CONSOLIDATION SETTLEMENT beneath a flexible rectangular loaded area (after Fadum)

Project: Grays Inn Road
Position: Centre of basement
Units: kN, m

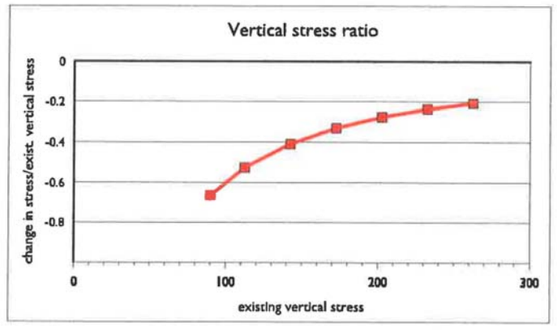
length 2L	breadth 2B	applied stress q
94.0	29.00	-60

No soft clay layer

layer no.	layer thickness	z	m = L/z	n = B/z	Ir	sigma z = 4Ir*q	existing effective vert. stress sigma v'	sigma v' + ½ sigma z	mv (estimated)	settlement (mm)	heave (mm) to 20% cut-off
1	1.5	3.00	15.67	4.83	0.249	-60	90	60	0.132	-12	-12
2	3.0	5.25	8.95	2.76	0.247	-59	113	83	0.125	-22	-22
3	3.0	8.25	5.70	1.76	0.243	-58	143	113	0.115	-20	-20
4	3.0	11.25	4.18	1.29	0.237	-57	173	144	0.107	-18	-18
5	3.0	14.25	3.30	1.02	0.232	-56	203	175	0.095	-16	-16
5	3.0	17.25	2.72	0.84	0.228	-55	233	205	0.092	-15	-15
5	3.0	20.25	2.32	0.72	0.228	-55	263	235	0.085	-14	-14
				FOX	depth, D	12.00		oedometer settlement			-117
					L/B	3.2		fox's depth correction		0.91	
					D/root(2L*2B)	0.23		geological factor		0.5	
					root(2L*2B)/D	4.35		**actual settlement**			**-53**

(negative value represents heave)

layer no.	increase in vertical stress sigma z kPa	existing vertical stress sigma v' kPa	sigma z / sigma v'
1	-60	90	-66.400%
2	-59	113	-52.693%
3	-58	143	-40.926%
4	-57	173	-32.974%
5	-56	203	-27.496%
5	-55	233	-23.535%
5	-55	263	-20.846%



CONSOLIDATION SETTLEMENT beneath a flexible rectangular loaded area (after Fadum)

Project: Grays Inn Road
Position: Centre of basement
Units: kN, m

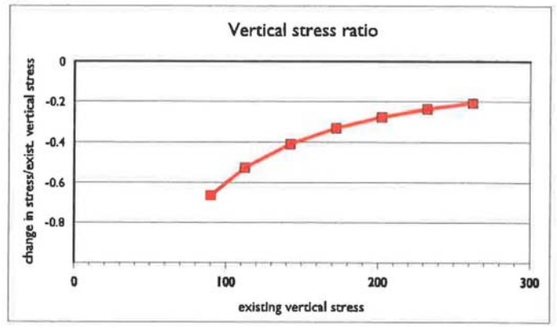
length 2L	breadth 2B	applied stress q
94.0	29.00	-60

Soft clay layer

layer no.	layer thickness	z	m = L/z	n = B/z	Ir	sigma z = 4Ir*q	existing effective vert. stress sigma v'	sigma v' + ½ sigma z	mv (estimated)	settlement (mm)	heave (mm) to 20% cut-off
1	1.5	3.00	15.67	4.83	0.249	-60	90	60	0.210	-19	-19
2	3.0	5.25	8.95	2.76	0.247	-59	113	83	0.125	-22	-22
3	3.0	8.25	5.70	1.76	0.243	-58	143	113	0.115	-20	-20
4	3.0	11.25	4.18	1.29	0.237	-57	173	144	0.107	-18	-18
5	3.0	14.25	3.30	1.02	0.232	-56	203	175	0.095	-16	-16
5	3.0	17.25	2.72	0.84	0.228	-55	233	205	0.092	-15	-15
5	3.0	20.25	2.32	0.72	0.228	-55	263	235	0.085	-14	-14
				FOX	depth, D	12.00		oedometer settlement			-124
					L/B	3.2		fox's depth correction		0.91	
					D/root(2L*2B)	0.23		geological factor		0.5	
					root(2L*2B)/D	4.35		**actual settlement**			**-57**

