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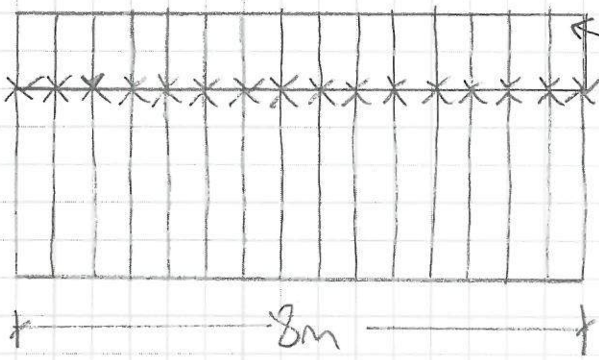
Date	Job no.	Sheet
NOV 2015	1706/02	7
Engineer: FGo		
Checked by: SBo		
Project: ELLERDALE ROAD		

BASEMENT SLAB DESIGN TO BS 8110-1

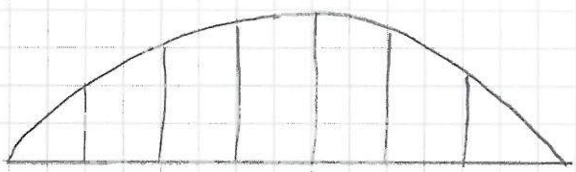
DESIGN TO WITHSTAND HYDROSTATIC UPLIFT



SLAB DEAD LOAD 14.4 kN/m
ASSUME 600mm SLAB

HYDROSTATIC PRESSURE 552 kN/m
$[(7.6-3.0)\times 10\times 1.2]$

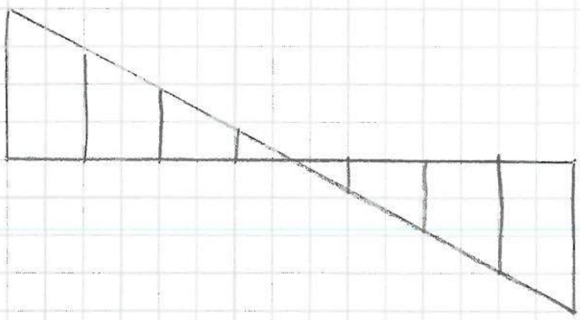
BENDING



$$M = \frac{(552-14.4)\times 8^2}{8}$$

$$= 326.4\ \text{KNm}$$

SHEAR



$$V = \frac{(55.2-14.4)\times 8}{2}$$

$$= 163.2\ \text{KN}$$

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Date	Job no.	Sheet
NOV 2015	1706/02	8
Engineer: FLSO		
Checked by: SLSO		
Project: ELLERDALE ROAD		

SLAB DESIGN

$M = 326.4$
$V = 163.4$

$f_{cu} = 30$ (FNDZ)
$d_{eff} = 600 - 40 - \frac{20}{2}$
$= 550\,mm$

BENDING

$$K = \frac{M}{f_{cu}\, b d^2} = \frac{326 \times 10^6}{30 \times 1000 \times 550^2}$$

$$= 0.036$$

TAKE LEVER ARM FACTOR 0.95

$Z = 0.95 . d_{eff}$

$= 0.95 \times 550$

$= 522.5\,mm$

$$A_s = \frac{M}{0.87 \times f_y \times Z} = \frac{326 \times 10^6}{0.87 \times 500 \times 522.5}$$

$$= 1434\,mm^2/m$$

USE B20s @ 175mm c/c = $1795\,mm^2/m$

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Date Nov 2015	Job no. 1706/92	Sheet 9
Engineer FLo		
Checked by SR		
Project ELLERDALE ROAD		

SHEAR

$$v = \frac{V}{b \times d} = \frac{163{,}000}{1000 \times 550}$$

$$= 0.29\ N/mm^2$$

$$\frac{A_s \times 100}{1000 \times 550} = \frac{1795 \times 100}{1000 \times 550}$$

$$= 0.33$$

$$v_c = 0.79 \times \sqrt[3]{\frac{100 A_s}{bd}} \times \sqrt[4]{\frac{400}{d}} \Big/ \gamma_m \qquad \gamma_m = 1.25$$

$$= 0.79 \times \sqrt[3]{0.33} \times \sqrt[4]{0.73} \Big/ 1.25$$

$$= 0.55 \times 0.74 \qquad \text{[TABLE 3.8]}$$

$$= 0.41$$

FOR $f_{cu} \geq 25$, v_c CAN BE MULTIPLIED BY $\sqrt[3]{\left(\frac{f_{cu}}{25}\right)}$ [TABLE 3.8]

$$= 0.41 \times \sqrt[3]{\frac{30}{25}}$$

$$= 0.43\ N/mm^2$$

$v_c > v$ ∴ OKAY FOR SHEAR

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BUILDING DAMAGE ASSESSMENT IN ACCORDANCE WITH CIRIA C580

FOLLOWING THE METHOD SET OUT IN THE FLOW CHART IN FIGURE 2.14 (P.2)

A CONTOR MAP HAS BEEN DRAWN (SEE P.3) TO DETERMINE THE STRUCTURES WITHIN THE ZONE OF INFLUENCE

THE DAMAGE TO THE BUILDINGS WILL BE DETERMINED BY CALCULATING THE STRAINS THE GROUND MOVEMENTS EXERT ON THE BUILDINGS, IN ACCORDANCE WITH BOX 2.5 AND FIGURE 2.18

THE FOLLOWING STRUCTURES HAVE BEEN IDENTIFIED AS BEING WITHIN THE ZONE OF INFLUENCE
THEIR LENGTHS AND HEIGHTS ARE SHOWN BELOW IN ACCORDANCE WITH THE PROCEDURE SET OUT IN BOX 2.5 OF FIG. 2.14

CONTOR	BUILDING	L(M)	H(M)	L/H
1m	a/ KITCHEN EXTENSION TO 1 ELLERDALE RD	5	3	1.7
0m	b/ GARDEN WALL	4	1.5	2.7
5m	c/ 1+3 ELLERDALE ROAD	13	12	1.1
15m	d/ 79-87 FITZJOHN'S AVENUE	15	12	1.3
20m	e/ COACH HOUSE	13	10	1.3
20m	f/ 14-16 PRINCE ARTHUR ROAD	15	12	1.3
30m	g/ 5 ELLERDALE ROAD	20	12	1.25

BUILDINGS a/, b/ AND c/ WILL BE ASSESSED SEPARATELY AS THEIR FOUNDATIONS ARE KNOWN TO EXTEND 2m BELOW THE GROUND LEVEL

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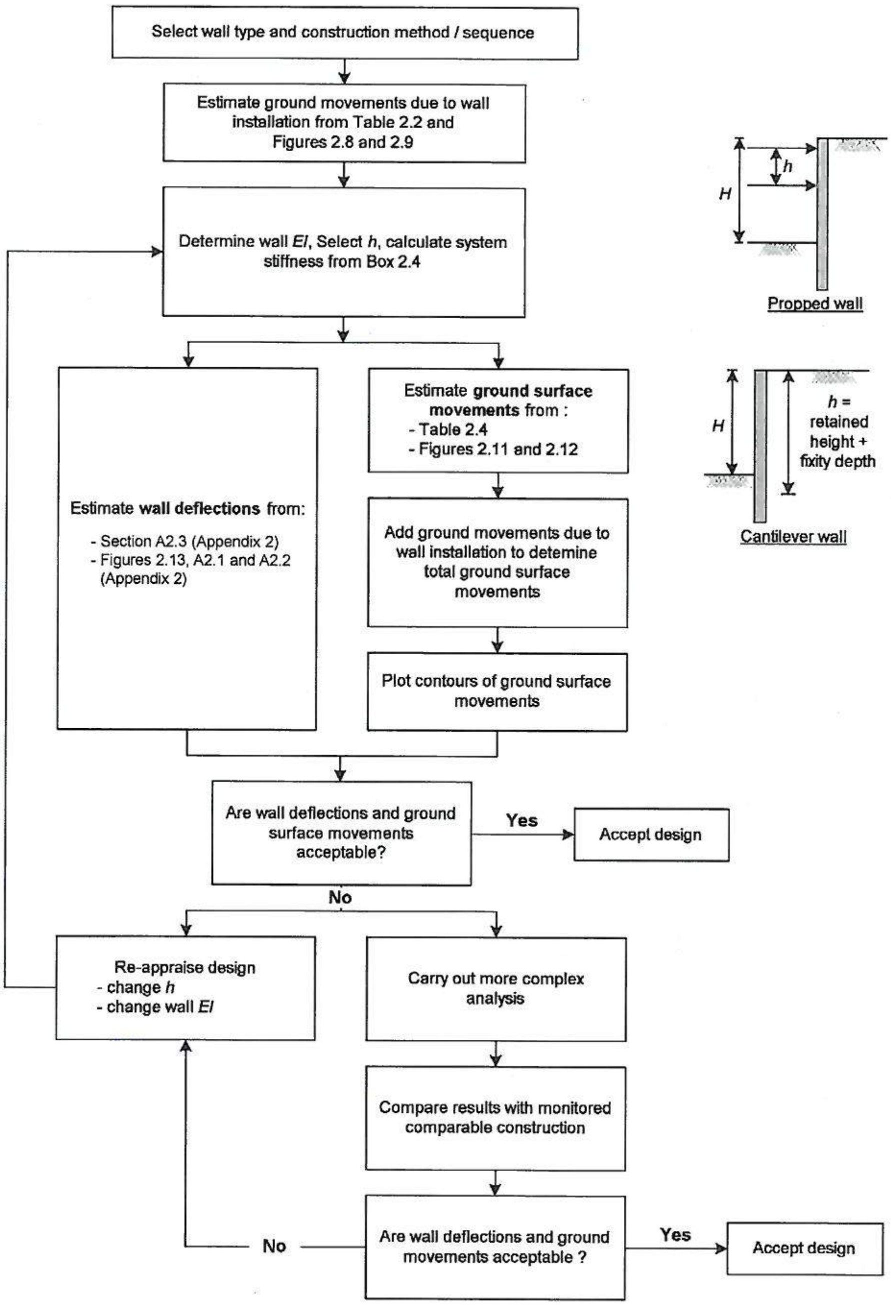

