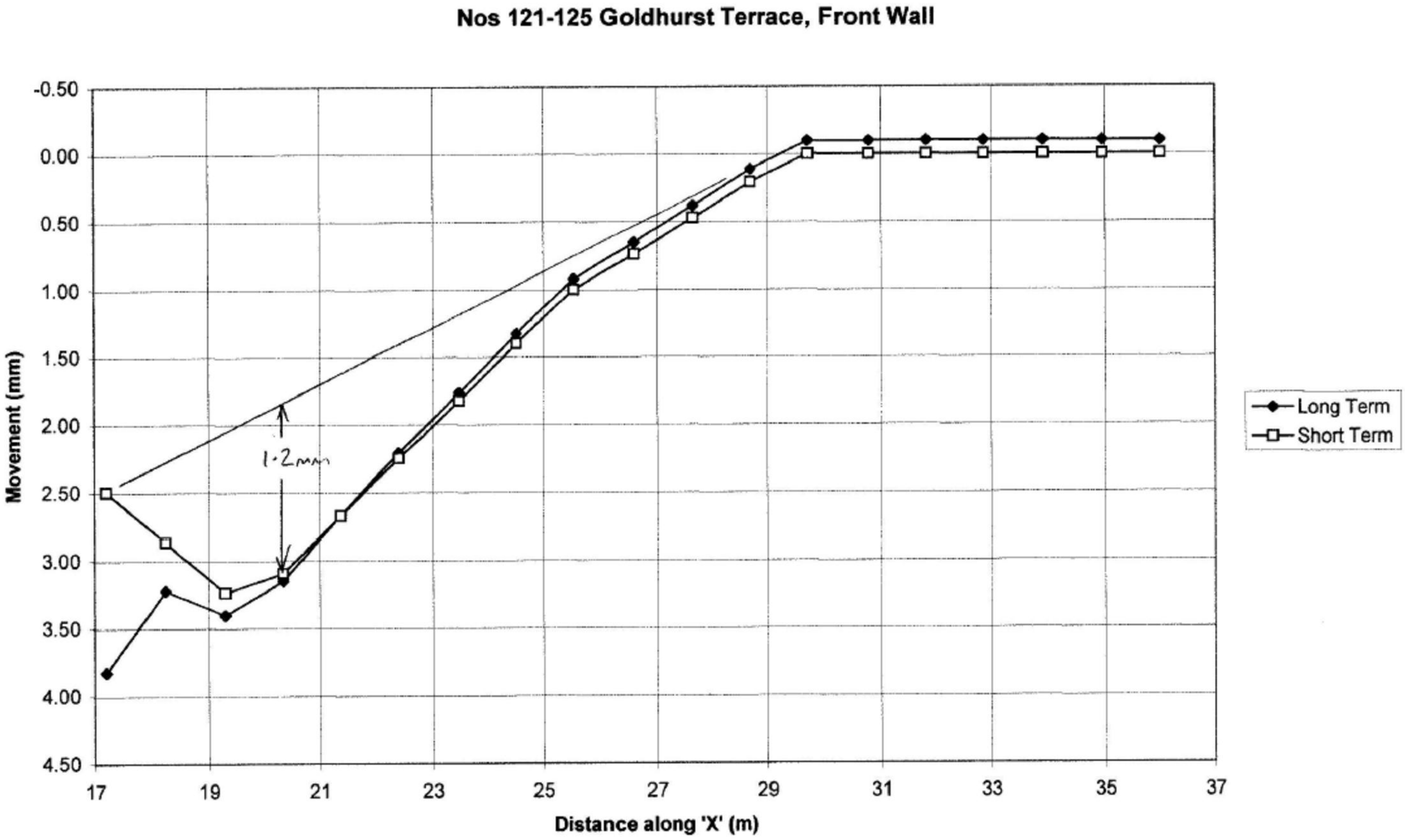


No 113 Goldhurst Terrace, Rear Extension Rear Wall
Movement (mm)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
-6
-6
-5
-5
-4
-4
-3
-3
-2
Distance along 'X' (m)
Long Term
Short Term