(negative value represents heave)

layer no.	increase in vertical stress sigma z kPa	existing vertical stress sigma v' kPa	sigma z / sigma v'
1	-60	90	-66.400%
2	-59	113	-52.693%
3	-58	143	-40.926%
4	-57	173	-32.974%
5	-56	203	-27.496%
5	-55	233	-23.535%
5	-55	263	-20.846%



APPENDIX F

Site Investigation Trial Pit Details

Pringuer-James
Consulting Engineers
10 Beulah Road, Wimbledon London SW19 3SB
Phone : 0208 940 4159
Email : Mail@pjce.com

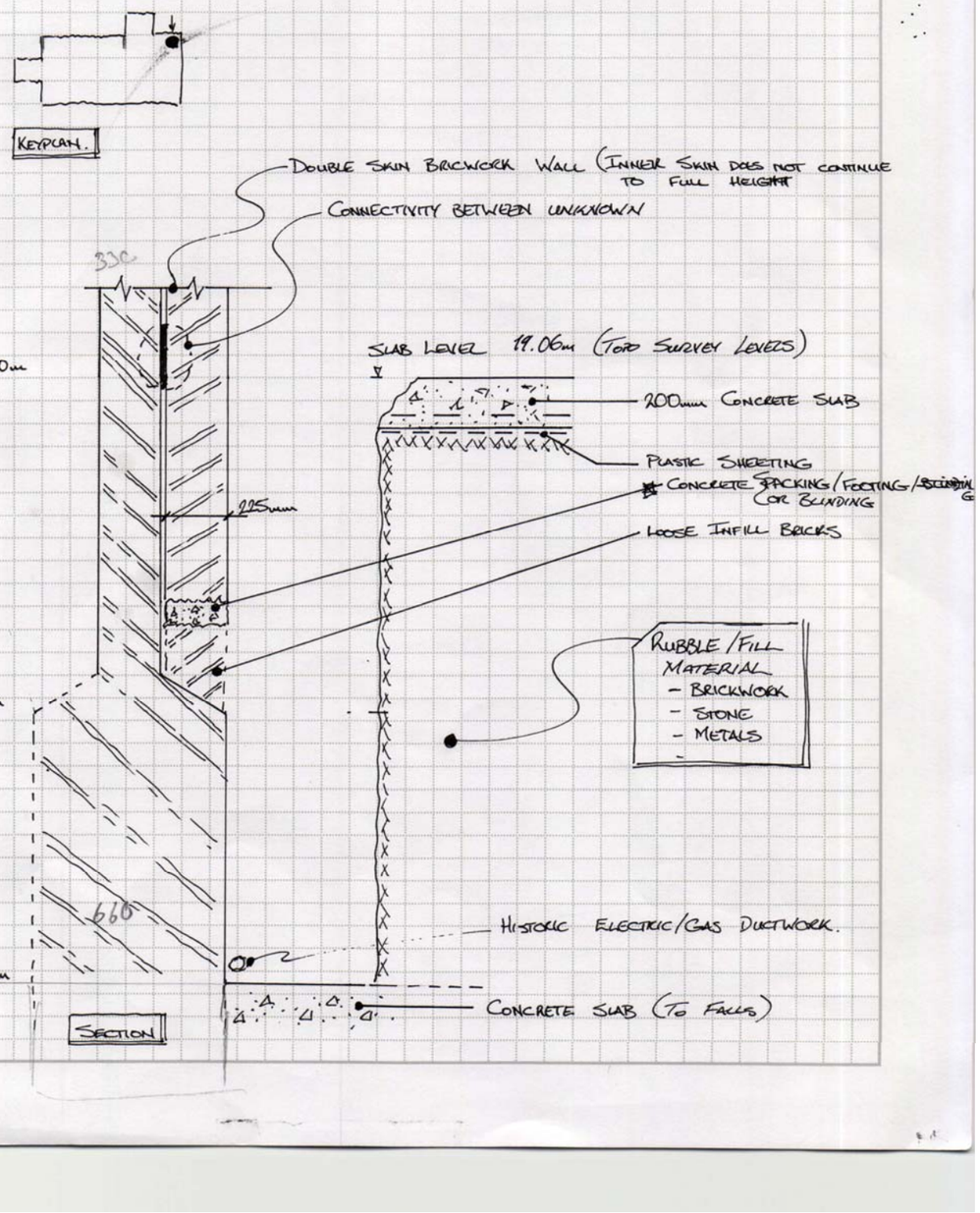
Sheet No : TP#1 (A)
Date : Jun 2014
By : C.C.

Job No. : L-1706
Item : Site Investigation
Trial Pit Details.

