Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no.	Sheet
Engineer DP	1636/03	.0
Checked by SN		
Project 62 Avenue Road		

Ground movement calculations for 62 Avenue Road

Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no.	Sheet
Engineer DP	1636/03	.1
Checked by SN		
Project 62 Avenue Road		

Ground Movements in accordance with CIRIA C580

Assume foundations to No. 60 Avenue Road = 1m below ground. House known not to have a basement

Assume foundations to No 64 Avenue Road = 3.5m below ground for main house House known to have basement

and 1m below ground for side annexe

Estimate ground movements using empirical relationships as per C580 - Embedded retaining walls

Pile depth below surface (Refer to pile design calculations on pgs PR1 - PR3)

= 15 - depth of footing

= 15 - 1 = 14m for No. 60 and No. 64 side annexe

= 15 - 3.5 = 11.5 for No. 64

Use worse case = 14m Δh for all - conservative.

Due to piling

Use Fig 2.8, CIRIA 580 ∴ using appropriate formulae of graph lines (p. 3)

Distance from wall (m)	Distance from wall ÷ 14 (x on graph)	y = horizontal movements % wall depth (%)	y = vertical movements % wall depth (%)
0	0	0.04	0.04
1	0.07	0.037	0.037
5	0.36	0.026	0.033
10	0.71	0.02	0.026
15	1.07	0.008	0.019
20	1.43	0	0.011

Alan Baxter

75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no. 1636/07	Sheet .2
Engineer DP		
Checked by SN		
Project 62 Avenue Road		

Based on depth = 14m

Distance from wall (m)	Horizontal movements (mm)	Vertical movements (mm)
0	5.6	5.6
1	5.2	5.5
5	3.6	4.6
10	2.8	3.6
15	1.1	2.7
20	0	1.5

$\boxed{y = c - mx}$

3

$c = 0.035$
$m = \frac{0.01}{0.5} = 0.02$
$\rightarrow y = 0.035 - 0.02x$

$c = 0.025$
$m = \frac{0.008}{0.5} = 0.016$
$\rightarrow y = 0.025 - 0.016x$

$c = 0.04$
$m = \frac{0.02}{0.5} = 0.04$
$\rightarrow y = 0.04 - 0.04x$

$C = 0.04$
$M = \frac{0.04}{2} = 0.02$
$y = 0.04 - 0.02x$

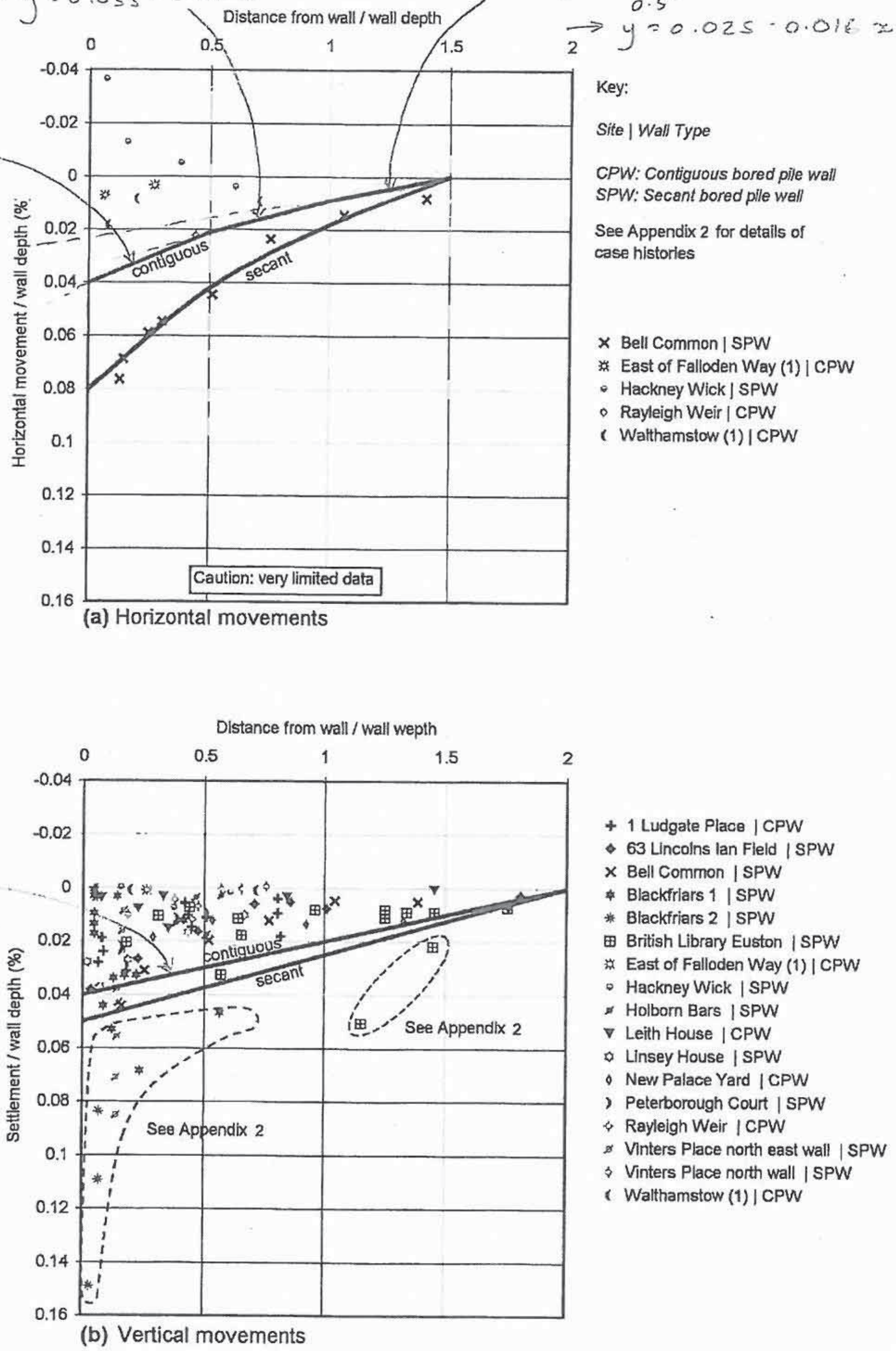


Figure 2.8 *Ground surface movements due to bored pile wall installation in stiff clay*

Due to excavation of basement

- The proposal is to use top down construction, therefore use high stiffness values.
- max excavation depth = 6.5m B.G.L ∴ 5.5m below No. 60
- Use fig 2.11, CIRIA 580.. using approximate formulae of graph lines (p.5)

Distance from wall (m)	x: Distance from wall ÷ 5.5m	y: Horizontal movements ÷ max elevation	Vertical movements ÷ max elevation (%)
0	0	0.15	0.045
1	0.18	0.14	0.061
5	0.9	0.12	0.07
10	1.82	0.08	0.04
15	2.73	0.05	0.01
20	3.64	0.01	0

Distance from wall (m)	Horizontal movement (mm)	Vertical movement (mm)
0	8.3	2.5
1	7.7	3.4
5	6.6	3.9
10	4.4	2.2
15	2.8	0.6
20	0.6	0

$\boxed{y = c - mx}$

(5)

