Project No. 1587	July 2017

27 Gladys Road
Ground Movement Assessment

constructure

Structural Designers

Constructure
15 Bell Yard Mews
London SE1 3TY

constructure.co.uk
office@constructure.co.uk
020 7403 7989

Project No. 1587	Sheet 01	Revision	
Date 5-7-17	Engineer TC	Checked	Project GLADYS ROAD

GROUND MOVEMENT ANALYSIS

FRONT EXCAVATION 3.3m
MAIN EXCAVATION 1.1m

USING CIRCA C580
'COUNTERFORT WALL'

FROM TABLE 2.2 [REF: pg 03]
DURING INSTALLATION
EXPECTED VERTICAL MOVEMENT:

FRONT = 3.3m x 0.1% = 3.3mm   3.3 - 0
MAIN = 1.1m x 0.1% = 1.1mm.   1.1 - 0

EXPECTED HORIZONTAL MOVEMENT

FRONT = 3.3m x 0.05% = 1.65mm
MAIN = 1.1m x 0.05% = 0.55mm.

DISTANCE BEHIND WALL TO NEGLIGIBLE MOVEMENT:

HORIZONTAL & VERTICAL ⇒ FRONT = 3.3 x 1.5 = 4.95m.
MAIN = 1.1 x 1.5 = 1.65m

FROM FIGURE 2.11 & TABLE 2.4 [REF: pg 04-05]
'LOW SUPPORT STIFFNESS'
DURING EXCAVATION
EXPECTED VERTICAL MOVEMENT

FRONT = 3.3m x 0.35% = 11.55mm
MAIN = 1.1m x 0.35% = 3.85mm

EXPECTED HORIZONTAL MOVEMENT

FRONT = 3.3m x 0.4% = 13.2mm
MAIN = 1.1m x 0.4% = 4.4mm

DISTANCE BEHIND WALL TO NEGLIGIBLE MOVEMENT

HORIZONTAL & VERTICAL ⇒ FRONT = 3.3 x 4 = 13.2m
MAIN = 1.1 x 4 = 4.4m

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MAIN HOUSE

MAXIMUM STRAIN

HEIGHT EAVES – BASEMENT = 8.6m

DURING INSTALLATION

VERTICAL 1.1mm OVER 1.65m

HORIZONTAL 0.55mm OVER 1.65m.

$$\sqrt{1.1mm^2 + 0.55mm^2} = 1.23mm$$

$$\text{DISTANCE} = \sqrt{1.65m^2 + 8.6^2} = 8.75685m.$$

$$1.23 / 8.75685 \times 10^3 = 0.01405\%$$

CIRIA C580 TABLE 2.5

→ CAT 0 ⇒ NEGLIGIBLE

DURING INSTALLATION

DURING EXCAVATION

VERTICAL 3.85mm OVER 4.4m

HORIZONTAL 4.4mm OVER 4.4m.

$$\sqrt{3.85mm^2 + 4.4mm^2} = 5.85mm$$

$$\text{DISTANCE} = \sqrt{4.4^2 + 8.6^2} = 9.66023m$$

$$5.85 / 9.66023 \times 10^3 = 0.06056\%$$

CIRIA C580 TABLE 2.5

→ CAT 1 ⇒ VERY SLIGHT

DURING EXCAVATION

TOTAL MOVEMENT = 0.01405 % + 0.0605 %.

= 0.07455 %

CIRIA C580 TABLE 2.5

→ CAT 1 ⇒ VERY SLIGHTLY

Figures 2.8 and 2.9 show the combined data collated from Clough and O'Rourke (1990), Thompson (1991), Carder (1995) and Carder *et al* (1997) and can be used to estimate ground surface movements arising from the construction of bored pile and diaphragm walls embedded in stiff clays. Table 2.2 summarises the magnitude and extent of the monitored ground movements for walls installed under conditions of good workmanship. The data presented in Figures 2.8 and 2.9 are relatively limited, particularly measurements of horizontal movements for walls. Ground movement estimates based on Figures 2.8 and 2.9 and Table 2.2 should therefore be treated as indicative only. **At locations where such movements are of importance, appropriate instrumentation should be installed and the ground movements monitored accordingly.**

Table 2.2 *Ground surface movements due to bored pile and diaphragm wall installation in stiff clay*