TITLE : No 227 Grays Inn Road

LOCATION	CALCULATIONS	OPTIONS

Trial Pit #1 – Greys Inn Road Elevation



Pringuer-James
Consulting Engineers
10 Beulah Road, Wimbledon London SW19 3SB
Phone : 0208 940 4159
Email : Mail@pjce.com

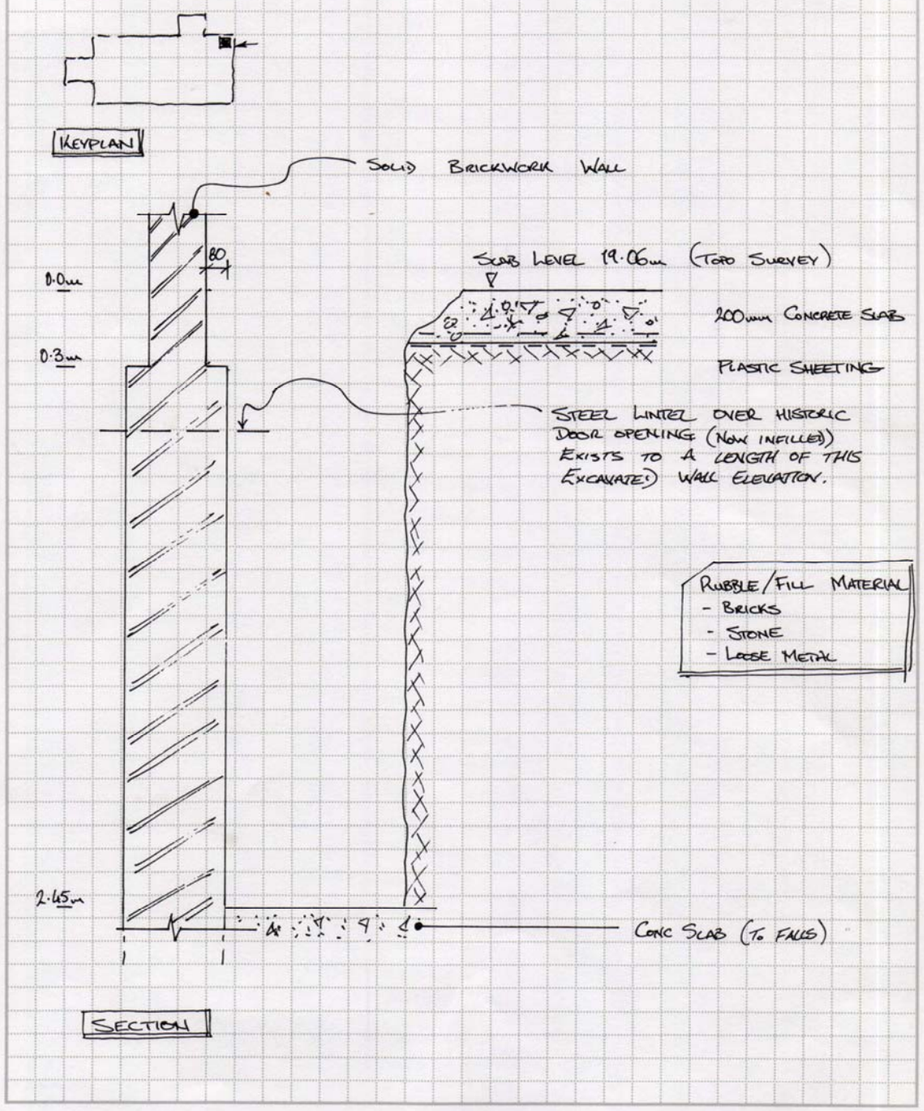
Sheet No : TP#1 (B)
Date : Jun 2014
By : C.C.

Job No. : L-1706
Item : Site Investigation
Trial Pit Details

TITLE : No 227 Grays Inn Road

LOCATION	CALCULATIONS	OPTIONS

Trial Pit #1



Pringuer-James
Consulting Engineers
10 Beulah Road, Wimbledon London SW19 3SB
Phone : 0208 940 4159
Email : Mail@pjce.com

Sheet No : TP#2 (A)
Date : JUN 2014
By : C.C.