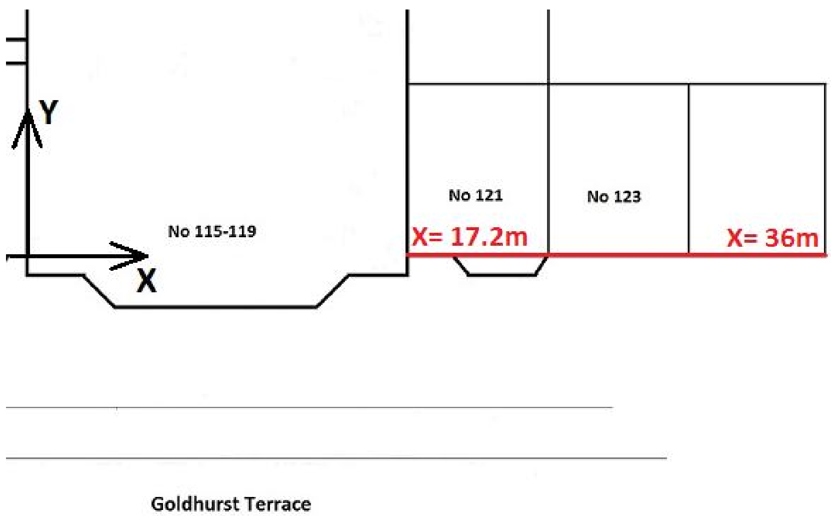


X= -5.9m
X= -2.2m
Y
No 111
No 113
No 115-119
X
Goldhurst Terrace

Figure 8

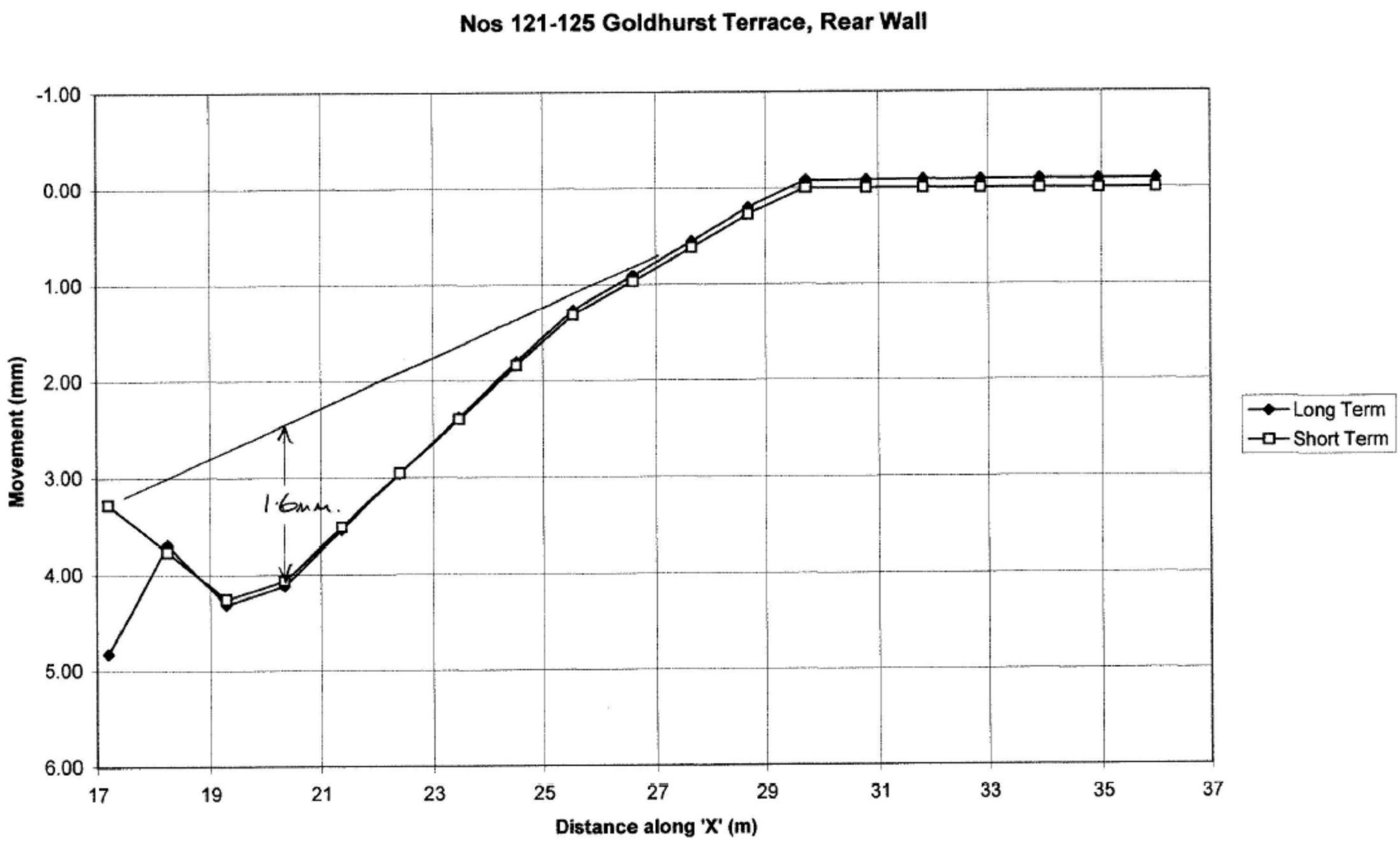


Nos 121-125 Goldhurst Terrace, Front Wall
Movement (mm)
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
17
19
21
23
25
27
29
31
33
35
37
Distance along 'X' (m)
Long Term
Short Term
1·2mm