Wall type	Horizontal movements		Vertical movements	
	Surface movement at wall (per cent of wall depth)	**Distance behind wall to negligible movement** (multiple of wall depth)	**Surface movement at wall** (per cent of wall depth)	**Distance behind wall to negligible movement** (multiple of wall depth)
Bored piles				
Contiguous	0.04	1.5	0.04	2
Secant	0.08	1.5	0.05	2
Diaphragm walls				
Planar	0.05	1.5	0.05	1.5
Counterfort	0.1	1.5	0.05	1.5

Notes

1. Maximum surface movement occurs close to the wall and is calculated as a percentage of the pile depth/diaphragm wall trench depth, as appropriate.
2. Extent of movement is calculated non-dimensionally by dividing by the pile depth/diaphragm wall trench depth, as appropriate

Ground movements arising from excavation in front of wall

Ground movements associated with excavations comprise "global" and "local" movements. Global movements are caused by elastic movements in the ground, whereas local movements are concentrated and plastic and arise as the soil approaches its limiting strength. Movements induced by the excavation are made up of the response to the removal of lateral support to the sides of the wall and the response to the removal of the vertical load at the base of the excavation.

04

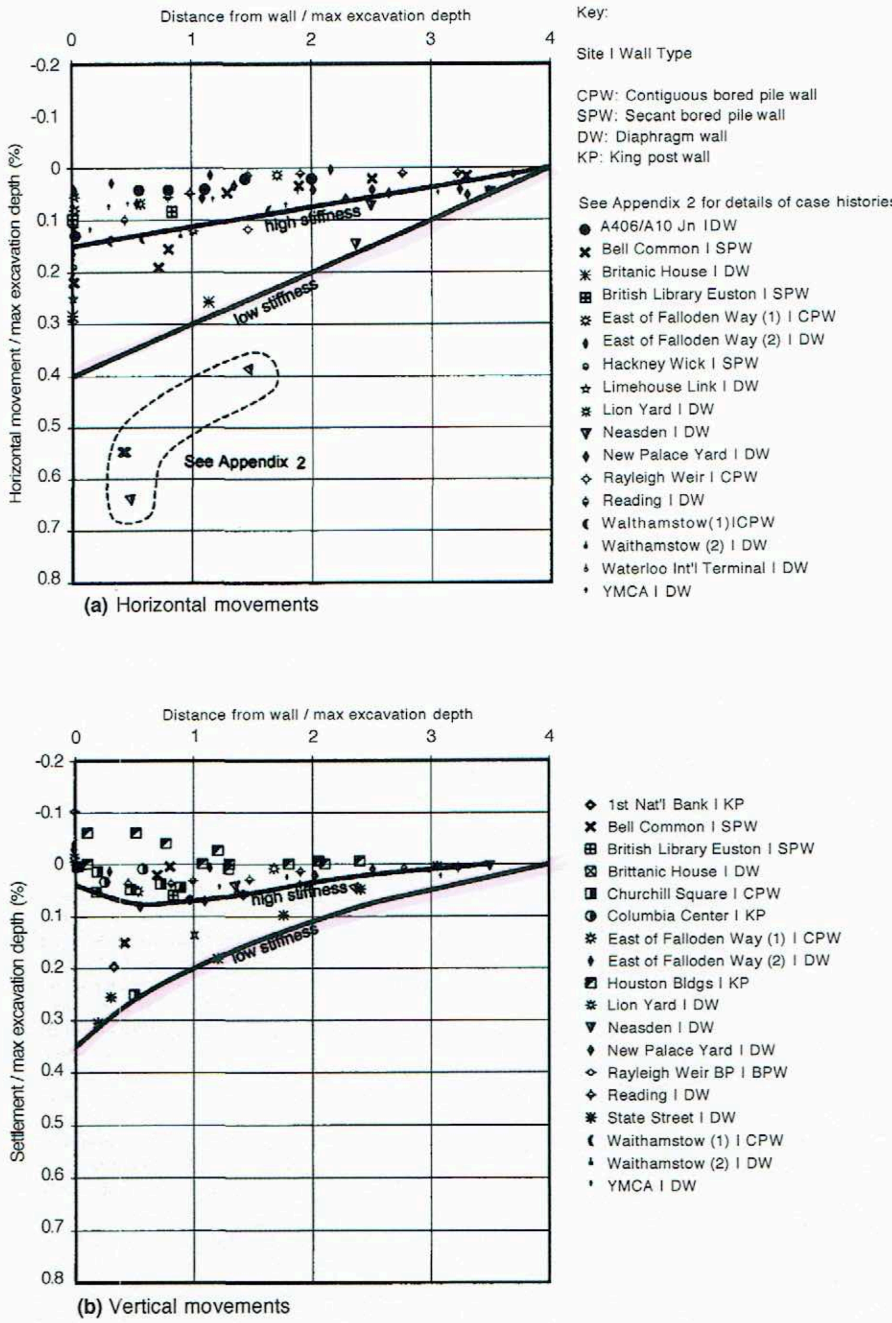


Figure 2.11 *Ground surface movements due to excavation in front of wall in stiff clay*

Table 2.3 *Support stiffness categories (Carder, 1995)*

Support stiffness	Description/examples
High	*Top-down construction*, temporary props installed before permanent props at *high* level
Moderate	Temporary props of high stiffness installed before permanent props at *low* level
Low	*Cantilever walls*, temporary props of *low* stiffness or temporary props installed at low level

Table 2.4 summarises the magnitude and extent of the monitored ground surface movements due to excavation in front of bored pile, diaphragm and sheet pile walls wholly embedded in stiff clay under conditions of good workmanship. The case history data, upon which Table 2.4 is based, relate to excavations that range in depth from 8 m to 31 m, have a factor of safety against base heave in excess of 3 and where walls are wholly embedded in stiff clay.

Table 2.4 *Ground surface movements due to excavation in front of bored pile, diaphragm wall and sheet pile walls wholly embedded in stiff clays*

Movement type	High support stiffness (high propped wall, top-down construction)		Low support stiffness (cantilever or low-stiffness temporary props or temporary props installed at low level)	