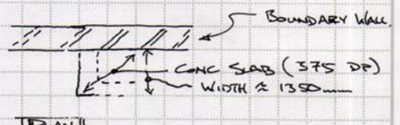
Job No. : L-1706
Item : SITE INVESTIGATION
TRIAL PIT DETAILS

TITLE : No 227 GRAYS INN ROAD

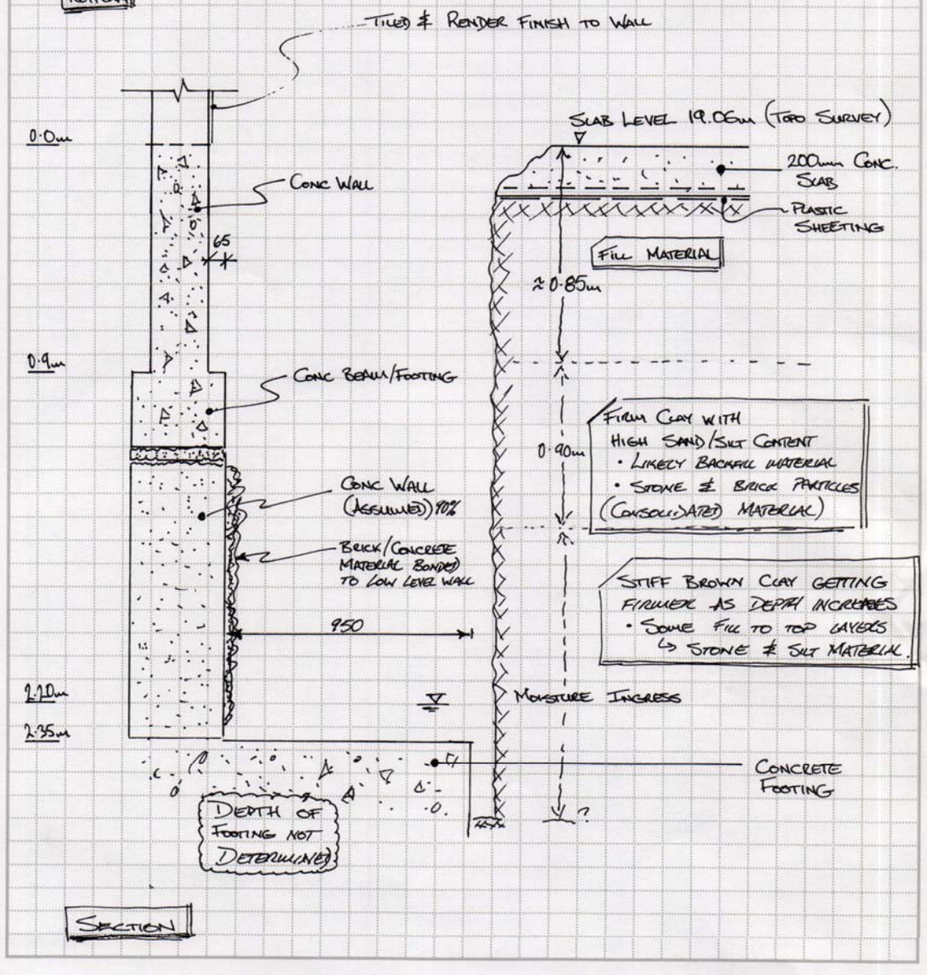
LOCATION | CALCULATIONS | OPTIONS

TRIAL PIT #2 - WALL FOOTING

KEYPLAN



PLAN



SECTION

Pringuer-James
Consulting Engineers
10 Beulah Road, Wimbledon London SW19 3SB
Phone : 0208 940 4159
Email : Mail@pjce.com

Sheet No : TP # 2 (B)
Date : JUN 2014
By : C. G.

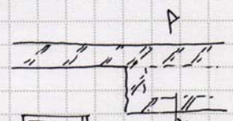
Job No. : L-1706
Item : SITE INVESTIGATION
TRIAL PIT DETAILS