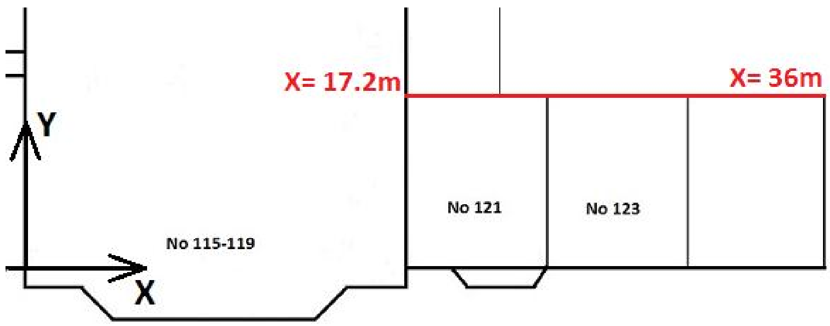


Y
X
No 115-119
No 121
No 123
X= 17.2m
X= 36m
Goldhurst Terrace

Figure 9

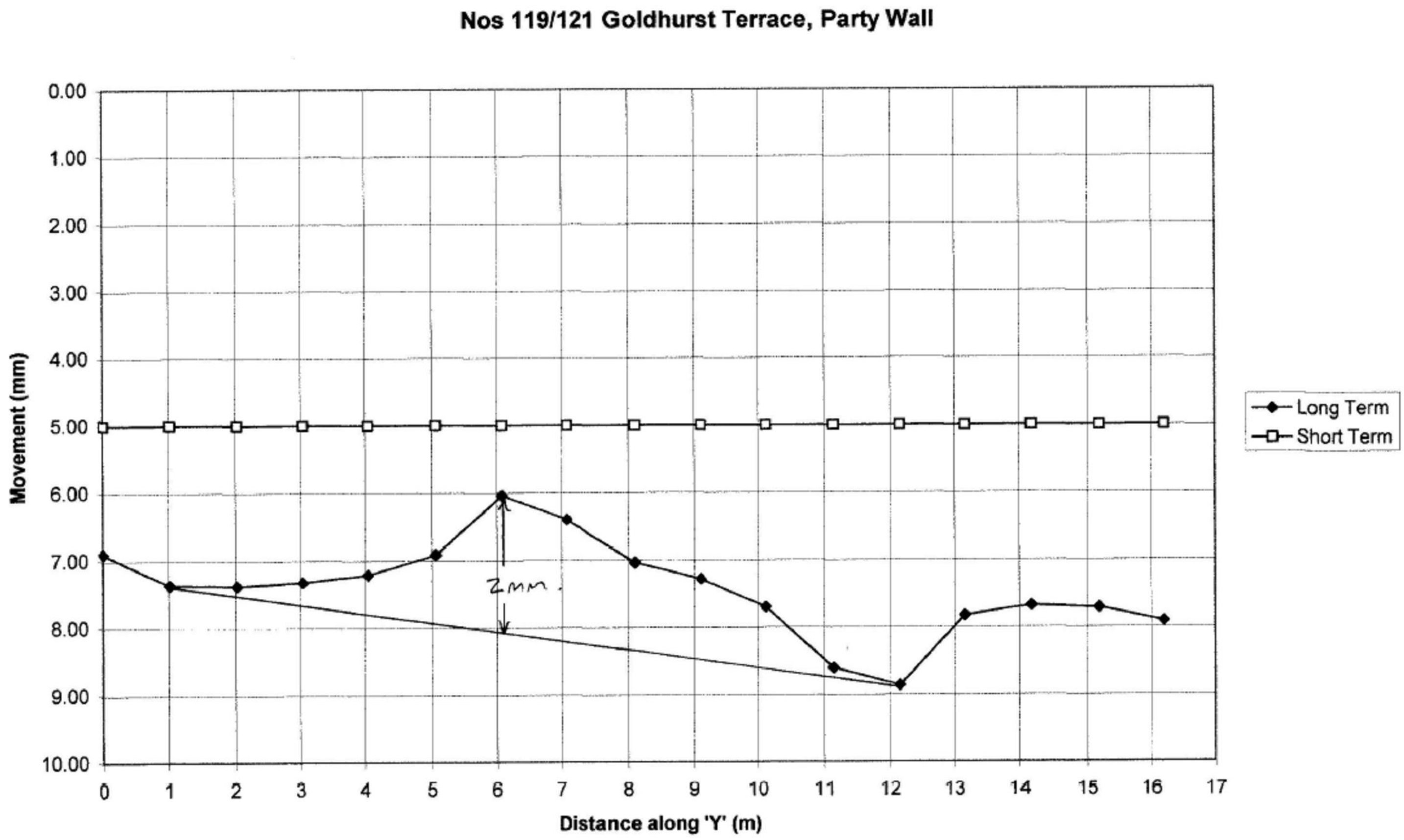


Nos 121-125 Goldhurst Terrace, Rear Wall