$c = 0.15$

$m = \frac{0.15}{4} = 0.038$

$\rightarrow y = 0.15 - 0.038x$

$c = 0.1$

$m = \frac{0.1}{3} = 0.033 \rightarrow y = 0.1 - 0.033x$

$c = 0.045$

$m = \frac{0.045}{0.5} = -0.09$

$\rightarrow y = 0.045 + 0.09x$

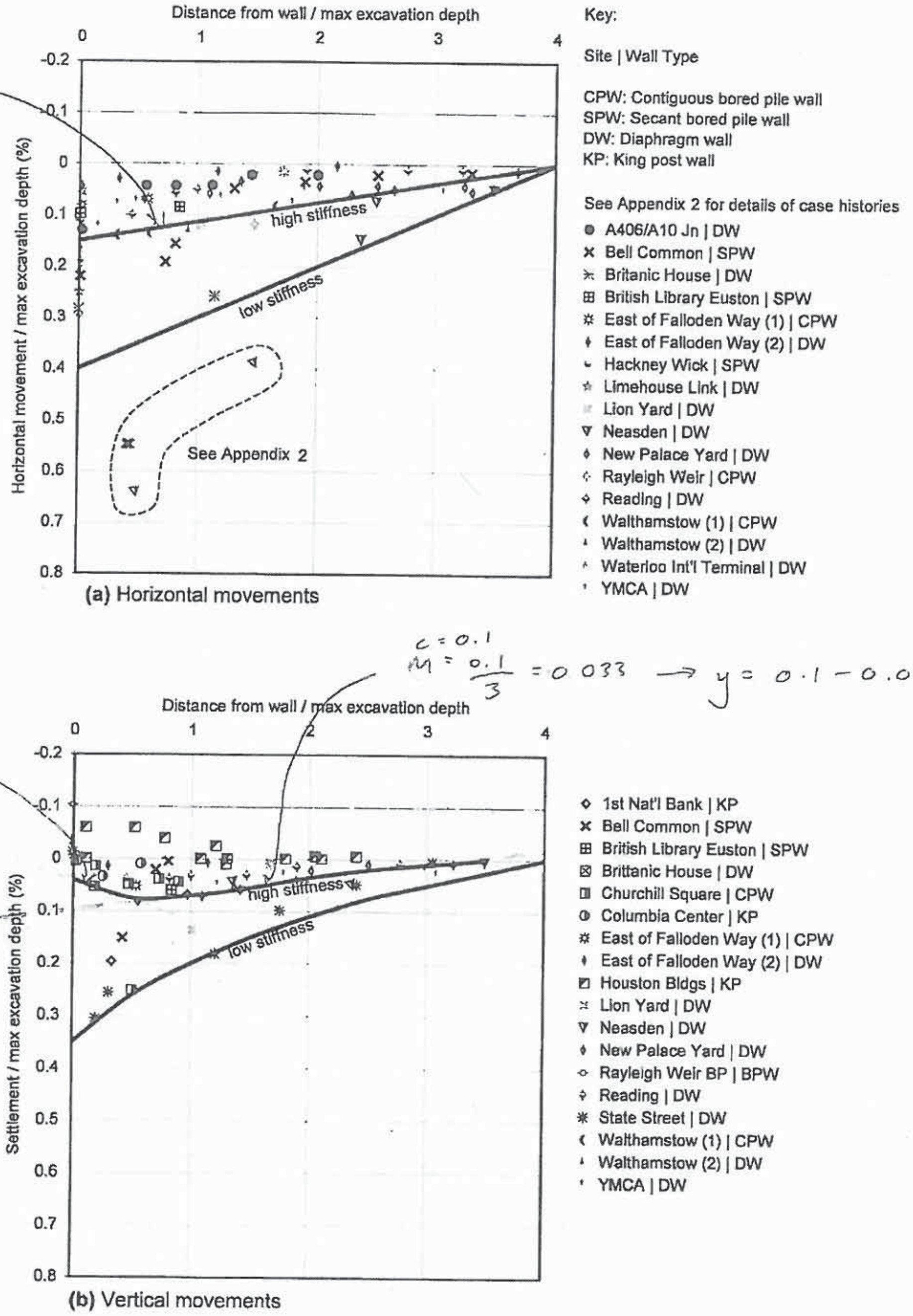


Figure 2.11 *Ground surface movements due to excavation in front of wall in stiff clay*

Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no. 1636/03	Sheet .6
Engineer DI		
Checked by SN		
Project 62 Avenue Road		

Assume corners can only move due to piling and not excavation

Total movements (at centre of piled wall

Distance from wall	Horizontal (mm)	Vertical (mm)
0	13.9	8.1
1	12.9	8.9
5	10.2	8.5
10	7.2	5.6
15	3.9	3.3
20	0.6	1.5

Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
July 16	1636/02	7
Engineer DP		
Checked by SN		
Project 62 Avenue Road		

These figures are used to plot a contour plot of the ground movements. Note movements due to piling and excavation are combined
The contour plot takes into consideration the relative stiffness of RC piled wall based on its geometry note the movements calculated are the upper bound and in reality movements are likely to be much less.
From the movements plotted on the contour plot the Burland damage category has been assessed

The adjacent buildings comprise:
No. 60 and No. 64 Avenue Road main house + annexe

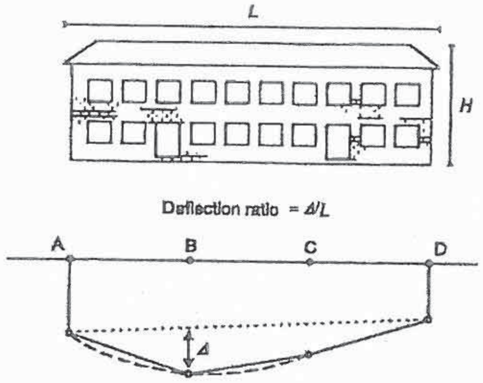
The dimensions of these are shown below

	L (m)	H (m)	L/H
No 64 Rear	18	14	1.28
No 64 side	21	14	1.5
No 64 side annexe	16	4.5	3.5
No 60 front	18	13	1.38
No 60 side	14	13	1.08

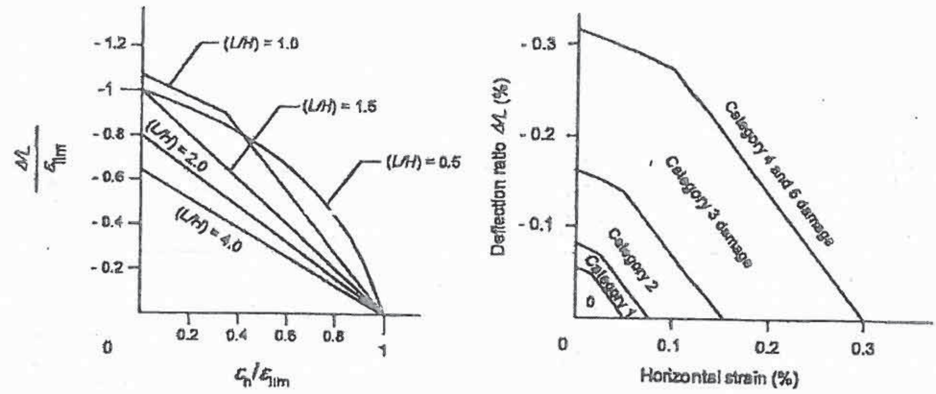
Alan Baxter

75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
fax 020 7250 3022
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no.	Sheet
Engineer DP	1636/02	.8
Checked by SN		
Project 62 Avenue Road		



(a) Definition of deflection ratio.



(b) Influence of horizontal strain on Δ/L / ε_{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 2.6 *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 $(= \delta_h/L)$ 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.

Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
fax 020 7250 3022
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

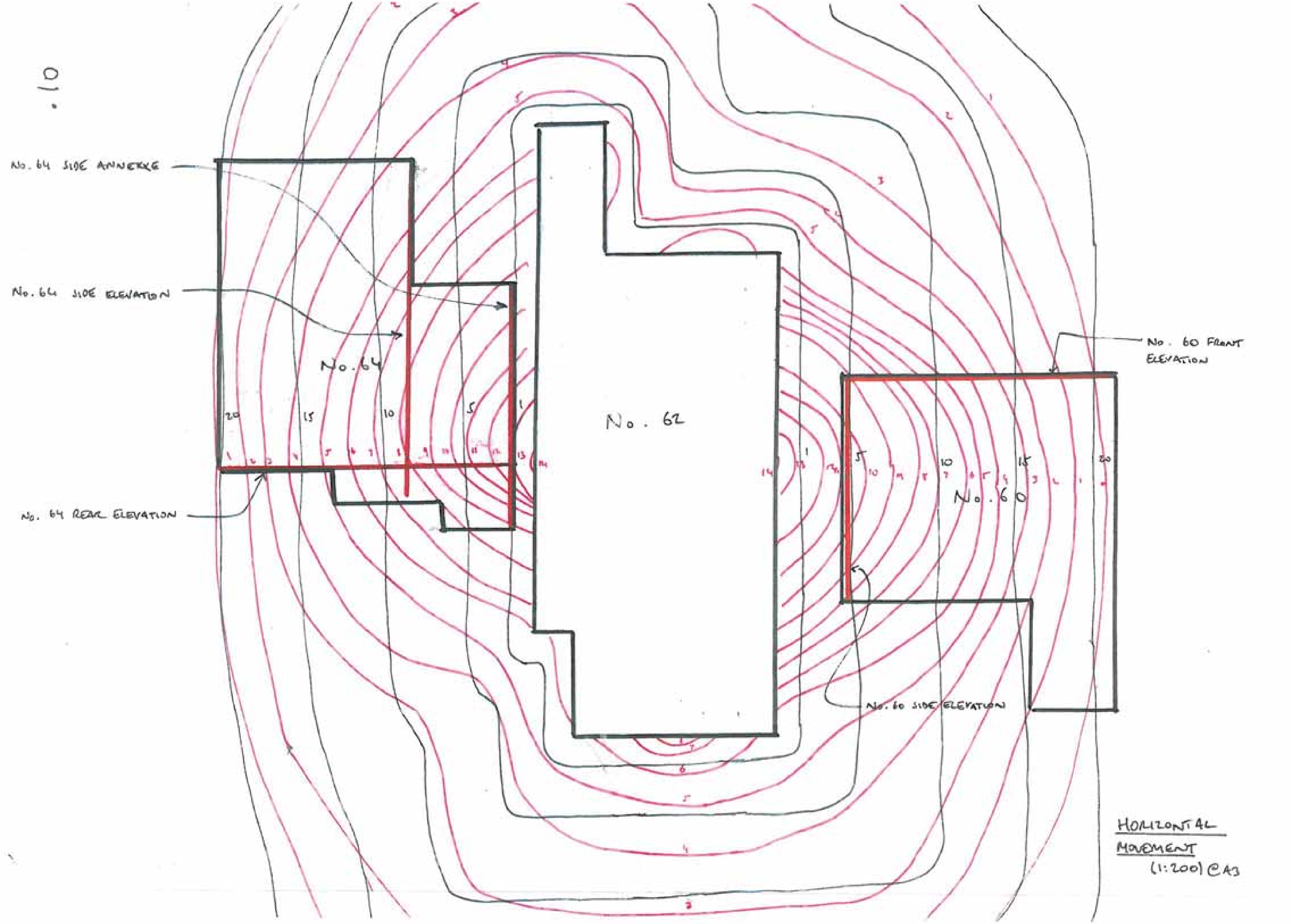
Date	Job no.	Sheet
July 16	1636/03	9
Engineer: DP		
Checked by: SN		
Project: 6C Avenue Road		

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	<u>Fine cracks that can easily be treated during normal decoration.</u> Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	<u>Cracks easily filled. Redecoration probably required.</u> Several slight fractures showing inside of building. Cracks are visible externally and <u>some repointing may be required externally</u> to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	<u>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.</u> 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	<u>Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows.</u> 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	<u>This requires a major repair involving partial or complete rebuilding.</u> Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks.	