	Surface movement at wall (per cent of max excavation depth)	**Distance behind wall to negligible movement** (multiple of max excavation depth)	**Surface movement at wall** (per cent of max excavation depth)	**Distance behind wall to negligible movement** (multiple of max excavation depth)
Horizontal	0.15	4	0.4	4
Vertical	0.1	3.5	0.35	4

Notes

1. Maximum surface movement occurs close to the wall and is expressed as a percentage of maximum excavation depth in front of the wall.
2. Extent of movement is calculated non-dimensionally by dividing by maximum excavation depth.
3. Movements exclude those arising from wall installation effects.
4. Movements correspond to good workmanship and to walls wholly embedded in stiff clays retaining stiff clays or competent soils.
5. Movements will be greater where soft soils are encountered at formation level; see Appendix 2.

Stage 1

Ground movements behind the retaining wall should be estimated as described in Section 2.5.2 assuming greenfield conditions, ie ignoring the presence of the building or utility and the ground above foundation level. Contours of ground surface movements should be drawn and a zone of influence established based on specified settlement and distortion criteria. All structures and utilities within the zone of influence should be identified.

Stage 2

A condition survey should be carried out on all structures and utilities within the zone of influence before starting work on site. The structure or utility should be assumed to follow the ground (ie it has negligible stiffness), so the distortions and consequently the strains in the structure or utility can be calculated. The method of damage assessment should adopt the limiting tensile strain approach as described by Burland *et al* (1977), Boscardin and Cording (1989) and Burland (2001); see Table 2.5 and Figure 2.18.

Table 2.5 *Classification of visible damage to walls (after Burland* et al, *1977, Boscardin and Cording, 1989; and Burland, 2001)*

Category of damage	**Description of typical damage** (ease of repair is underlined)	**Approximate crack width (mm)**	**Limiting tensile strain** ε_{lim} **(per cent)**
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible.	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5–15 or a number of cracks > 3	0.15–0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks.	

Notes

1. In assessing the degree of damage, account must be taken of its location in the building or structure.
2. Crack width is only one aspect of damage and should not be used on its own as a direct measure of it.