Movement (mm)
Distance along 'X' (m)
Long Term
Short Term
1·6mm.



X= 17.2m
X= 36m
Y
X
No 115-119
No 121
No 123

Figure 10


Nos 119/121 Goldhurst Terrace, Party Wall
Movement (mm)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Distance along 'Y' (m)
Long Term
Short Term
2mm

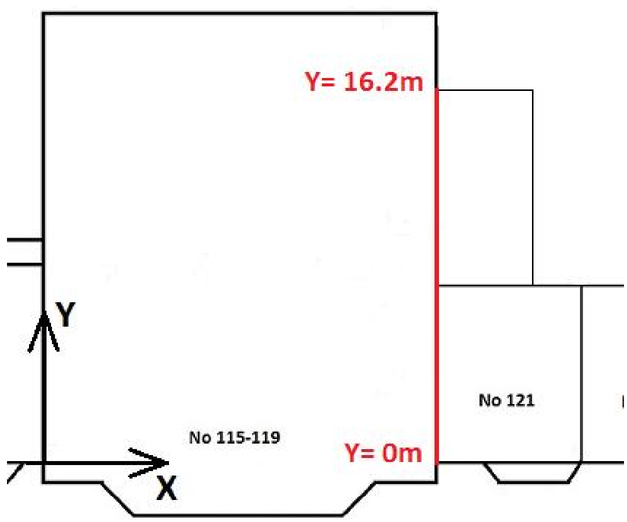
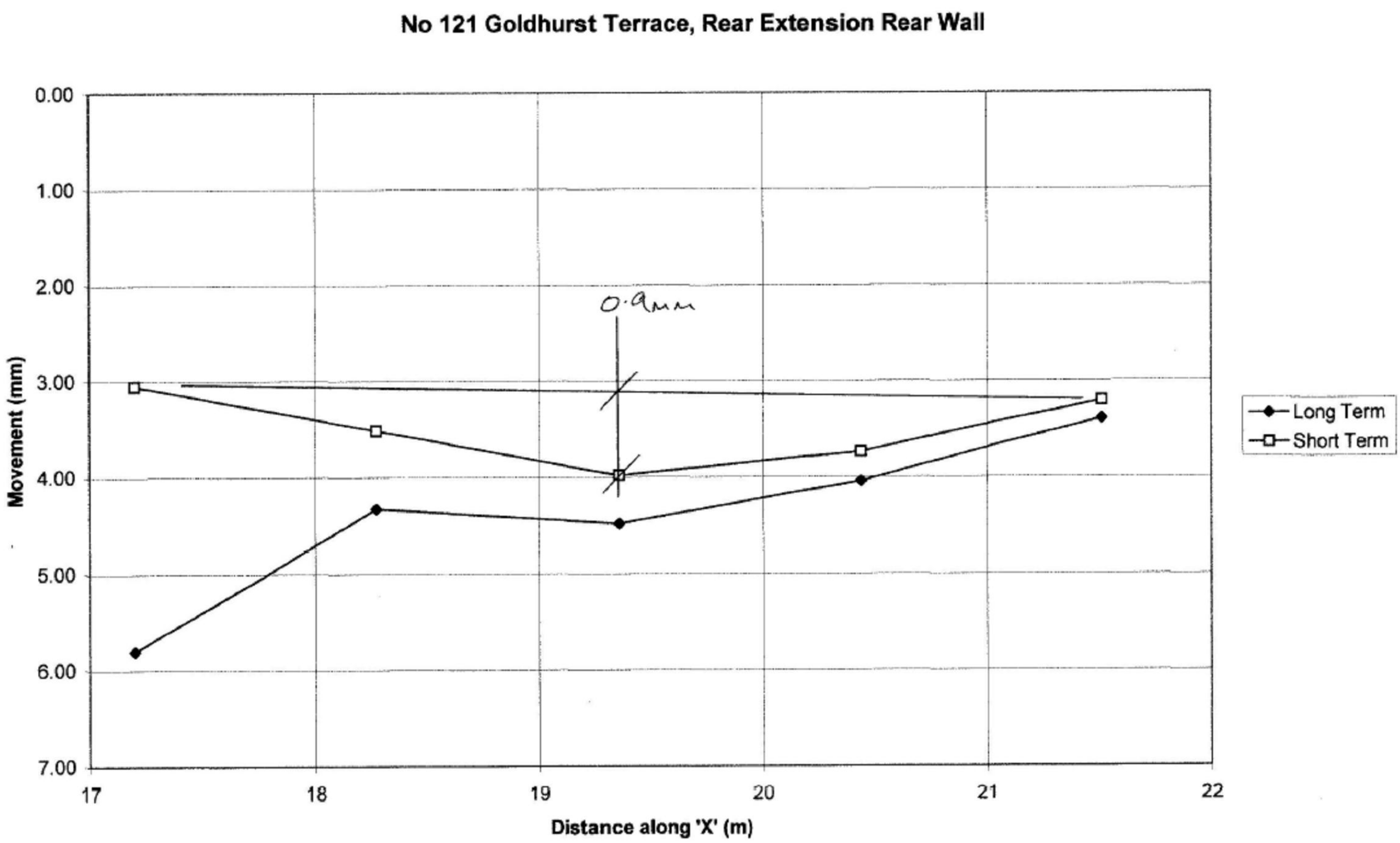
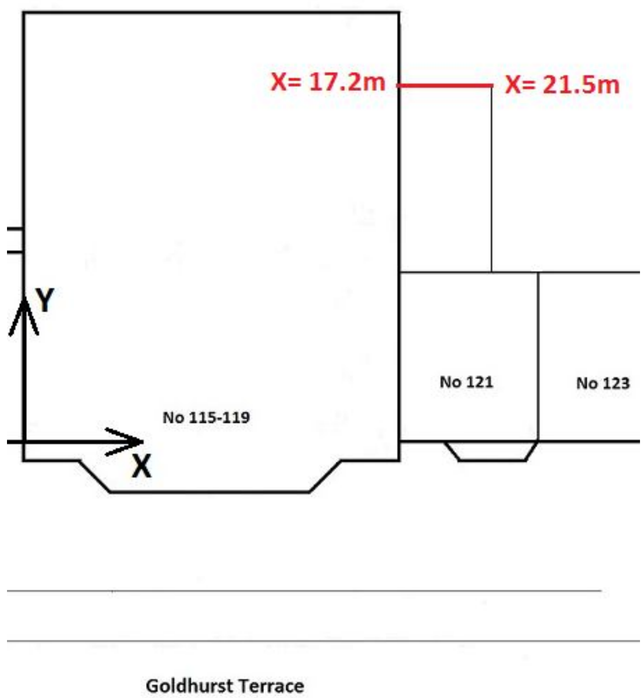