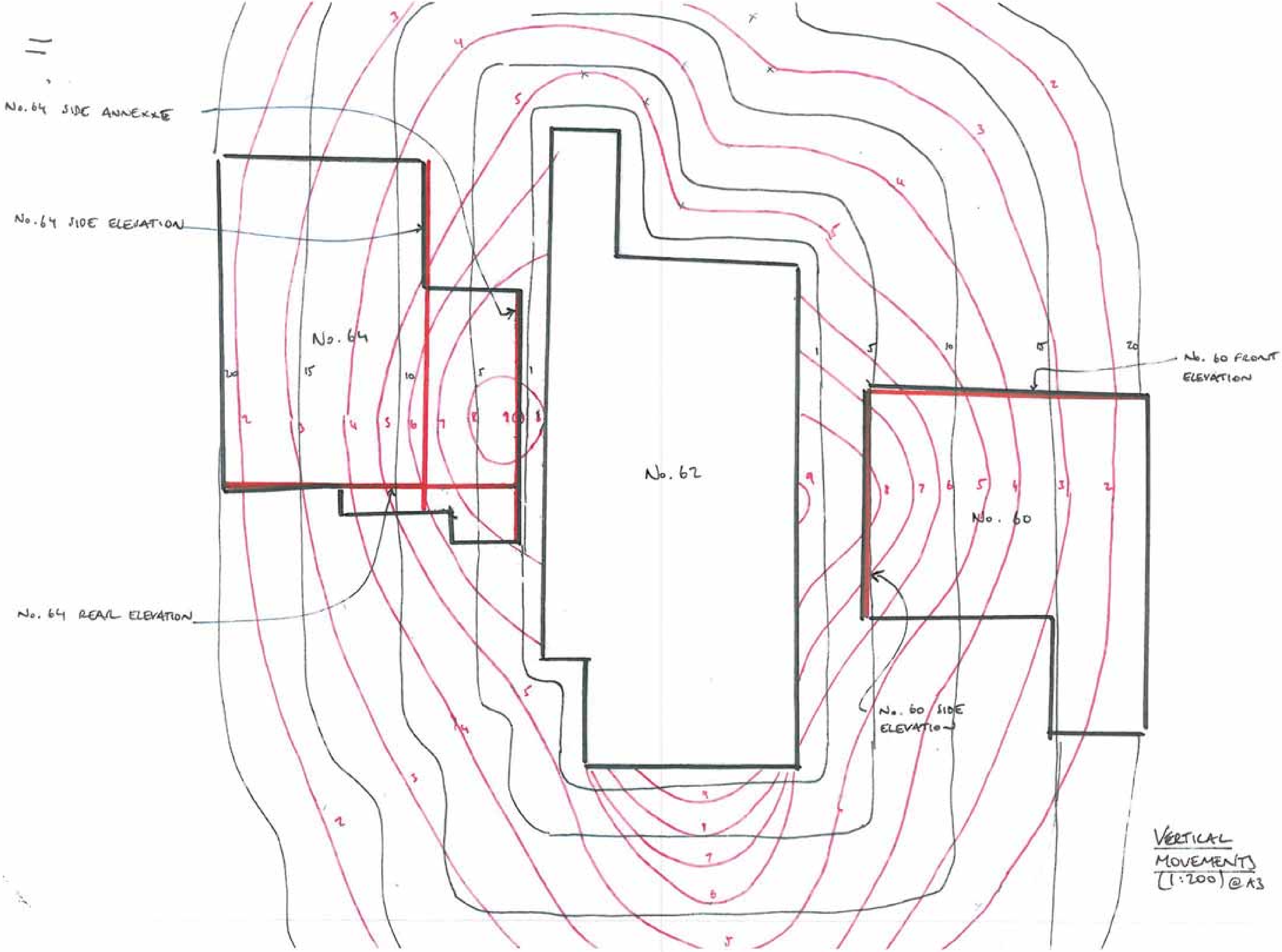
Notes

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.



HORIZONTAL MOVEMENT
(1:200) @A3

11



VERTICAL MOVEMENTS (1:200) @ A3

Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no.	Sheet
Engineer DP	1636/03	.12
Checked by SN		
Project 62 Avenue Road		

Graphs for No. 64 Avenue Road

A Rear - vertical
Horizontal

B Side - Vertical
Horizontal

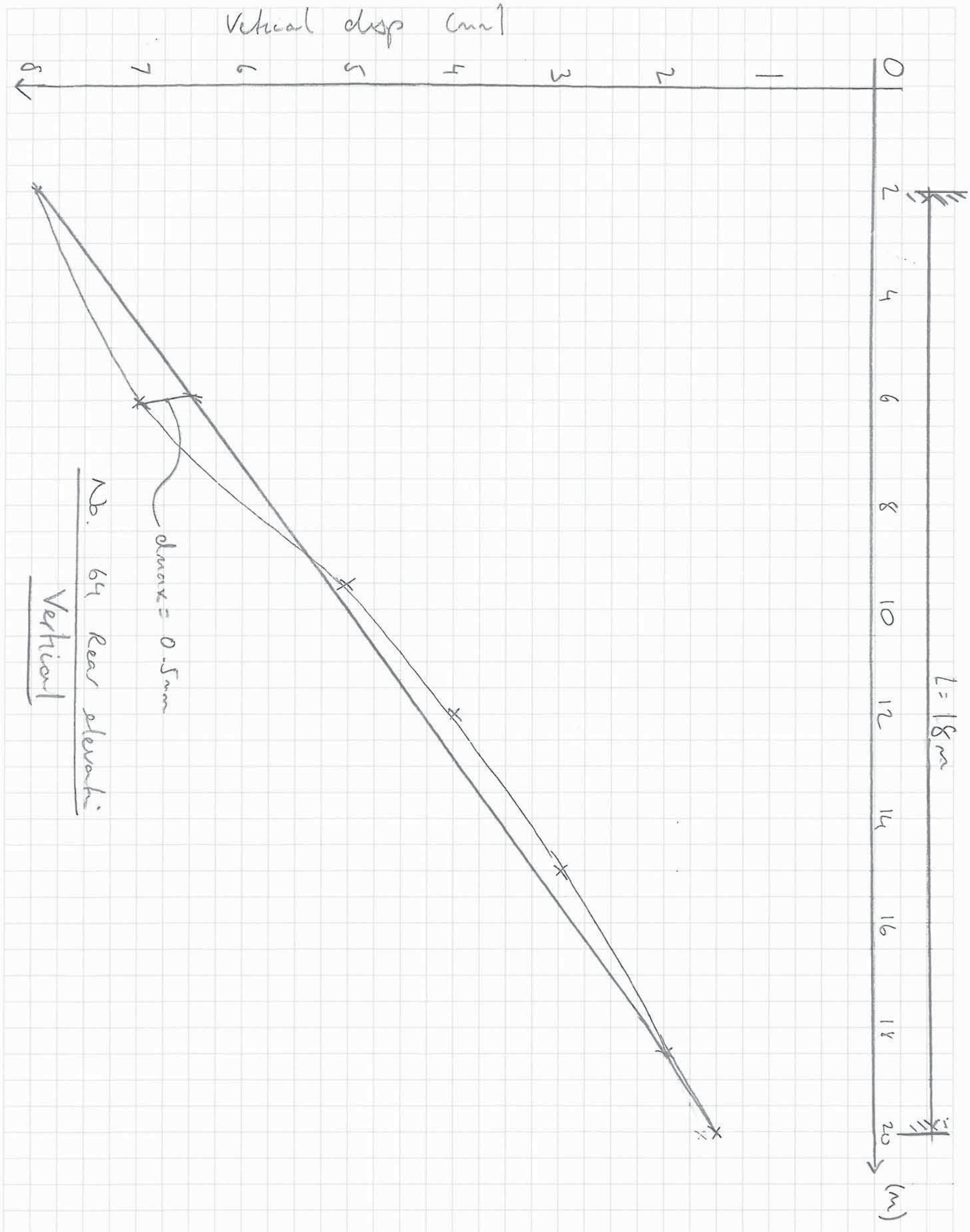
C Annexe - vertical
Horizontal

Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
July 16	1636/07	.13.
Engineer DP		
Checked by SN		
Project: 62 Avenue Road		