Figure 2.14 *Procedure for prediction of wall deflections and ground surface movements*

Estimates of wall deflections and associated ground surface movements should follow the procedure shown in Figure 2.14. Case-history-based empirical methods of prediction are to be preferred to use of complex analyses, unless such analyses are first "calibrated" against reliable measurements of well-monitored comparable excavations and wall systems. Table 2.4, in conjunction with Figure 2.11, can be used to estimate *ground surface movements associated with walls wholly embedded in stiff clay.* Figure 2.12 can be used for walls wholly embedded in sands. Preliminary estimates of *wall deflection* can be obtained from Figure 2.13 and from Section A2.3 in Appendix 2. This will depend upon the system stiffness, ρ_s, and the factor of safety against base heave. System stiffness is defined in Box 2.4. The reader is referred to CIRIA publication C517 (1999), Appendix 4, for a good definition and explanation of base stability.

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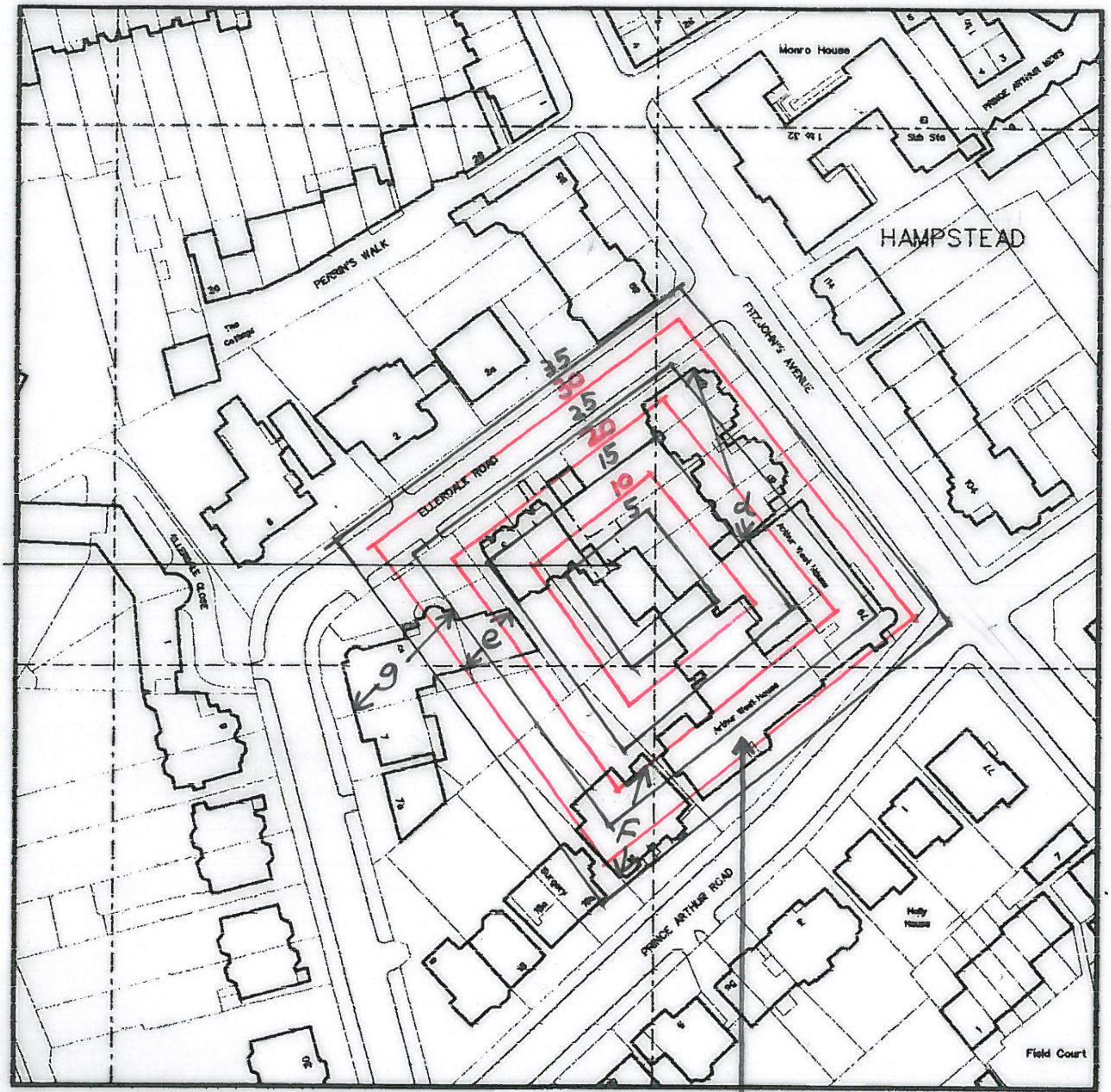
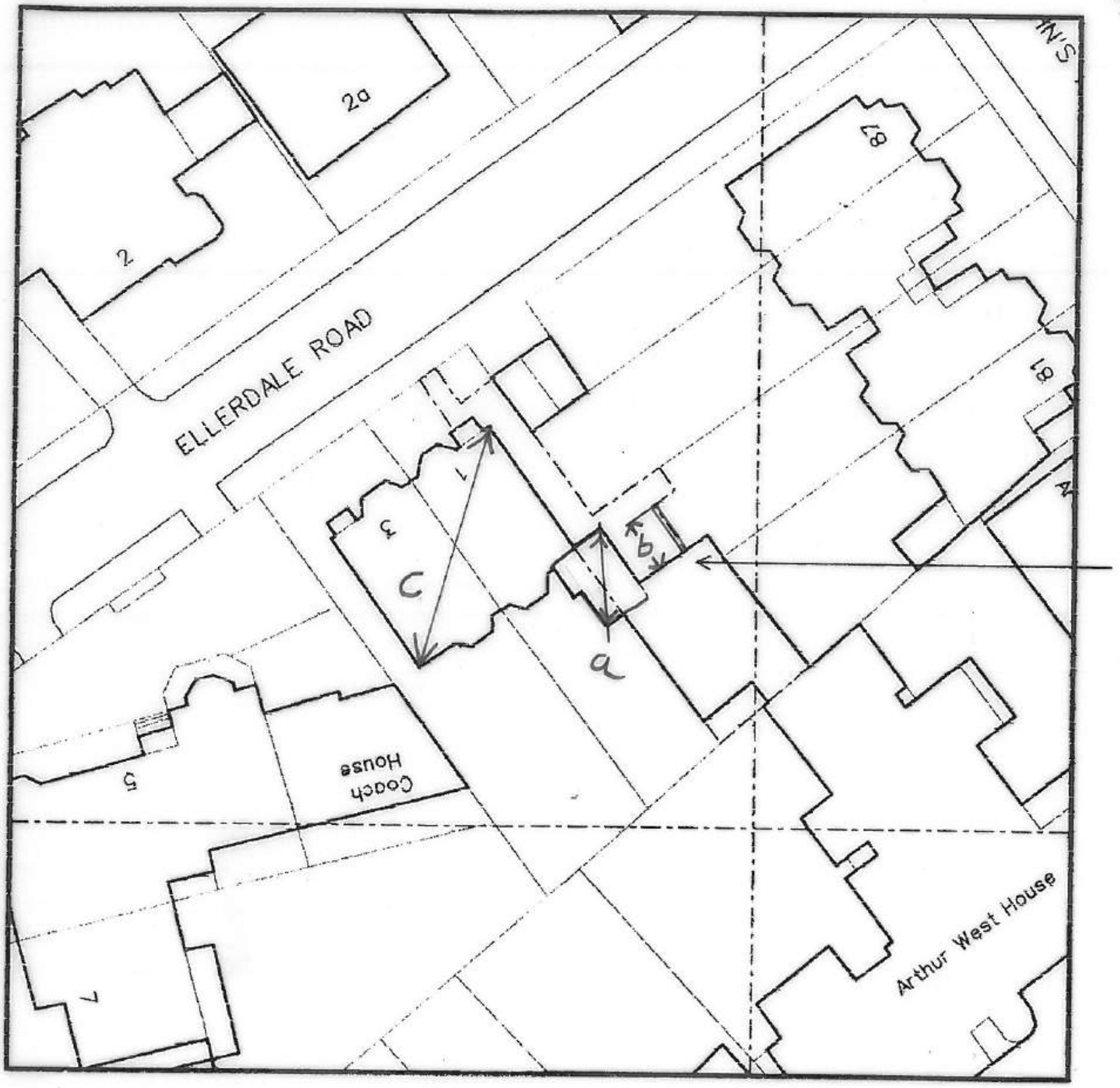