Y= 16.2m
Y
No 121
No 115-119
Y= 0m
X

Figure 11

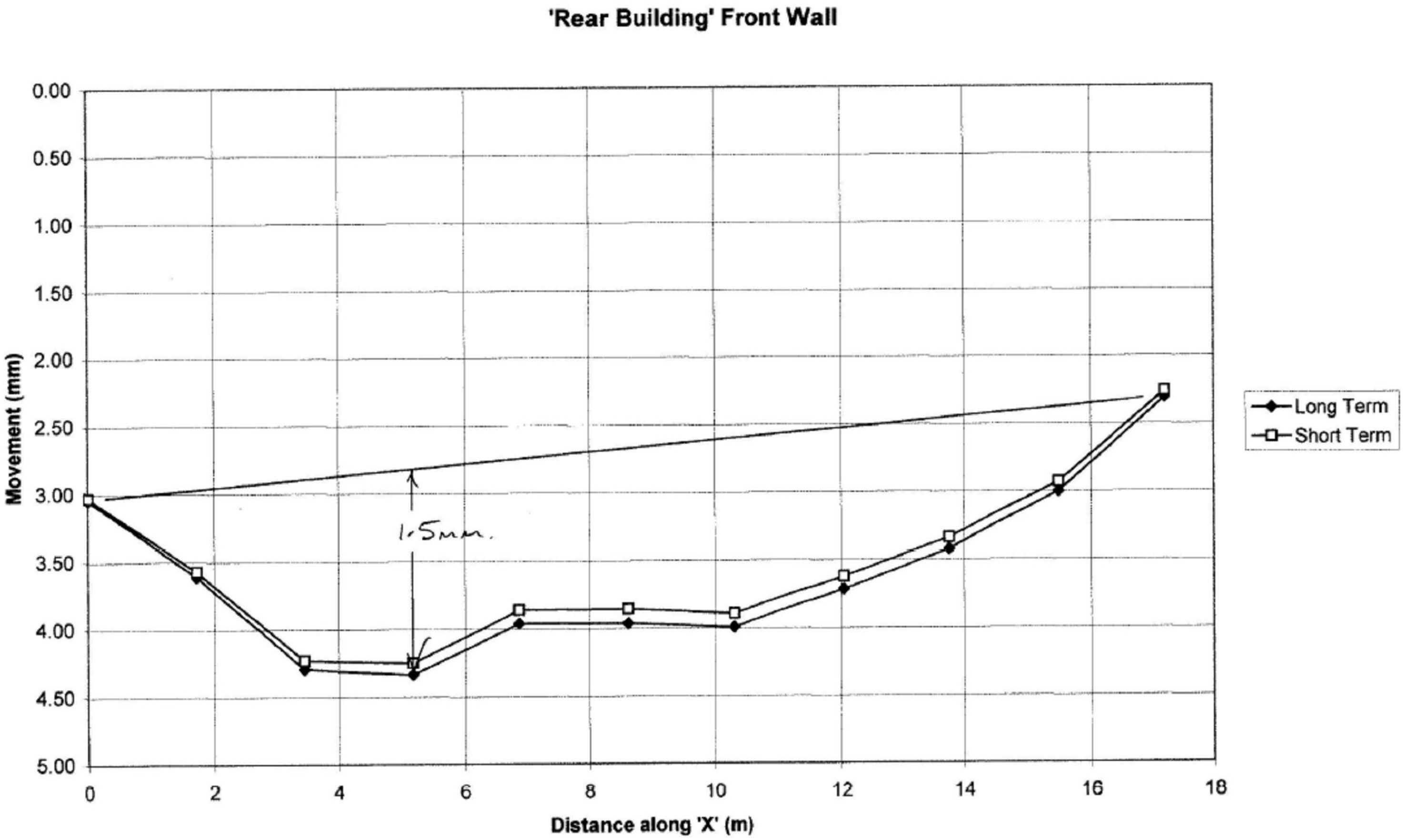


No 121 Goldhurst Terrace, Rear Extension Rear Wall
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Movement (mm)
17
18
19
20
21
22
Distance along 'X' (m)
Long Term
Short Term
0.9mm



X= 17.2m
X= 21.5m
Y
X
No 115-119
No 121
No 123
Goldhurst Terrace

Figure 12


'Rear Building' Front Wall
Movement (mm)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
0
2
4
6
8
10
12
14
16
18
Distance along 'X' (m)
Long Term
Short Term
1.5mm.