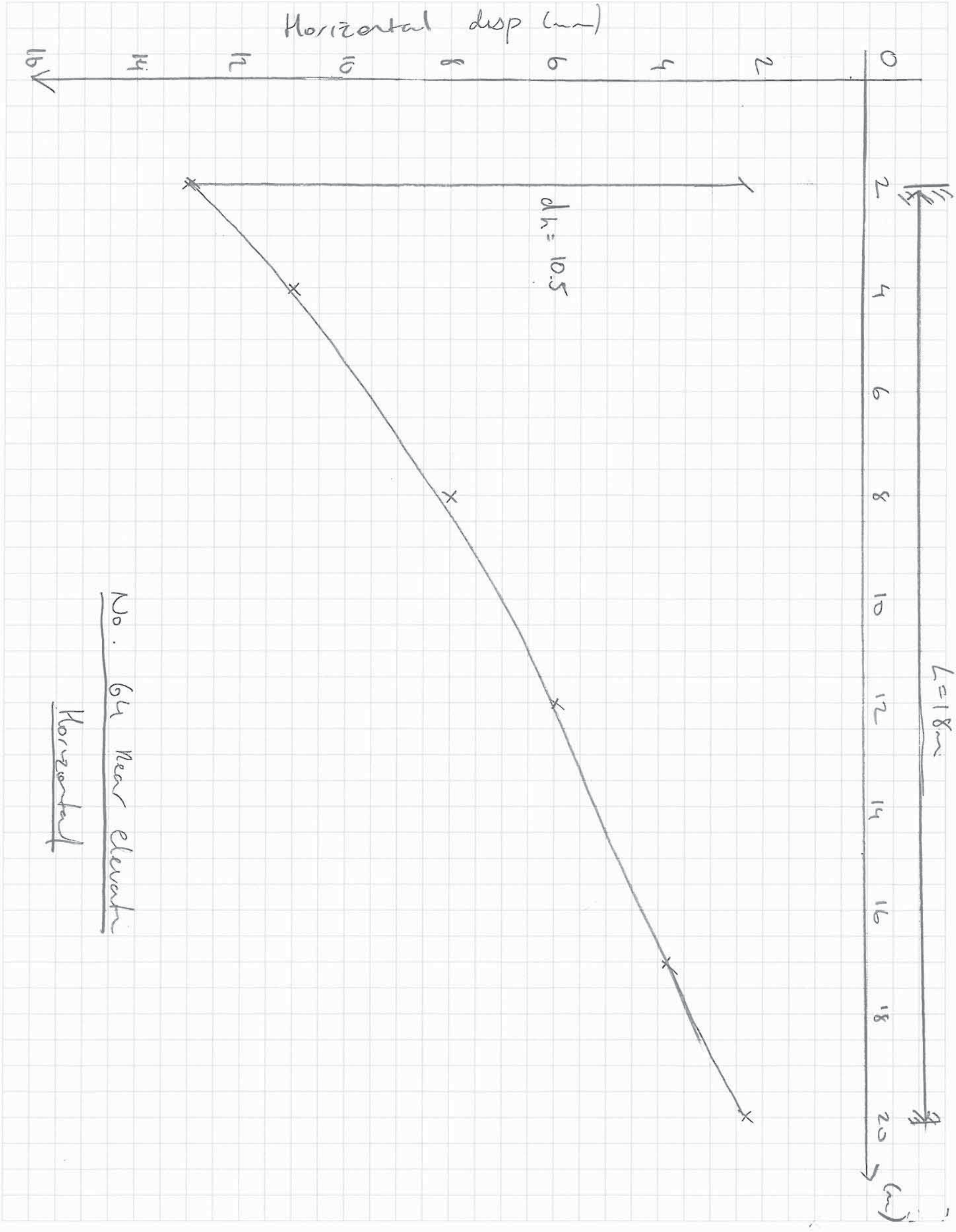


Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July '16	Job no. 1636/07	Sheet .14
Engineer DP		
Checked by SN		
Project 62 Avenue Road		



Alan Baxter	Date July 16	Job no.	Sheet
75 Cowcross Street London EC1M 6EL tel 020 7250 1555 email aba@alanbaxter.co.uk www.alanbaxter.co.uk	Engineer DP Checked by SN	1636/03	.15
	Project 62 Avenue Road		

No 64 Rear Elevation

Max vertical deflection = 0.5mm

$L = 18m$ or $18{,}000mm$ $\therefore \frac{d_{max}}{\Delta L} = \frac{0.5}{18{,}000} \times 100 = 0.0027\%$

$\epsilon_h = \frac{\delta h}{L} = \frac{10.5}{18{,}000} \times 100 = 0.058\%$

$\frac{L}{H} = 1.28$ (pg .7)

Assuming cat 1 $\therefore \epsilon_{lim} = 0.075$

$\therefore \frac{d_{max}}{\Delta L} / \epsilon_{lim} = \frac{0.0027}{0.075} = 0.03$

$\frac{\epsilon_h}{\epsilon_{lim}} = \frac{0.058}{0.075} = 0.77$

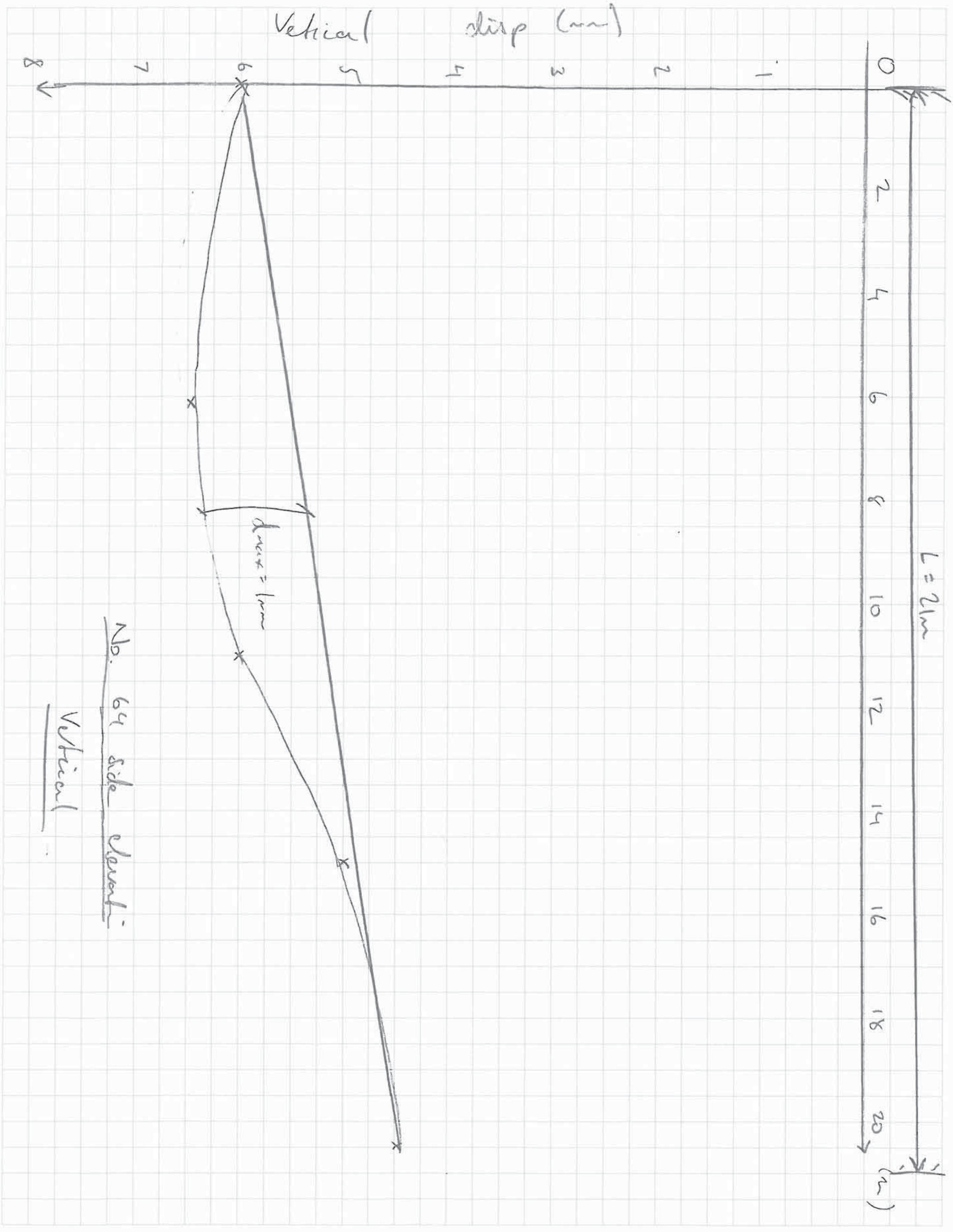
Using figure 2.18 on pg .8

Damage catagory = 1

Alan Baxter

75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
July 16	1636/03	.16
Engineer DP		
Checked by SN		
Project 62 Avenue Road		