Site Location

SCALE 1:1250

N

ARTHUR WEST HOUSE
CURRENTLY UNDER
DEMOLITION



Block Plan

N

SCALE 1:500

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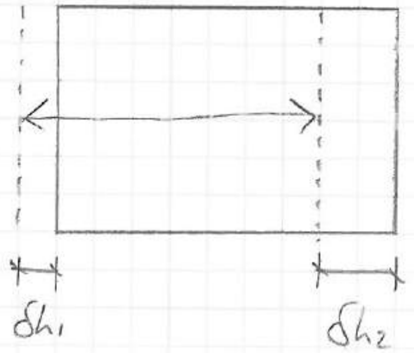
Date OCT '2015	Job no. 1706/02	Sheet 5
Engineer FLo		
Checked by HB/SPe		
Project ELLERDALE ROAD		

CALCULATIONS OF HORIZONTAL AND VERTICAL STRAINS IN THE BUILDINGS DUE TO THE DEFLECTIONS

HORIZONTAL STRAINS

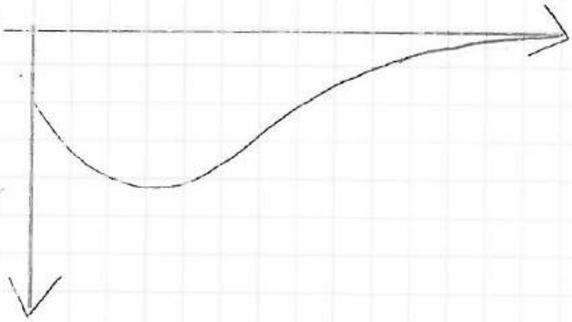


HORIZONTAL STRAIN

$$\varepsilon_h = \frac{\delta h_2 - \delta h_1}{L}$$

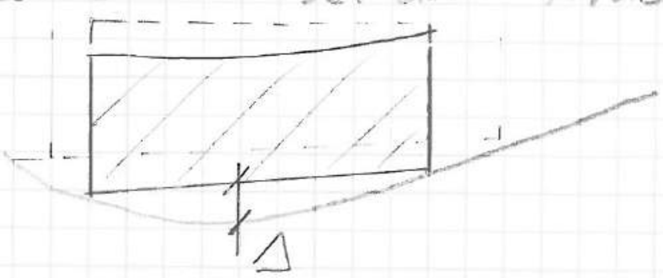
VERTICAL STRAINS

THE TOTAL VERTICAL DEFLECTION FOLLOWS THE FOLLOWING RELATIONSHIP:



VERTICAL STRAINS ARE MORE COMPLICATED TO CALCULATE THAN HORIZONTAL STRAINS

THE BUILDING WILL DEFORM THUS:



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Date NOV 2015	Job no. 1706/02	Sheet 6
Engineer FG		
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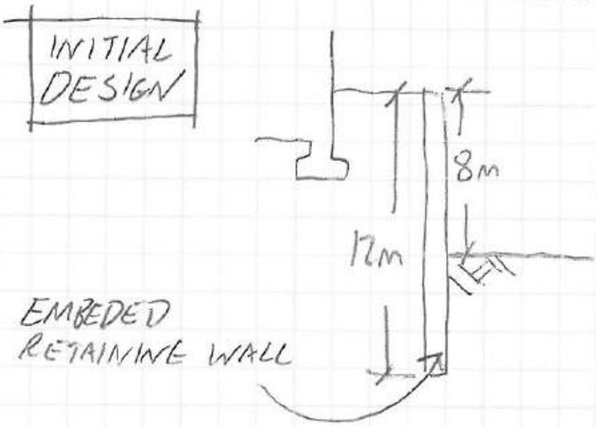
Project ELLERDALE ROAD		

CALCULATE PREDICTED GROUND MOVEMENTS TO REAR EXTENSION OF 1 ELLERDALE ROAD (CONTOR 1m TO 6m)

INITIAL DESIGN



PILE DEPTH : 12m
PILE TYPE : CONTIGUOUS

EXCAVATION DEPTH : 8m
ASSUME LOW SUPPORT STIFFNESS

1/ MOVEMENT DUE TO PILE INSTALLATION

BASED ON FIGURE 2.8 - C580

DISTANCE FROM WALL FACE (m)	MOVEMENT DUE TO PILE INSTALLATION HORIZONTAL (mm)	VERTICAL (mm)
1	4.4	4.6
2		4.0
6	2.4	3.6
8		3.0

2/ MOVEMENT DUE TO EXCAVATION - ASSUME LOW SUPPORT STIFFNESS

[TABLE 2.3] - C580 AND FIGURE 2.11

DISTANCE FROM WALL FACE (m)	MOVEMENT DUE TO EXCAVATION HORIZONTAL (mm)	VERTICAL (mm)
1	31.0	26.0
2		24.0
6	26.0	18.0
8		16.0

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Date NOV 2015	Job no. 1706/02	Sheet 7
Engineer FGO		
Checked by SPB		
Project ELLERDALE ROAD		

TOTAL MOVEMENT

DISTANCE FROM WALL FACE (m)	TOTAL MOVEMENT HORIZONTAL (mm)	VERTICAL (mm)
1	35.4	30.4
2	—	28.0
6	28.4	21.6
8	—	19.0

DAMAGE ASSESSMENT FOR EXTENSION TO 1 ELLERDALE ROAD

THE HORIZONTAL AND VERTICAL STRAIN WILL BE USED TO ASSESS THE BURLAND CATEGORY, IN ACCORDANCE WITH LIMITING STRAINS FOR EACH CATEGORY OUT LINED IN TABLE 2.5 C580 AND FIGURE 2.18