TITLE : No 227 GRAYS INN ROAD

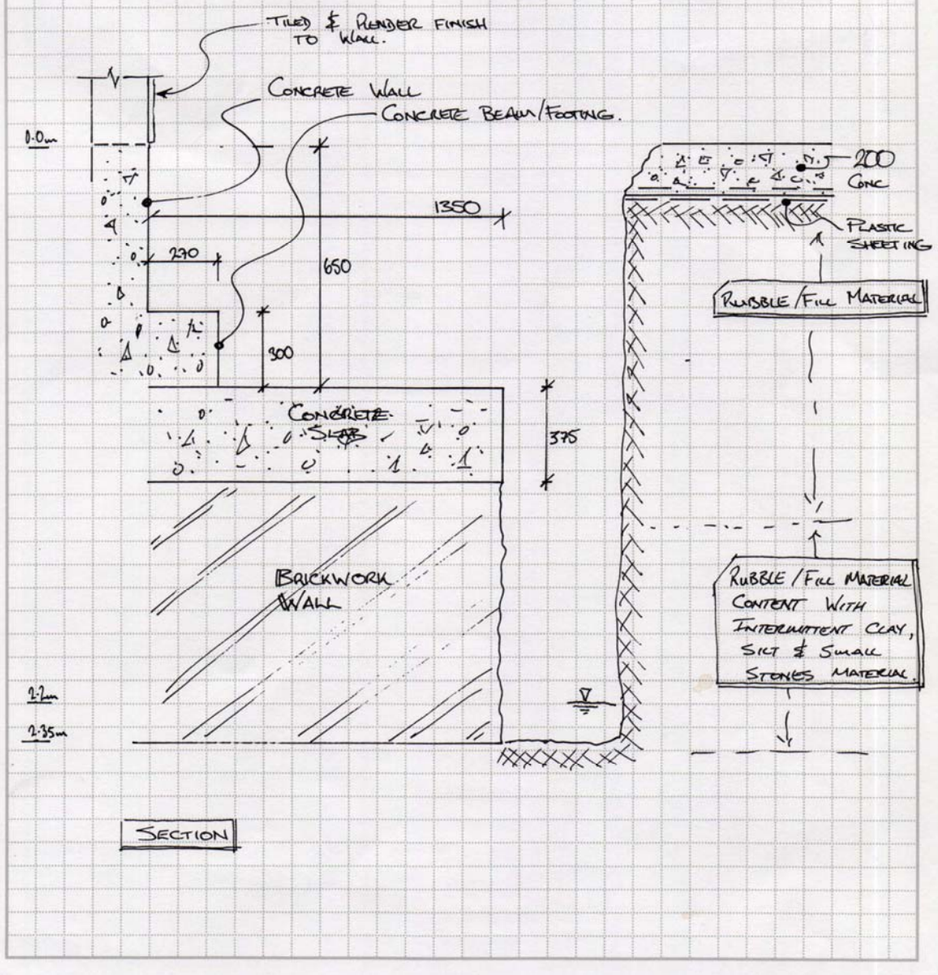
LOCATION | CALCULATIONS | OPTIONS

TRIAL PIT # 2 - PIER FOOTING.

KEYPLAN



PLAN



SECTION

Pringuer-James
Consulting Engineers
10 Beulah Road, Wimbledon London SW19 3SB
Phone : 0208 940 4159
Email : Mail@pjce.com

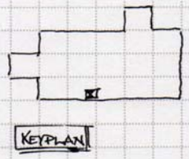
Sheet No : TP#3(A)
Date : Jun 2014
By : C.C.

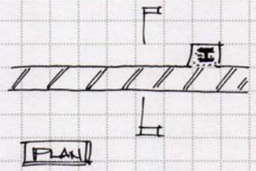
Job No. : L-1706
Item : Site Investigation
Trial Pit Details