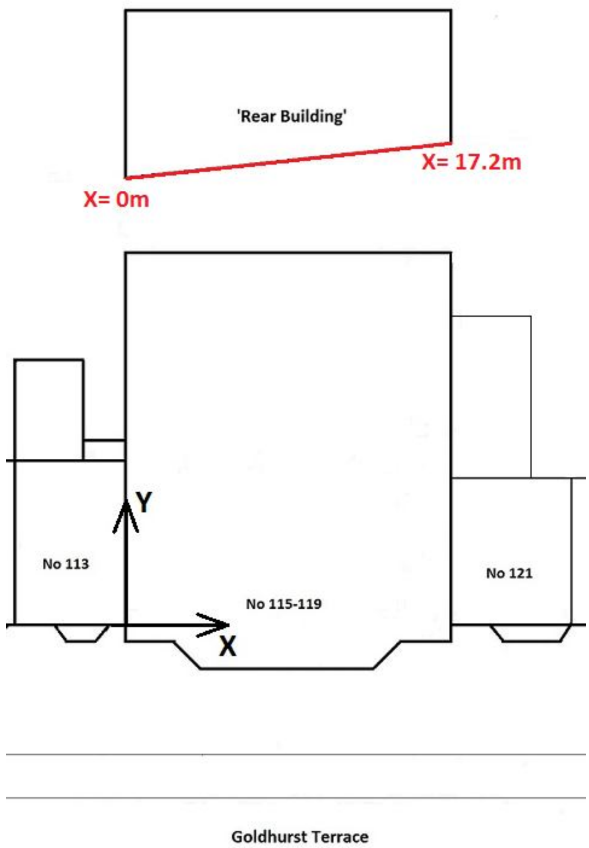
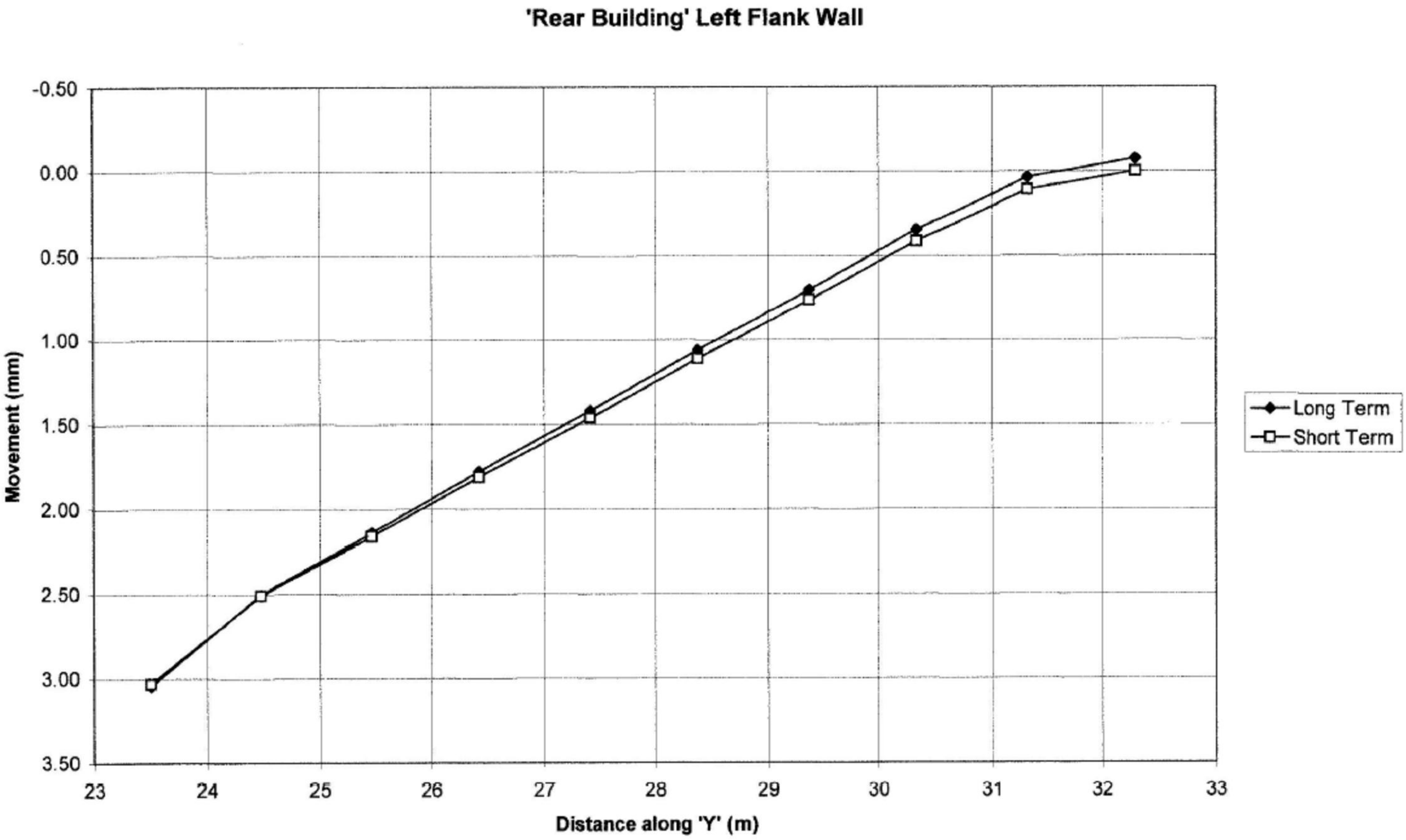
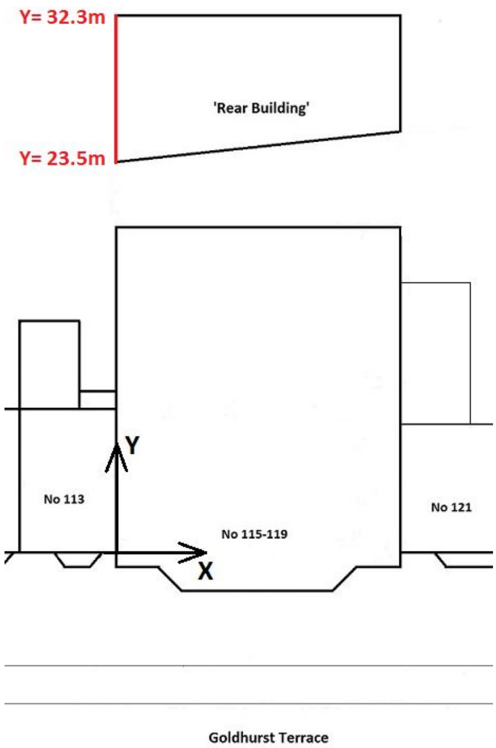