HORIZONTAL

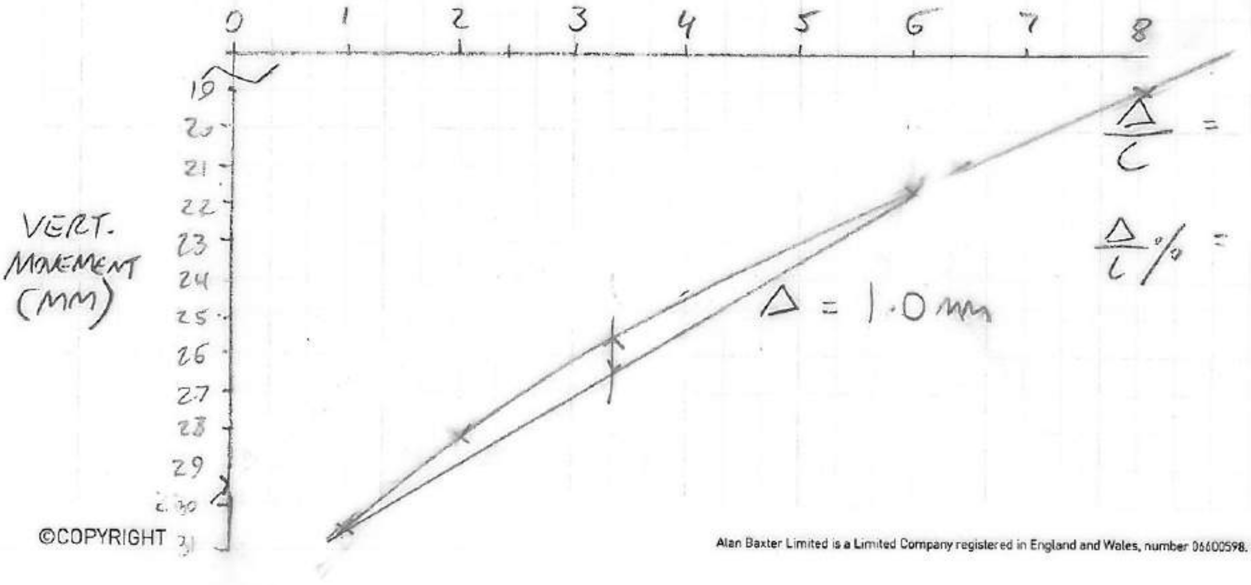
$\delta h_1 - \delta h_2 = 7$

$\varepsilon h = \dfrac{\delta h_1 - \delta h_2}{L}$

$= \dfrac{7}{5000}$

$\varepsilon h \% = 0.14\%$

VERTICAL



$\dfrac{\Delta}{L} = \dfrac{1.0}{5000}$

$\dfrac{\Delta}{L} \% = 0.02$

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Date NOV 2015	Job no. 1706/02	Sheet 8
Engineer FLo		
Checked by SBa		
Project ELLERDALE ROAD		

LIMIT STRAIN TO 0.15% BURLAND CAT 2 = SLIGHT

$\varepsilon_{lim} = 0.15$

$$\frac{\Delta/L}{\varepsilon_{lim}} = \frac{0.02}{0.15} = 0.13$$

$$\frac{\varepsilon_L}{\varepsilon_{lim}} = \frac{0.14}{0.15} = 0.93$$

$L/H = 1.7$ FROM FIGURE 2.18 → $\boxed{\text{NOT OKAY}}$

DAMAGE CATEGORY TO EXTENSION EXCEEDS BURLAND CAT. 2

RE RUN ASSESSMENT TO INCLUDE MITIGATION MEASURES (TEMPORARY PROPS TO PROVIDE HIGH SUPPORT STIFFNESS

ALSO TAKE INTO ACCOUNT THE RELATIVE DEPTH OF FOUNDATION TO 1 ELLERDALE ROAD AND REAR EXTENSION

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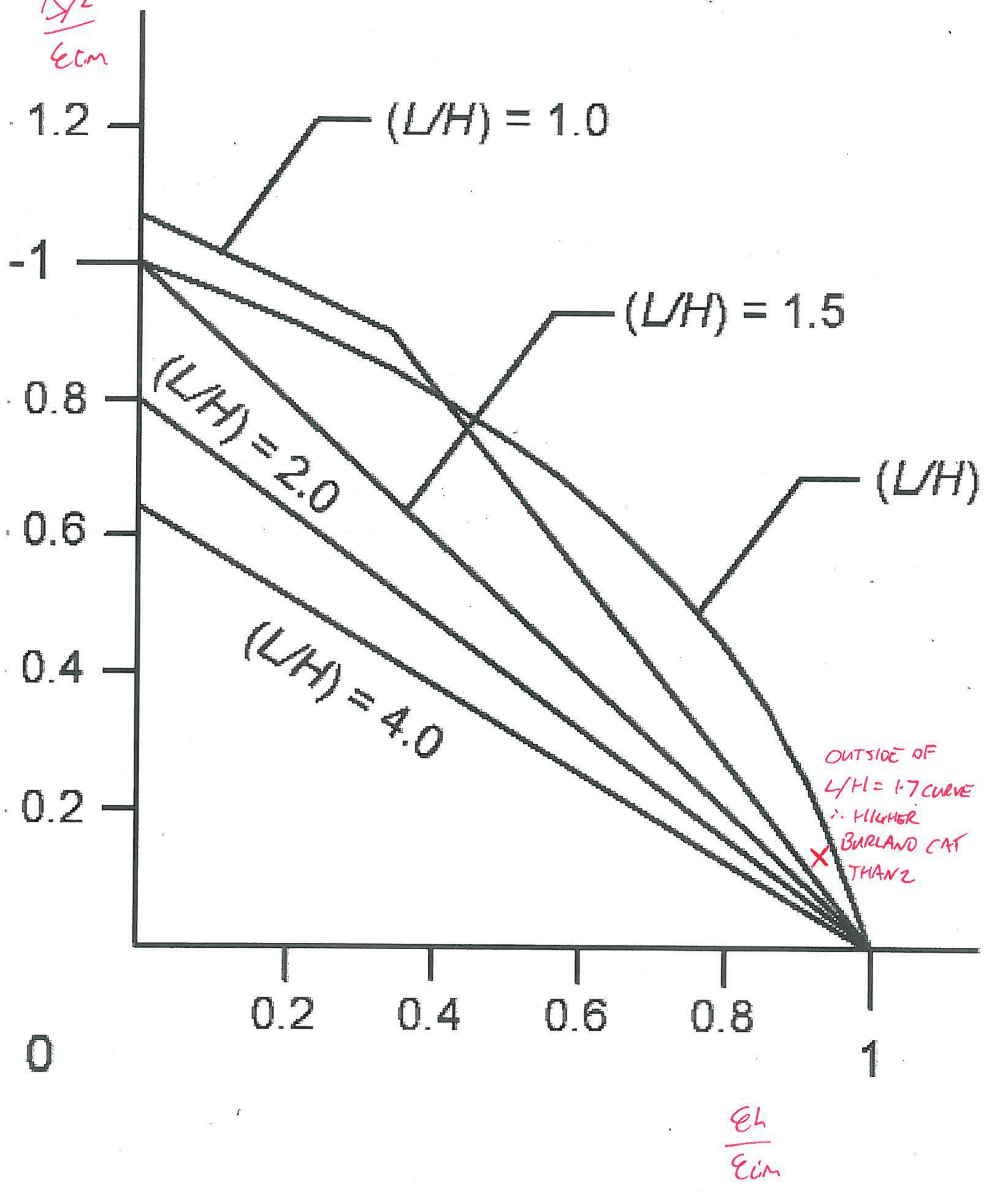

Δ/L
εlim
1.2
1
0.8
0.6
0.4
0.2
0
(L/H) = 1.0
(L/H) = 1.5
(L/H)
(L/H) = 2.0
(L/H) = 4.0
OUTSIDE OF
L/H = 1.7 CURVE
∴ HIGHER
BURLAND CAT
THAN 2
0.2
0.4
0.6
0.8
1
εh
εlim

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Date NOV 2015	Job no. 1706/02	Sheet 10
Engineer FGo		
Checked by SBe		
Project ELLERDALE ROAD		

GROUND MOVEMENT ESTIMATE IN ACCORDANCE WITH CIRIA C580 FOR BUILDINGS: b/, d/-g/

ESTIMATE MOVEMENTS USING EMPIRICAL RELATIONSHIPS AS PER C580 - EMBEDED RETAINING WALLS

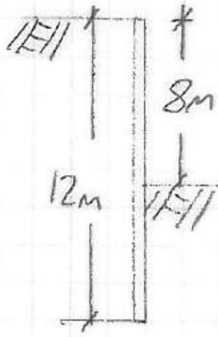
1 - MOVEMENT DUE TO PILE INSTALLATION

FINAL DESIGN

INCLUDE HIGH STIFFNESS PROPPING

BASED ON FIGURE 2.8 - C580

WALL TYPE: CONTIGUOUS PILE WALL
PILE DEPTH ≈ 12m



MOVEMENTS DUE TO PILE INSTALLATION
BASED ON FIG 2.8 CIRIA C580

DISTANCE FROM FACE OF WALL	MOVEMENT DUE TO PILE INSTALLATION HORIZONTAL (mm)	VERTICAL (mm)
0	4.8	4.8
1	4.4	4.6
5	2.8	3.8
10	1.6	2.8
15	0.6	1.8
20	0	0.8
25	0	0

DISTANCE BEHIND WALL TO NEGLIGIBLE HORIZONTAL MOVEMENT

$= 1.5d = 1.5 \times 12 = 18m$ [TABLE 2.2]