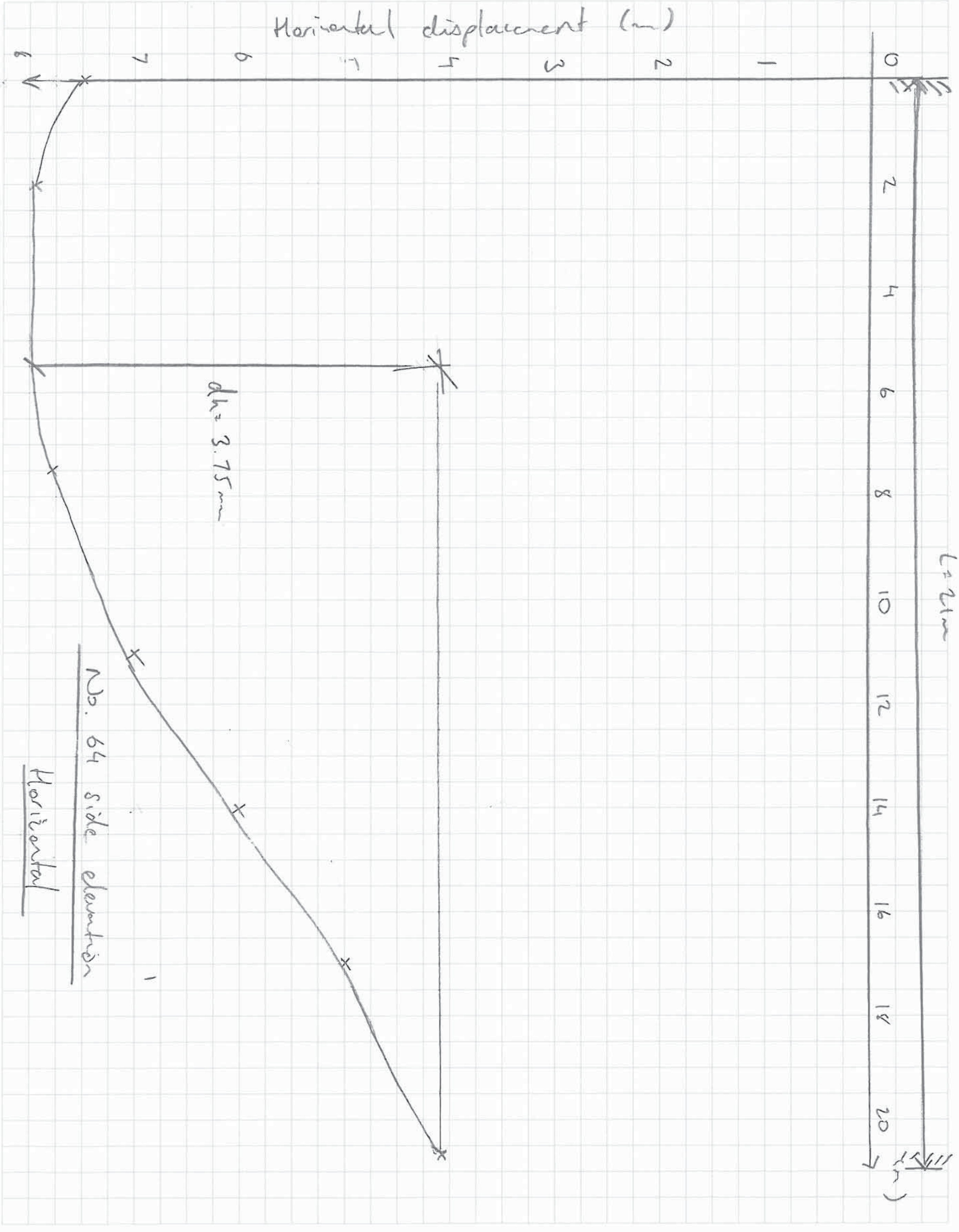


Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no.	Sheet
Engineer OP	1636/07	.17
Checked by SN		
Project 62 Avenue Road		



Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
July 16	1036/02	.18
Engineer DP		
Checked by SN		
Project 62 Avenue Road		

No. 64 side elevation

Max vertical deflection = 1mm

L = 21m or 21,000mm $\therefore \frac{d_{max}}{L} = \frac{1}{21,000} \times 100 = 0.0047\%$

$\varepsilon h = \frac{\delta h}{L} = \frac{3.75}{21,000} \times 100 = 0.018$

$\frac{L}{H} = 1.5$ (pg. 7)

Assuming Category 0 $\therefore \varepsilon l_{im} = 0.05$

$\frac{d_{max}/\Delta L}{\varepsilon l_{im}} = \frac{0.0047}{0.05} = 0.09$

$\frac{\varepsilon h}{\varepsilon l_{im}} = \frac{0.018}{0.05} = 0.36$

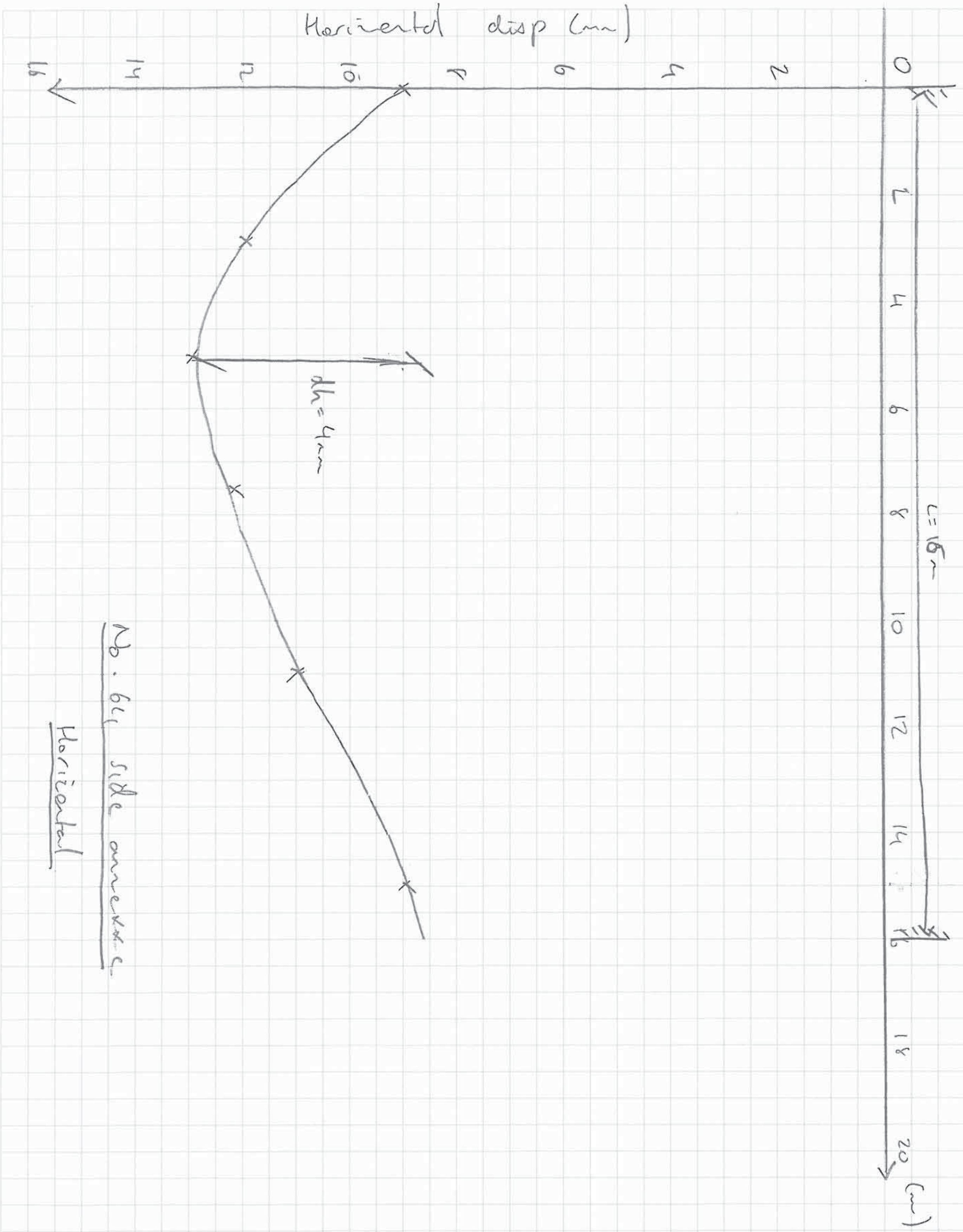
Using figure 2.18 on pg. 8
Damage category = 0

Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

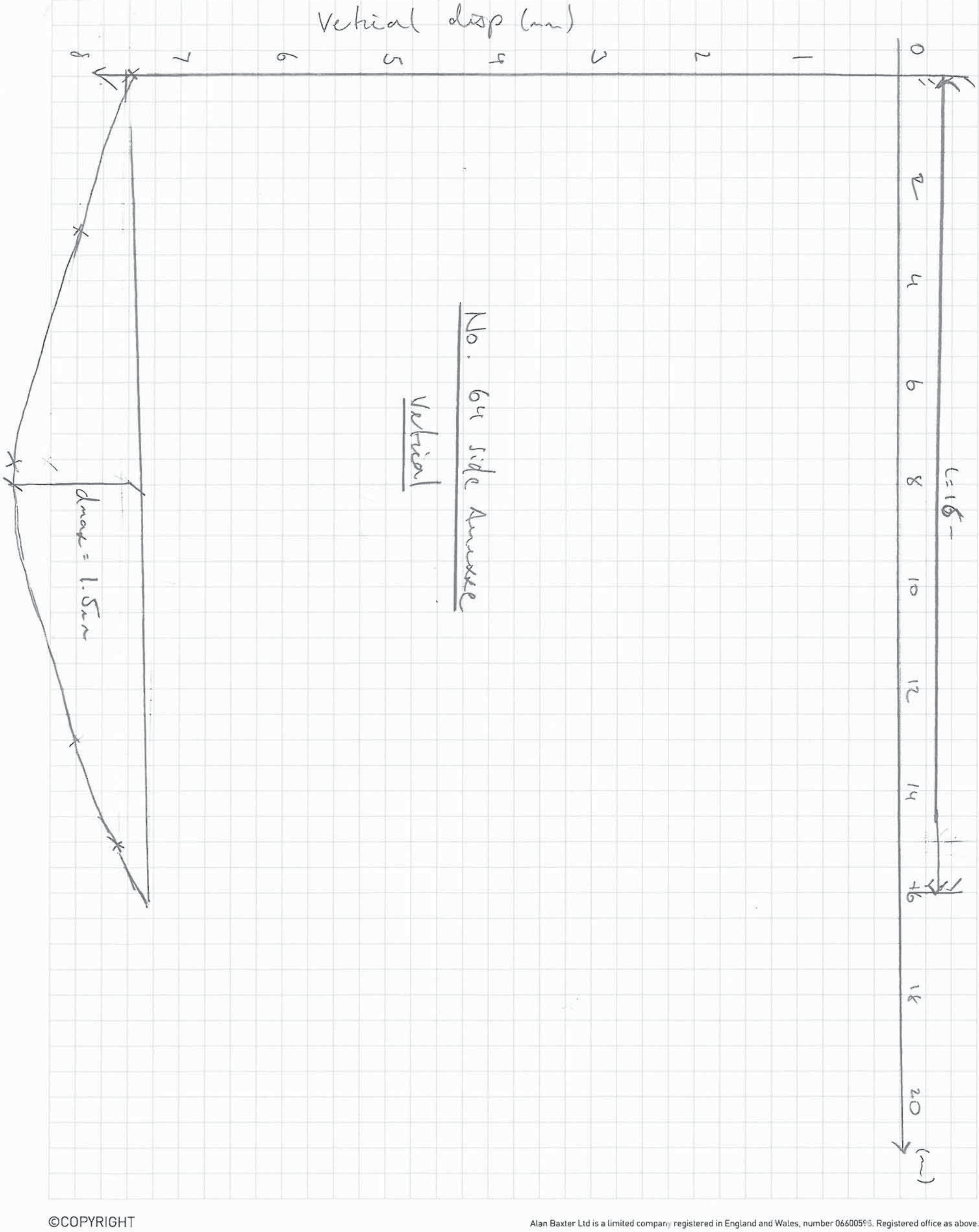
Date July 16	Job no.	Sheet
Engineer DP	1036/02	.19
Checked by SN		
Project 62 Avenue Road		



Alan Baxter

75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
July 16	1636/07	.20
Engineer: DD		
Checked by: SN		
Project: 62 Avenue Road		



Alan Baxter

75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no.	Sheet
Engineer DY	1636/03	.21
Checked by SW		
Project 62 Avenue Road		

No. 64 Annexe

Max vertical deflection = 1.5mm

$L = 16m$ or $16{,}000mm$ $\therefore \frac{d_{max}}{L} = \frac{1.5}{16{,}000} \times 100 = 0.009\%$

$\varepsilon_h = \frac{d_h}{L} = \frac{4}{16{,}000} \times 100 = 0.025$

$\frac{L}{H} = 3.5$ (pg. 7)

Assuming catagory 0 $\therefore \varepsilon_{lim} = 0.05$

$\frac{d_{max}/\Delta L}{\varepsilon_{lim}} = \frac{0.009}{0.05} = 0.18$

$\frac{\varepsilon_h}{\varepsilon_{lim}} = \frac{0.025}{0.05} = 0.5$

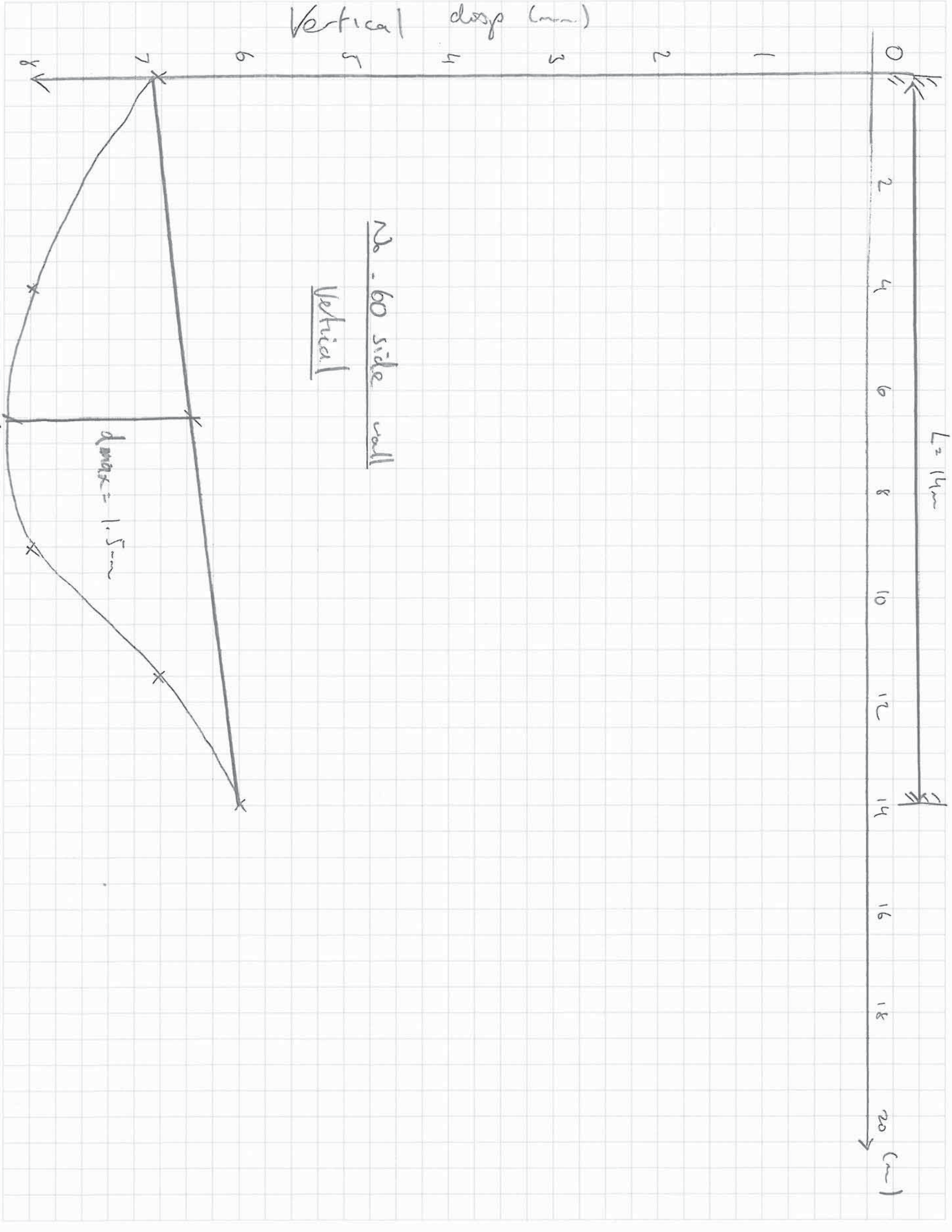
Using figure 2.18 on pg. 8

Damage catagory = 0

Alan Baxter

75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
July 16	1036/07	.22
Engineer: DP		
Checked by: SN		
Project: 62 Avenue Road		