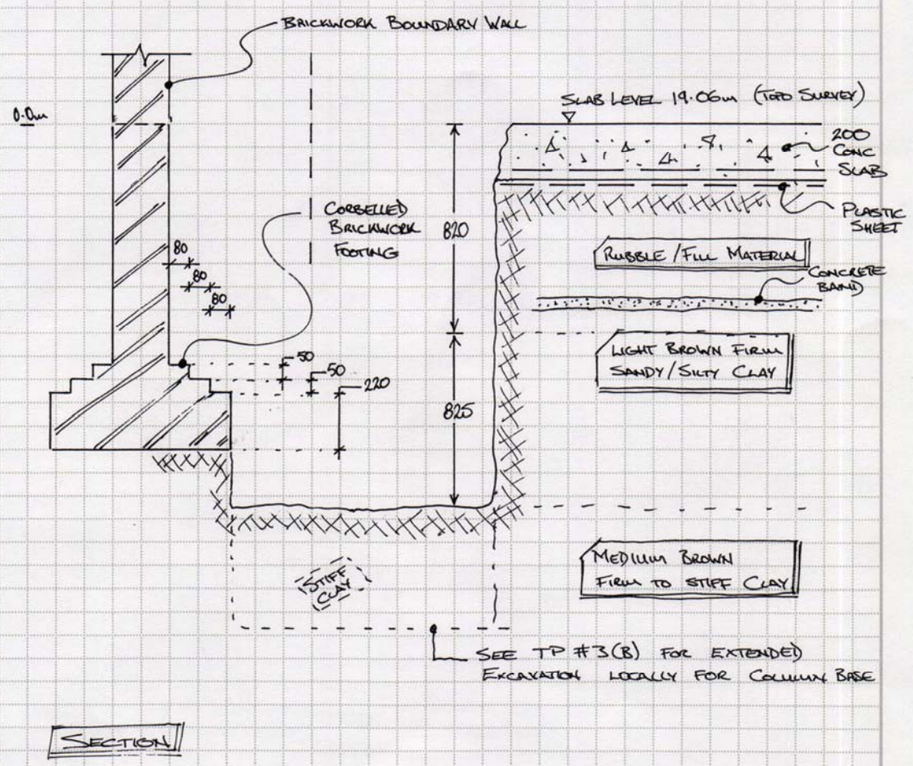
TITLE : No 227 Grays Inn Road

LOCATION | CALCULATIONS | OPTIONS

Trial Pit #3 – Wall Footing







SECTION

Pringuer-James
Consulting Engineers
10 Beulah Road, Wimbledon London SW19 3SB
Phone : 0208 940 4159
Email : Mail@pjce.com

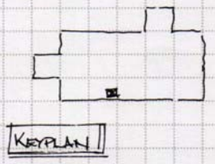
Sheet No : TP#3(B)
Date : Jun 2014
By : C.C.

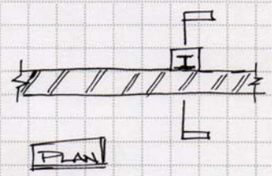
Job No. : L-1706
Item : Site Investigation
Trial Pit Details

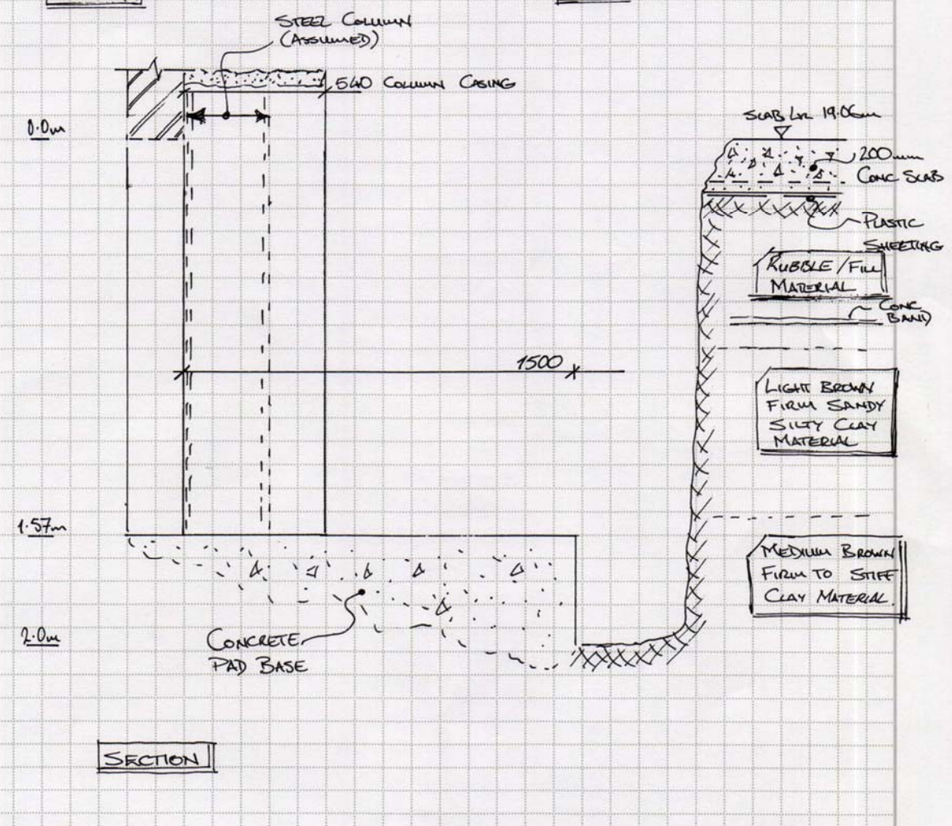
TITLE : No 227 Grays Inn Road

LOCATION | CALCULATIONS | OPTIONS

Trial Pit #3 – Column Footing







SECTION

APPENDIX G

Preliminary Structural Design
(Boundary Piling & Underpinning)

PROJECT	227A Grays Inn Road	R&E Geotechnical Consultants
TITLE	Propped Wall Adjacent to Highway	Design Cover Sheet
Reference No. RE1172 des 011	Revision No. 0	Date of Previous Design (if revision)
		1 of 62

Activity	Initials	Signature	Date
Design By			12/09/14
Verified By			

Design Input

Retained Height 3.5m adjacent to Highway

Herts & Essex Site Investigation report ref MRS/12138 dated 2nd June 2014
& Draft logs BHD & E August 14
Su profile presented on sheet 62