DISTANCE BEHIND WALL TO NEGLIGIBLE VERTICAL MOVEMENT

$= 2.0d = 2.0 \times 12 = 24m$ [TABLE 2.2]

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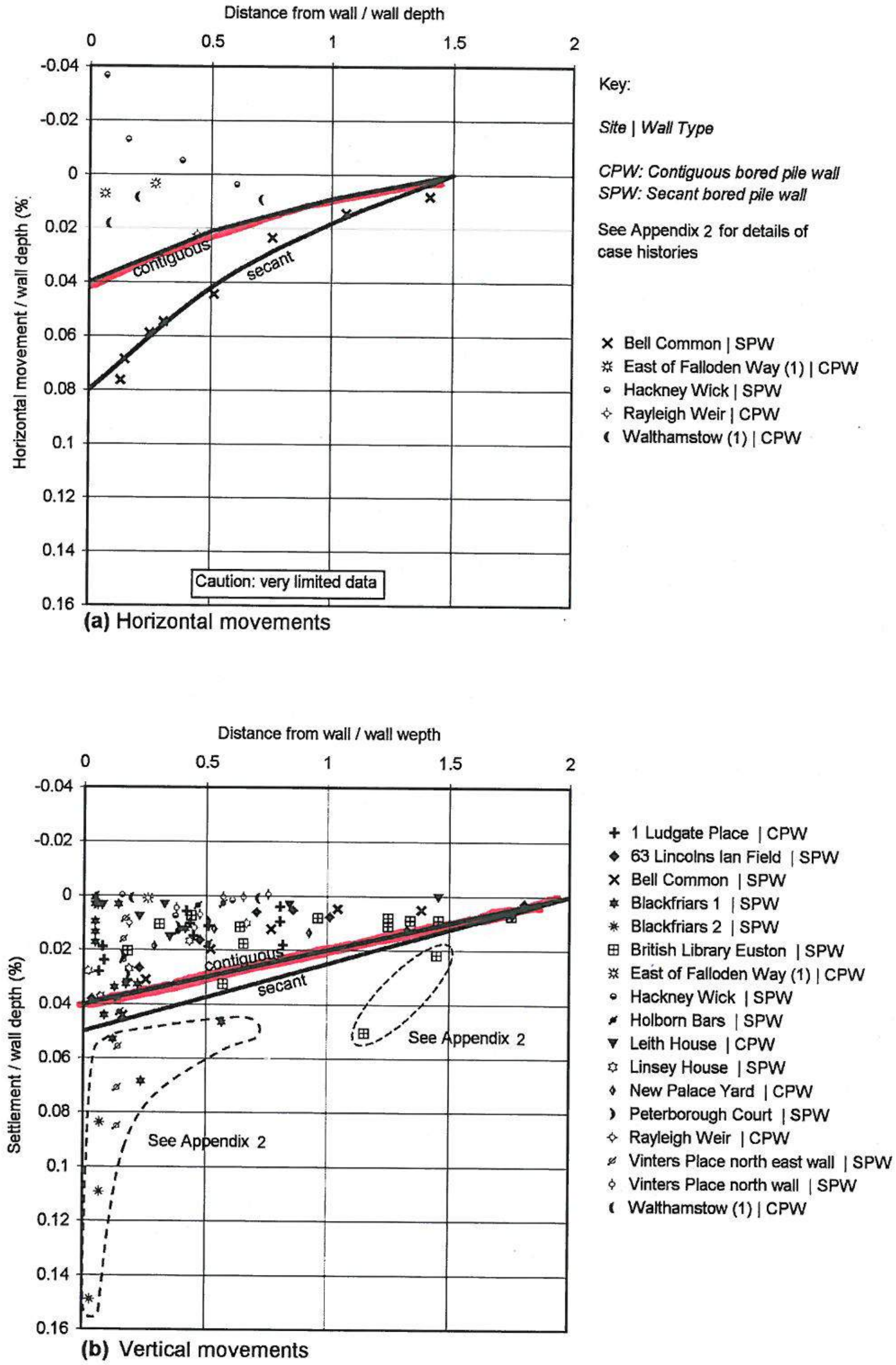

Figure 2.8 *Ground surface movements due to bored pile wall installation in stiff clay*

12

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.

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Date NOV' 2015	Job no. 1706/02	Sheet 13
Engineer FGO		
Checked by Sba		
Project ELLERDALE ROAD		

2 - MOVEMENT DUE TO EXCAVATION

ASSUME HIGH SUPPORT STIFFNESS AS TEMPORARY PROPS INSTALLED BEFORE PERMANENT PROPS (SLABS) AT HIGH LEVEL

[TABLE 2.3]

DEPTH OF EXCAVATION = 8m BASED ON FIGURE 2.11

DISTANCE FROM FACE OF WALL m	MOVEMENT DUE TO EXCAVATION	
	HORIZONTAL (mm)	VERTICAL (mm)
0	12.0	3.3
1	11.6	4.1
5	10.1	6.2
10	8.3	5.2
15	6.4	3.3
20	4.5	1.5
25	2.6	0.7
30	0.8	0
35	0	0

DISTANCE BEHIND WALL TO NEGLIGIBLE HORIZONTAL MOVEMENT

= 4 × 8 = 32m

DISTANCE BEHIND WALL TO NEGLIGIBLE VERTICAL MOVEMENT

= 3.5 × 8 = 28m

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14

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.

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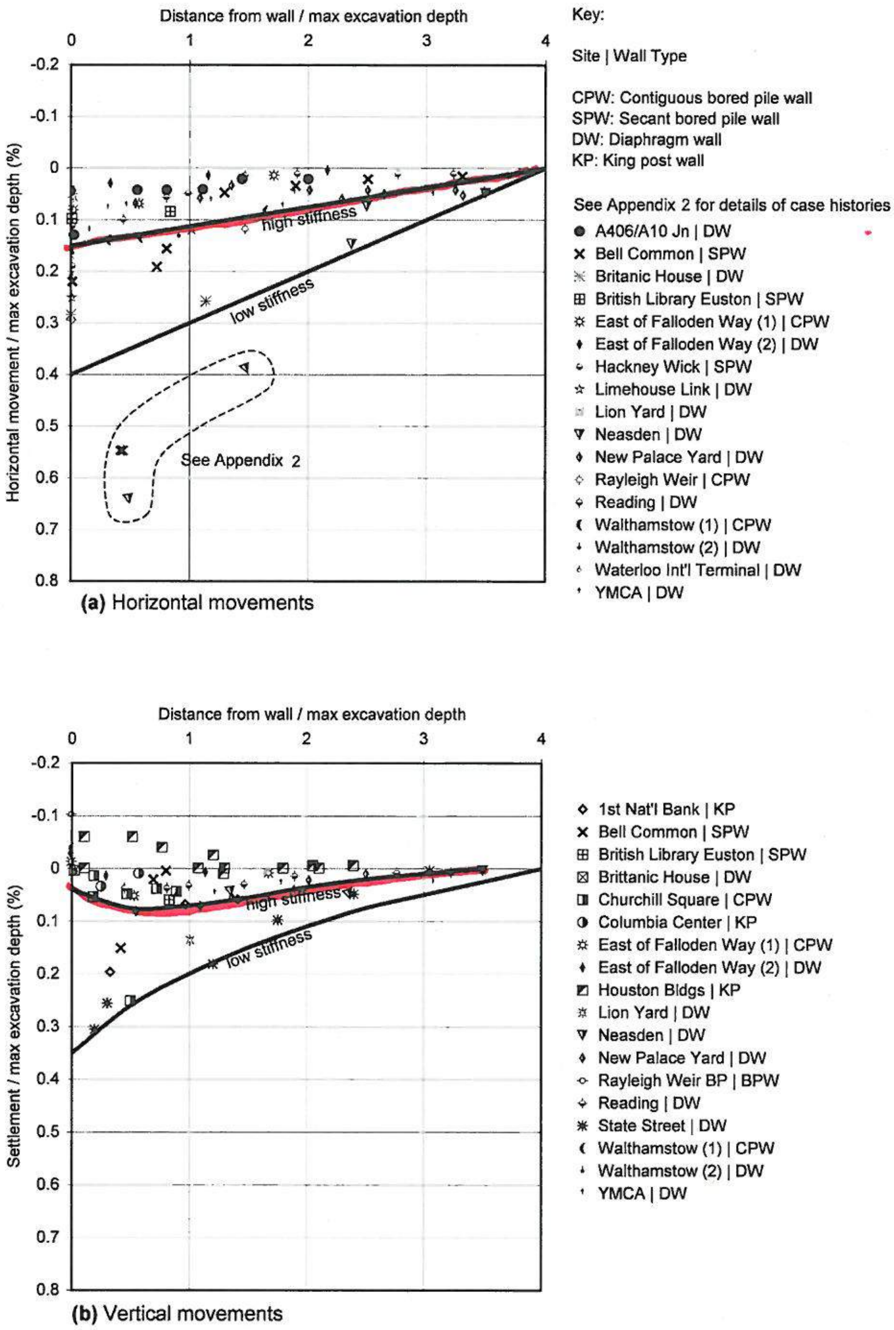