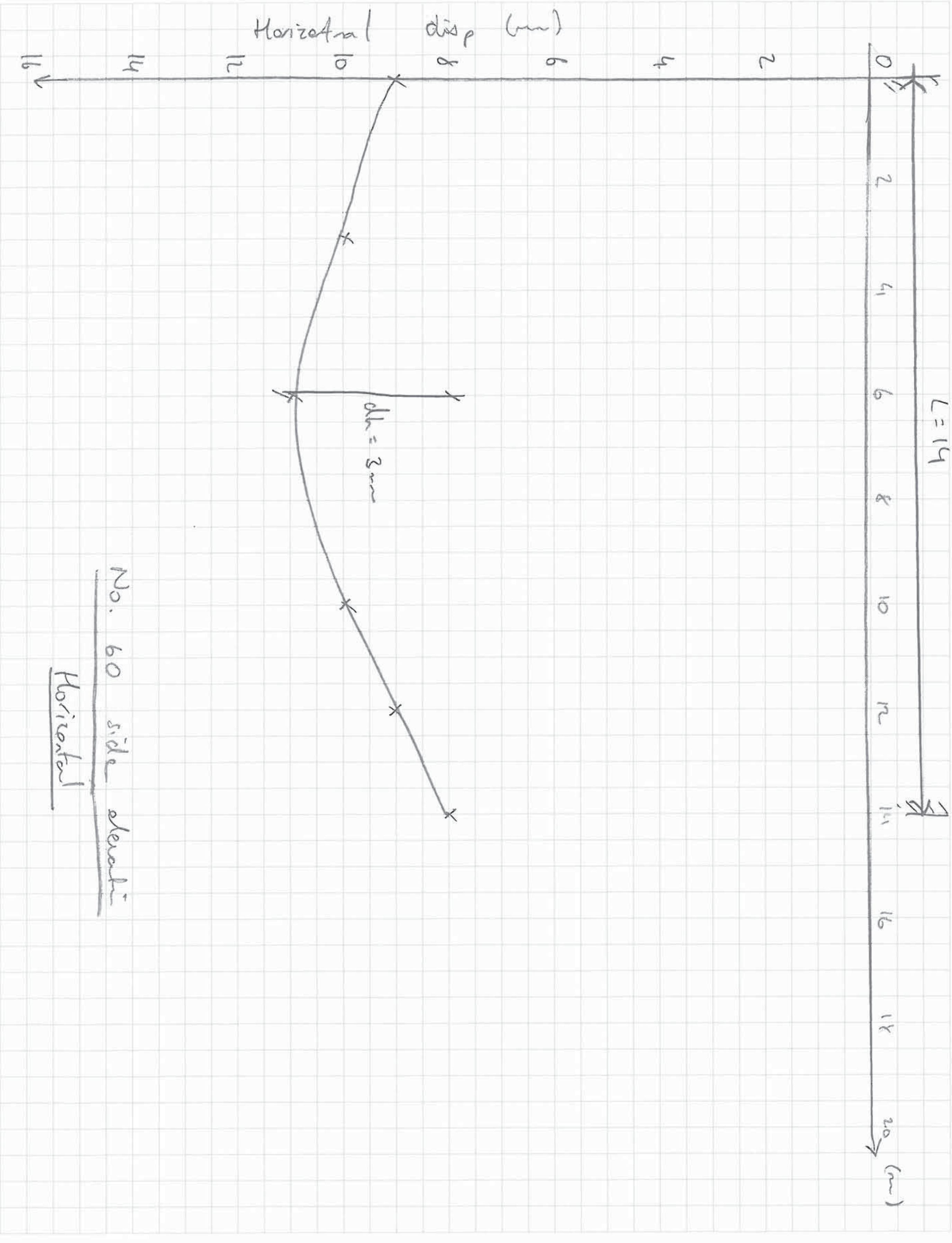


Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	July 10	Job no.	Sheet
Engineer	OR	1636/07	.23
Checked by	SN		
Project	62 Avenue Road		



Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
July 16	1636/07	.24
Engineer DQ		
Checked by SN		
Project 62 Avenue Road		

<u>No. 60 side wall</u>

Max vertical deflection = 1.5mm

$L = 14m$ or $14{,}000mm$ $\therefore \frac{d_{max}}{L} = \frac{1.5}{14{,}000} \times 100 = 0.011$

$\varepsilon_h = \frac{\delta h}{L} = \frac{3}{14{,}000} \times 100 = 0.021$

$\frac{L}{H} = 1.08$ (pg 7)

Assuming Cat 0 $\varepsilon_{lim} = 0.05$

$$\frac{\delta_{max}/L}{\varepsilon_{lim}} = \frac{0.011}{0.05} = 0.22$$

$$\frac{\varepsilon_h}{\varepsilon_{lim}} = \frac{0.021}{0.05} = 0.42$$

Using figure 2.18 on pg. 8

Damage catagory = 0

Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

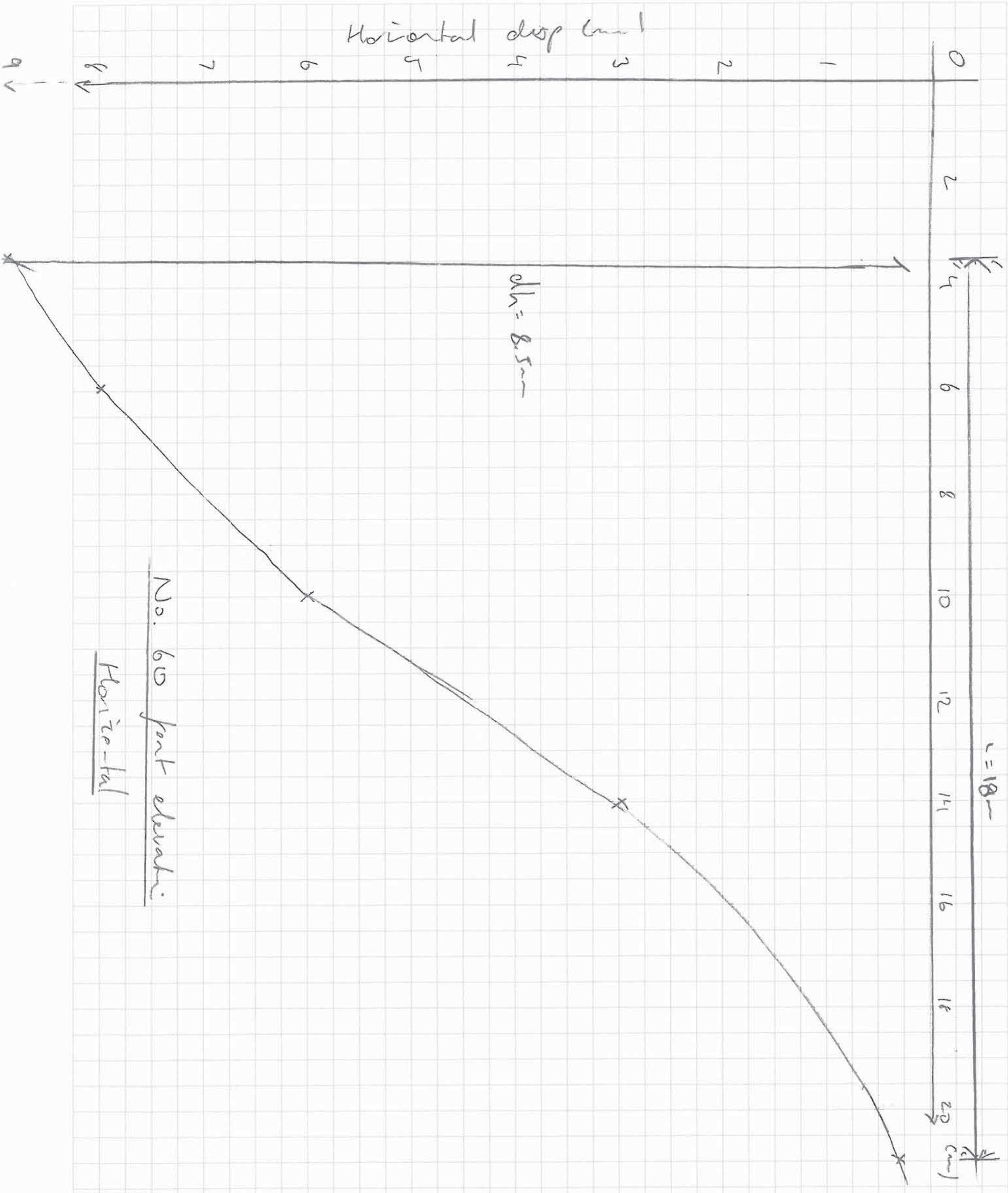
Date July 16	Job no. 1636/07	Sheet .25	
Engineer [illegible]			
Checked by SN			
Project 62 Avenue Road			

Alan Baxter

75 Cowcross Street
London EC1M 6EL

tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no. 1636/03	Sheet .26
Engineer DP		
Checked by SN		
Project 62 Avenue Road		



Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
July 16	1636/03	.27
Engineer DP		
Checked by SN		
Project 62 Avenue Road		

No. 60 front elevation

Max vertical deflection = 0.5mm

$L = 18$ or $18,000$mm $\therefore \frac{d_{max}}{L} = \frac{0.5}{18,000} \times 100 = 0.0027\%$

$\varepsilon_h = \frac{\delta_h}{L} = \frac{8.5}{18,000} \times 100 = 0.047$

$\frac{L}{H} = 1.38$

Assuming Cat 1 $\varepsilon_{lim} = 0.075$

$\frac{\delta_{max}/\Delta L}{\varepsilon_{lim}} = \frac{0.0027}{0.05} = 0.054$

$\frac{\varepsilon_h}{\varepsilon_{lim}} = \frac{0.047}{0.05} = 0.94$

Using figure 2.18 on pg. 8

Damage category = 1

Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date July 16	Job no. 1636/07	Sheet .28	
Engineer OP			
Checked by SN			
Project 62 Avenue Road			