Design to BS8002 / CIRIA C580
ULS analysis, to check depth, with unplanned overdig and factored soil strengths
SLS analysis with unfactored strengths and without overdig to checked factored SLS moments and shears

Two loadings considered; UDL 10kPa on pavement 20kPa on carriageway
secondly, accidental wheel loading; two 100kN point loads

450mm diameter at 600mm centres

Wall Propped at Capping Beam during Excavation

Design Output

Summary of analysis is presented on sheets 3 to 5, 17 to 19, 32 to 34 & 46 to 48

For calculated deflection look at SLS analysis sheets 32 to 59 only

For retained height 3.5m, temporary propped Wall
Pile Length 6m
Reinforcement 6B16 B8at175

Sequence is based on removing temporary prop after casting basement slab
Calculated deflection, maximum 14mm for accidental wheel loading
For cantilever wall above base, wheel loading more onerous than UDL

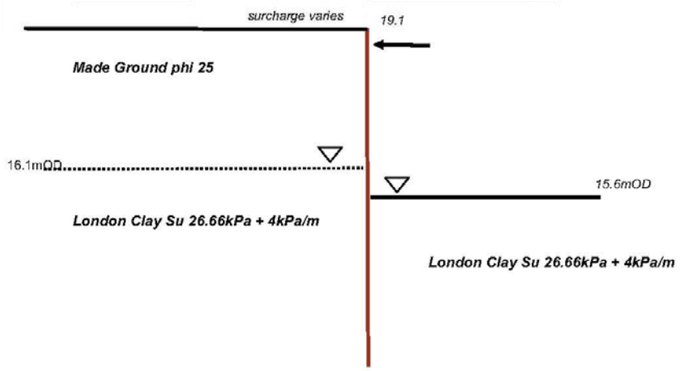
If ground floor is cast before removing temporary props then deflected profile from excavation stage will be retained

Revision	By	Date	Ver	Date	Description

RE1172 des 011.xls

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	2 of 62	
Reference						

Soil Properties **Factored Soil Strengths**



Made Ground

Bulk Density =	18 kN/m3	
Submerged Density =	19 kN/m3	
Shear Strength	phi = 25	c' = 0
Earth Pressure Coefficients		ka = 0.352
		ko = 0.55
		kp = 3.369
Elastic Modulus =	5,000kPa + 4,000kPa/m	

Undrained London Clay

Bulk Density =	20 kN/m3	
Submerged Density =	20 kN/m3	
Shear Strength Su =	26.66kPa + 4kPa/m	
Earth Pressure Coefficients	ka = 1	kac = 2.389
	ko = 1.25	
	kp = 1	kpc = 2.39
Elastic Modulus =	26,000kPa + 4,000kPa/m depth	

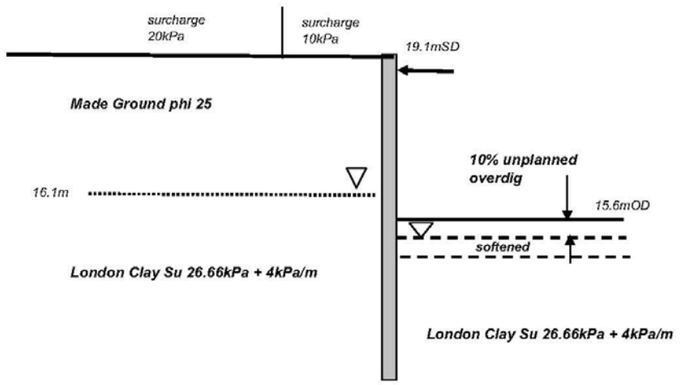
Drained London Clay

Bulk Density =	20 kN/m3	
Submerged Density =	20 kN/m3	
Shear Strength	phi = 19.4	c' 4 kPa
Earth Pressure Coefficients	ka = 0.445	kac = 1.577
	ko = 1.25	
	kp = 2.505	kpc = 4.274
Elastic Modulus =	20,000kPa + 3,200kPa/m depth	

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	3 of 62	

Reference

Adjacent to Highway UDL Loading - Propped
ULS Factored Soil Strengths and unplanned overdig