Figure 2.11 *Ground surface movements due to excavation in front of wall in stiff clay*

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Date NOV' 2015	Job no.	Sheet
Engineer FGo	1706/02	16
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Project ELLERDALE ROAD		

TOTAL GROUND SURFACE MOVEMENTS

ADD MOVEMENTS DUE TO PILE INSTALLATION AND EXCAVATION

DISTANCE FROM WALL FACE (M)	TOTAL MOVEMENT	
	HORIZONTAL (mm)	VERTICAL (mm)
0	16.8	8.1
1	16.0	8.7
5	12.9	10.0
10	9.9	8.0
15	7.0	5.1
20	4.5	2.3
25	2.6	0.7
30	0.8	0
35	0	0

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Date NOV '2015	Job no. 1706/02	Sheet 17
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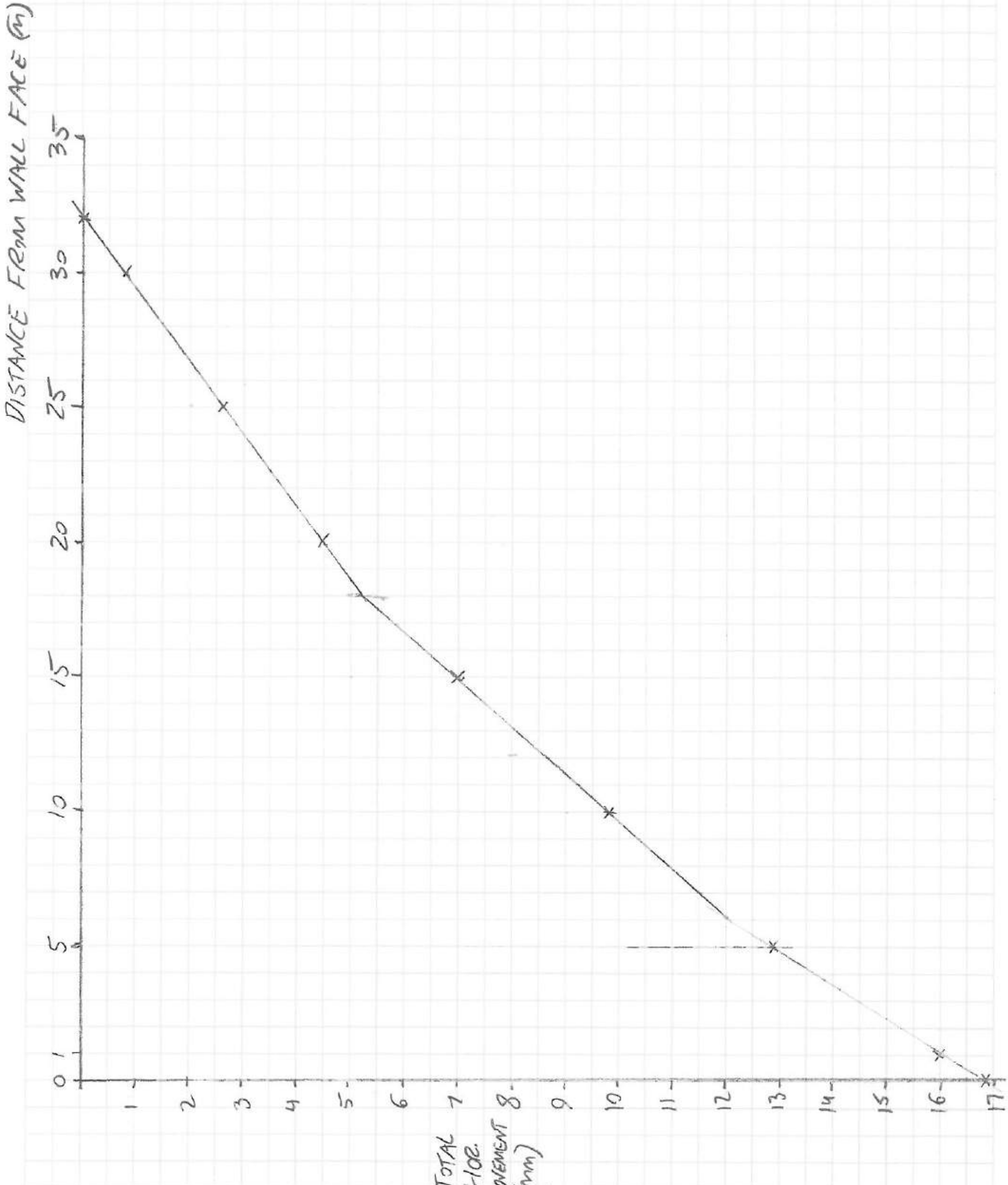

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Date NOV 2015	Job no. 1706/22	Sheet 18
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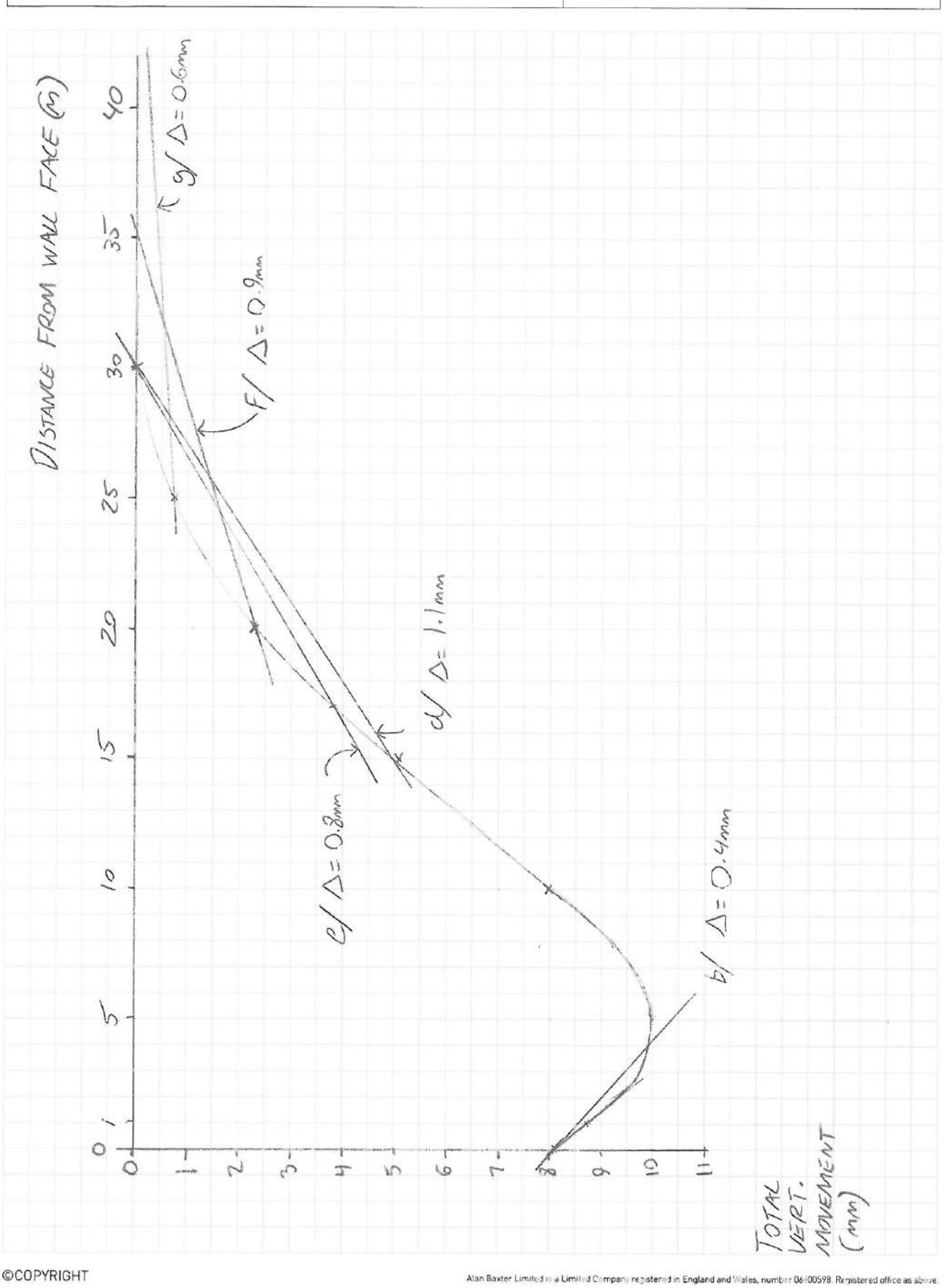