KEY

(mm)

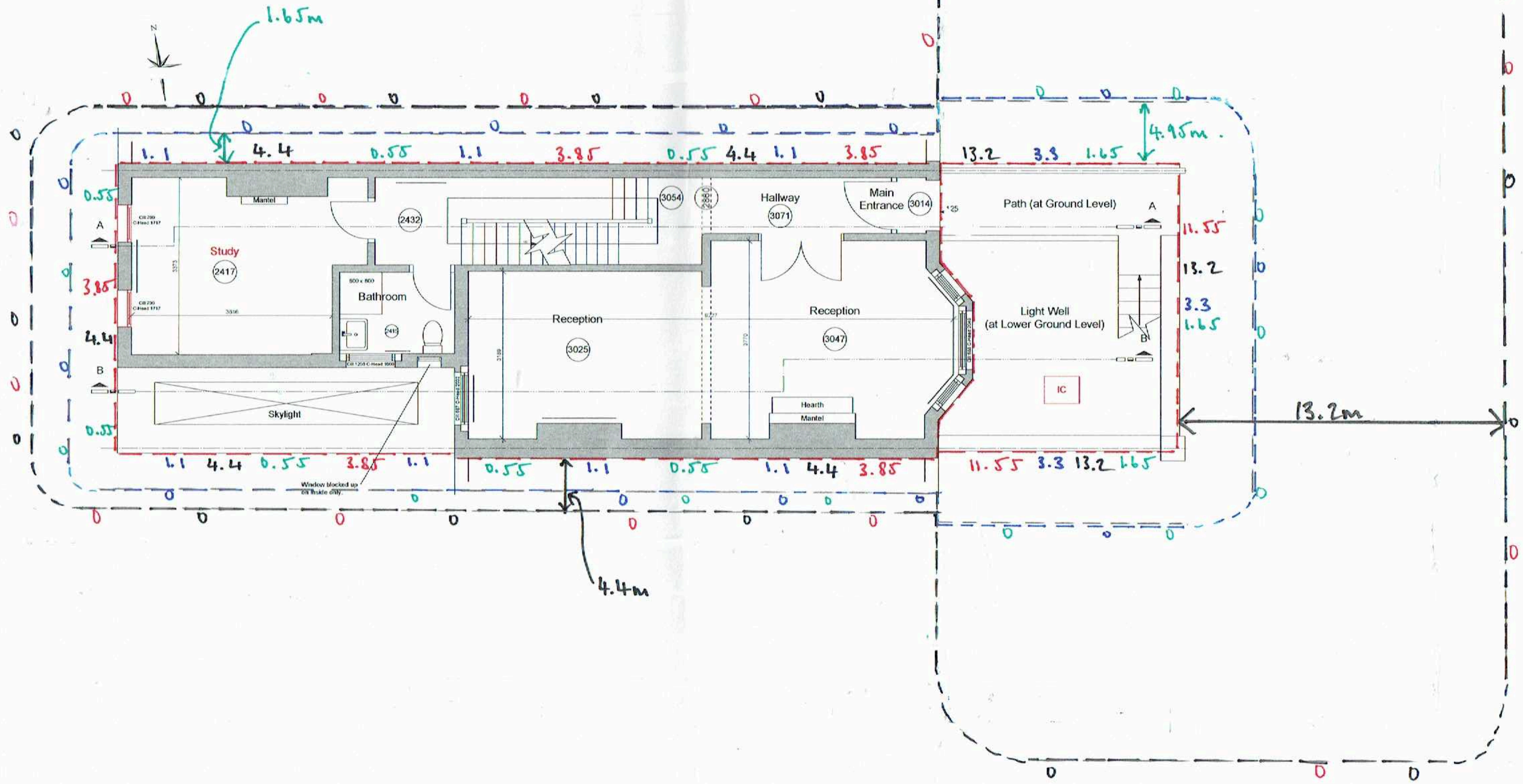
11.55 – 0 (FRONT) / 3.85 – 0 (MAIN) : EXPECTED VERTICAL MOVEMENT AS RESULT OF EXCAVATION

13.2 – 0 (FRONT) / 4.4 – 0 (MAIN) : EXPECTED HORIZONTAL MOVEMENT AS RESULT OF EXCAVATION

(mm)

3.3 – 0 (FRONT) / 1.1 – 0 (MAIN) : EXPECTED VERTICAL MOVEMENT AS RESULT OF INSTALLATION

1.65 – 0 (FRONT) / 0.55 – 0 (MAIN) : EXPECTED HORIZONTAL MOVEMENT AS RESULT OF INSTALLATION



(NOT TO SCALE)

GROUND MOVEMENT ANALYSIS PLAN

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