'Rear Building'
X= 17.2m
X= 0m
Y
No 113
No 115-119
No 121
X
Goldhurst Terrace

Figure 13



'Rear Building' Left Flank Wall
Movement (mm)
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
23
24
25
26
27
28
29
30
31
32
33
Distance along 'Y' (m)
Long Term
Short Term



Y= 32.3m
'Rear Building'
Y= 23.5m
Y
No 113
No 115-119
X
No 121
Goldhurst Terrace

Figure 14

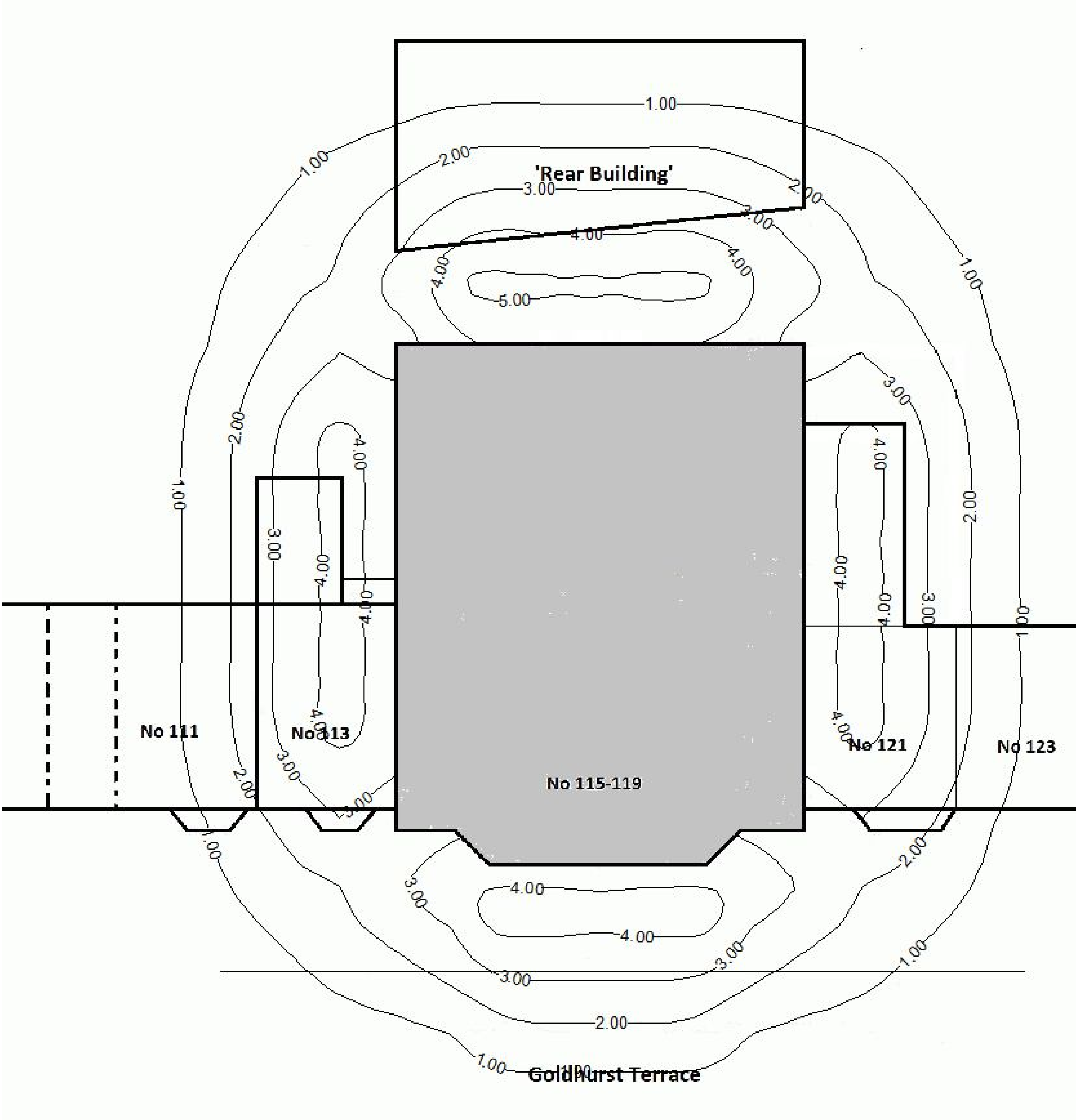


Figure 15
(Short-term ground settlement contours)