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Date NOV 2015	Job no.	Sheet
Engineer FGo	1706/02	19
Checked by [signature]		
Project ELLERDALE ROAD		

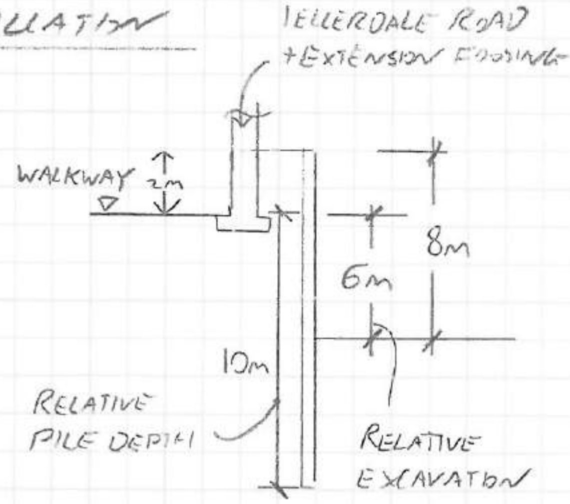
GROUND MOVEMENT ESTIMATE IN ACCORDANCE WITH

CIRIA C580 FOR BUILDINGS a/ + c/

ESTIMATE MOVEMENTS USING EMPIRICAL RELATIONSHIPS AS PER C580 - EMBEDED RETAINING WALLS. BUILDINGS a/ AND c/ ARE BEING CONSIDERED SEPARATELY AS THEY ARE KNOWN TO BE FOUNDED MORE THAN 2m BELOW GROUND LEVEL

1 - MOVEMENT DUE TO PILE INSTALLATION

BASED ON FIGURE 2.8 C580



DISTANCE FROM FACE OF WALL	MOVEMENT DUE TO PILE INSTALLATION HORIZONTAL (mm)	VERTICAL (mm)
0	4.0	4
2	3.2	3.6
4	2.4	3.2
6	1.8	2.8
8	1.3	2.4
10	0.9	2.0
12	0.5	1.6
14	0.2	1.2
20	0	0

DISTANCE BEHIND WALL TO NEGLIGIBLE HORIZONTAL MOVEMENT

$= 1.5d = 1.5 \times 10 = 15m$

DISTANCE BEHIND WALL TO NEGLIGIBLE VERTICAL MOVEMENT

$= 2.0d = 2.0 \times 10 = 20m$

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Date NOV 2015	Job no. 1706/02	Sheet 20
Engineer FEo		
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Project ELLERDALE ROAD		

2- MOVEMENT DUE TO EXCAVATION

ASSUME HIGH SUPPORT STIFFNESS AS TEMPORARY PROPS INSTALLED BEFORE PERMANENT PROPS (SLABS) AT HIGH LEVEL

[TABLE 2.3]

DEPTH OF EXCAVATION - RELATIVE TO 1 ELLERDALE ROAD = 6m BASED ON FIGURE 2.11

DISTANCE FROM FACE OF WALL (m)	MOVEMENT DUE TO EXCAVATION HORIZONTAL (mm)	VERTICAL (mm)
0	9.0	2.9
2	8.3	4.0
4	7.5	4.7
6	6.8	4.2
8	6.0	3.5
10	5.3	2.9
12	4.5	2.0
14	3.8	1.4
20	1.5	0.3
24	0	0

DISTANCE BEHIND WALL TO NEGLIGIBLE HORIZONTAL MOVEMENT

$= 4.0 \times d = 4.0 \times 6 = 24m$

DISTANCE BEHIND WALL TO NEGLIGIBLE VERTICAL MOVEMENT

$= 3.5 \times d = 3.5 \times 6 = 21m$

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Date NOV 2015	Job no.	Sheet
Engineer EKo	1706/02	21
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TOTAL GROUND SURFACE MOVEMENTS

ADD MOVEMENTS DUE TO PILE INSTALLATION AND EXCAVATION

DISTANCE FROM WALL FACE (m)	TOTAL MOVEMENT HORIZONTAL (mm)	VERTICAL (mm)
0	13.0	6.9
2	11.5	7.6
4	9.9	7.9
6	8.6	7.0
8	7.3	5.9
10	6.2	4.9
12	5.0	3.6
14	4.0	2.6
20	1.5	0.3
24	0	0

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Date NOV 2015	Job no. M06/02	Sheet 22
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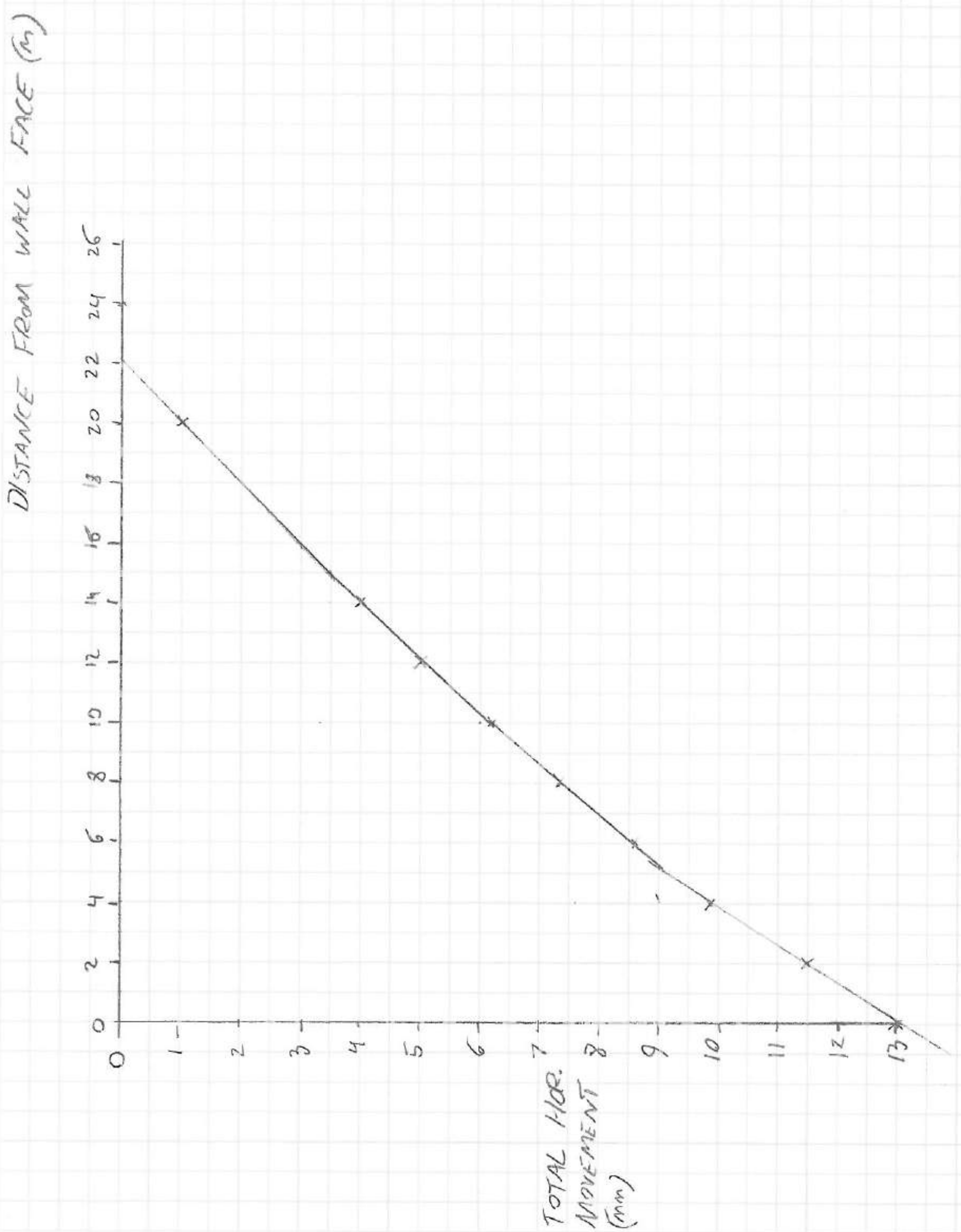
Project ELLERDALE ROAD		