Summary

No. 64	Rear	=	Cat 1
	Side	=	Cat 0
	Annexe	=	Cat 0
No 60	Side	=	Cat 0
	Front	=	Cat 1

Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date Aug 16	Job no.	Sheet	
Engineer DP	1636/01	PRO	
Checked by —			
Project 62 AVENUE ROAD			

Pile design calculations

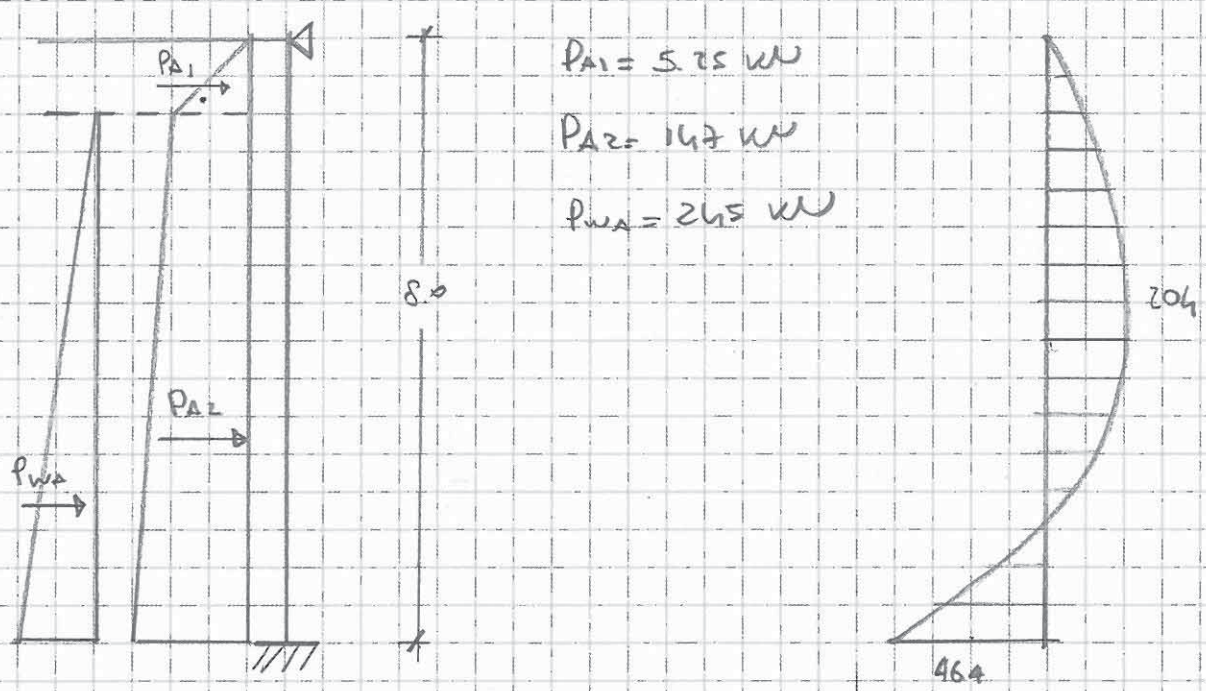
Alan Baxter
75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
fax 020 7250 3022
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
NOV 12	1636/01	PR1
Engineer: LF		
Checked by: DP		
Project: 62 AVENUE ROAD		

DESIGN OF PILE REINFORCEMENT

CAR LIFT AREA

LOAD ON PILES /m RUN AS PER PAGE CB1 OF CALCULATIONS.



$P_{A1} = 5.75$ kN

$P_{A2} = 147$ kN

$P_{WA} = 265$ kN

CONSIDERING Ø600 @ 750 c/c PILES, THE MAX BENDING MOMENT PER PILE WILL BE $M_{PILE} = 464 \times 0.75 = 348$ kNm (SLS)

M_{PILE} (ULS) = $348 \times 1.4 = 487$ kNm

VERTICAL LOAD = 75 kN/m $\times 0.75 = 56$ kN

PILE WEIGHT = $24 \times \pi \times \frac{0.6^2}{4} \times 8 = 54$ kN

N (SLS) = 110 kN

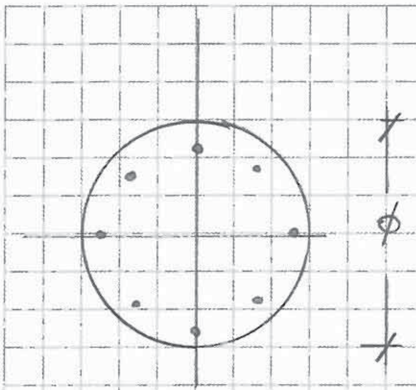
N (ULS) = $110 \times 1.5 = 165$ kN

DESIGN CIRCULAR SECTION FOR $N = 165$ kN, $M = 487$ kNm (ULS)

Alan Baxter

75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
fax 020 7250 3022
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

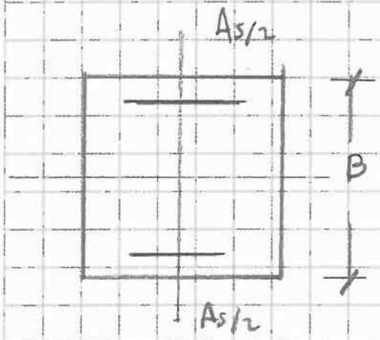
Date	Job no.	Sheet
NOV 12	1636 01	PR2
Engineer LF		
Checked by DP		
Project 62 AVENUE ROAD		



$$I = \frac{\pi \phi^4}{64} = \frac{3.14 \times 600^4}{64} = 6.36 \cdot 10^9 \text{ mm}^4$$

$$= B^4/12 \Rightarrow B = 526 \text{ mm}$$

ANALYSE THE CIRCULAR SECTION $\phi = 600$ mm AS A SQUARE SECTION WITH THE SAME $I \Rightarrow B = 526$ mm



$\delta = 100$ mm $d = 526 - 100 = 426$ mm

$d/B = 0.80$

$$M/bh^2 = M/B^3 = 487 \cdot 10^6 / 526^3 = 3.35$$

$$N/bh = N/B^2 = 165 \cdot 10^3 / 526^2 = 0.60$$

$$\frac{100\,As}{bh} = 2.5 \qquad As = \frac{2.5 \times B^2}{100} = \frac{2.5 \times 526^2}{100} = 6920 \text{ mm}^2$$

USE 11 ϕ32 = 8840 mm^2

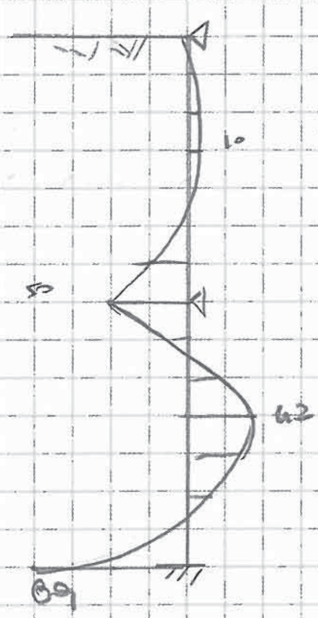
Alan Baxter

75 Cowcross Street
London EC1M 6EL
tel 020 7250 1555
fax 020 7250 3022
email aba@alanbaxter.co.uk
www.alanbaxter.co.uk

Date	Job no.	Sheet
10/12	16361/01	PR3
Engineer LF		
Checked by DP		
Project 62 AVENUE ROAD		

DOUBLE PROPPED PILES TO THE REAR OF BASEMENT

LOAD CASE AS PER PAGE CP14 OF THE CALCULATIONS



$M_{PILE} = 89 \times 0.6 = 53.4$ kNm

M_{PILE} (ULS) $= 53.4 \times 1.4 = 75$ kNm

VERTICAL LOAD $= 140$ kN/m $\times 0.60 = 84$ kN

PILE WEIGHT $= 3.14 \times \frac{0.45^2}{4} \times 7 \times 24 = 26$ kN

$N_{(SLS)} = 84 + 26 = 110$ kN

N (ULS) $= 165$ kN

DESIGN SECTION FOR

$N = 165$ kN

$M = 75$ kNm

(ULS)

$I = \frac{\pi \times 450^4}{64} = 2.01 \cdot 10^9$ mm^4 $= \frac{B^4}{12} \Rightarrow B = 394$ mm

$\delta = 100$ mm $\quad d = 394 - 100 = 294$ mm $\quad d/B = 0.75$

$M/bh^2 = 75 \cdot 10^6 / 394^3 = 1.23$

$N/bh = 165 \cdot 10^3 / 394^2 = 1.06 \Rightarrow \frac{100 A_s}{bh} = 0.6\%$

$A_s = 0.6 \times 394^2 / 100 = 931$ mm^2

USE 6 No. B16 $\quad A_s = 1210$ mm^2