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Date Nov 2015	Job no. 1706/02	Sheet 23
Engineer FGo		
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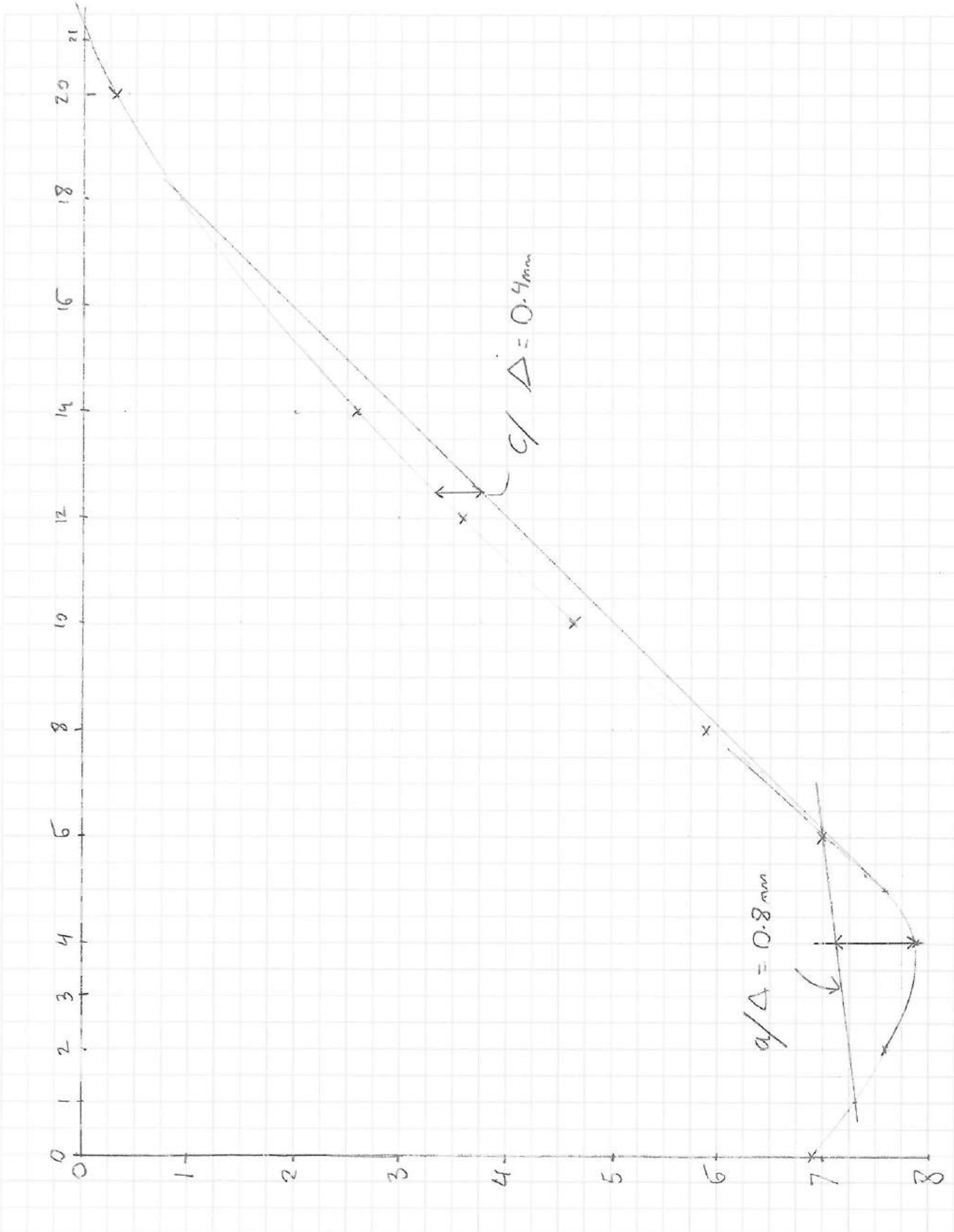
Project ELLERDALE ROAD		



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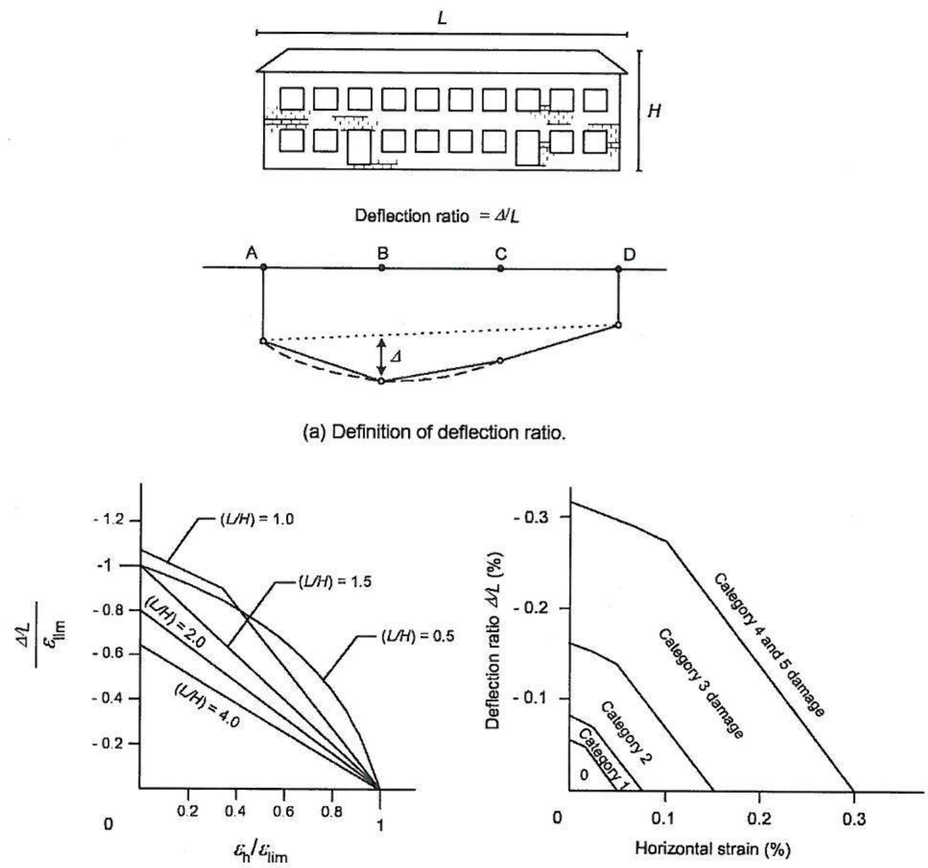

(b) Influence of horizontal strain on $\Delta L / \varepsilon_{lim}$ (after Burland, 2001)

(c) Relationship between damage category and deflection ratio and horizontal tensile strain for hogging for (L/H) = 1.0 (after Burland, 2001)

By adopting values of ε_{lim} associated with the various damage catgories given in Table 2.5, Figure (b) can be developed into an interaction diagram showing the relationship between Δ/L and ε_h for a particular value of L/H Figure (c) shows such a diagram for (L/H) = 1.0.

Figure 2.18 *Relationship between damage category, deflection ratio and horizontal tensile strain (after Burland, 2001)*

Reinforced concrete-framed structures are more flexible in shear than are masonry structures and are consequently less susceptible to damage. Nevertheless, for the purposes of a stage 2 assessment of potential damage, all structures should be treated as masonry structures.

Box 2.5 *Procedure for stage 2 damage category assessment*

The following steps should be undertaken in making a stage 2 assessment of the damage to a structure:

(i) establish L and H for the structure (see Figure 2.18(a) for definitions of L and H)

(ii) determine (L/H)

(iii) determine relationship between (Δ/L) and ε_h for the required (L/H) from Figure 2.18(b) for ε_{lim} values from Table 2.5

(iv) estimate vertical and horizontal ground surface movements in the vicinity of the structure from Figure 2.14

(v) determine (Δ/L) and ε_h (= δ_h/L) where δ_h is the horizontal movement

(vi) estimate damage category from the relationship between (Δ/L) and ε_h established from step (iii) above.

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