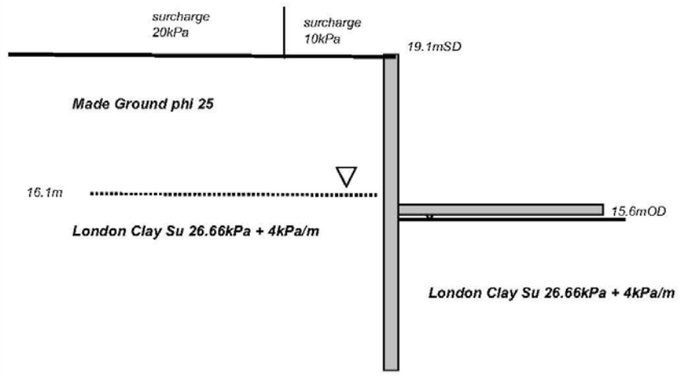


Excavation depth	15.6 15.2	mOD mOD	planned dig unplanned overdig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	1.53	> 1.0 for factored strengths and overdig	
Maximum Moment	70	kNm/m	
Maximum Shear	45	kN/m	
Waling Load	47	kN/m	
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	4 of 62	

Reference

Adjacent to Highway UDL Loading - remove temp prop after casting basement
ULS Factored Soil Strengths

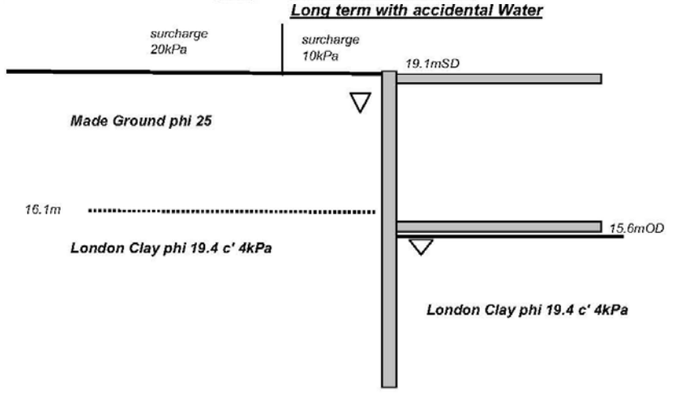


Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	multi-propped		
Maximum Moment	48	kNm/m	
Maximum Shear	63	kN/m	
Slab Load	109	kN/m	at basement
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	5 of 62	

Reference

Adjacent to Highway UDL Loading - following Propped Temporary Stage
ULS Factored Soil Strengths
Long term with accidental Water

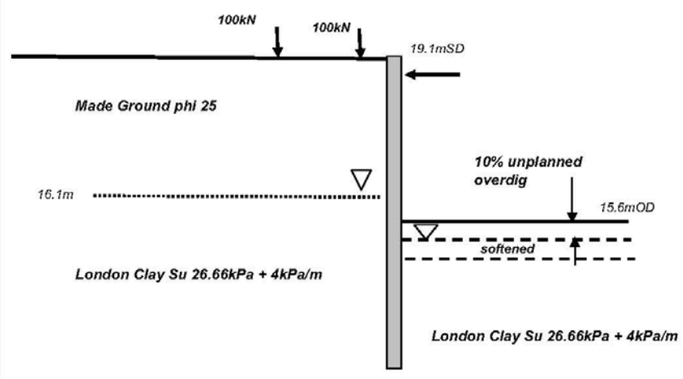


Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	multi-propped		
Maximum Moment	75	kNm/m	
Maximum Shear	76	kN/m	
Slab Load	2	kN/m	at ground floor
	142	kN/m	at basement
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	17 of 62	

Reference

Adjacent to Highway Wheel Loading - Propped
ULS Factored Soil Strengths and unplanned overdig

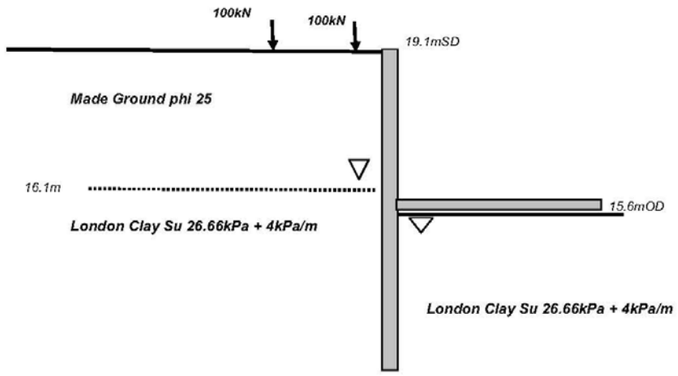


Excavation depth	15.6	mOD	planned dig
	15.2	mOD	unplanned overdig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	1.65	> 1.0 for factored strengths and overdig	
Maximum Moment	62	kNm/m	
Maximum Shear	48	kN/m	
Waling Load	53	kN/m	
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	18 of 62	

Reference

Adjacent to Highway Wheel Loading - remove Propping after casting basement
ULS Factored Soil Strengths

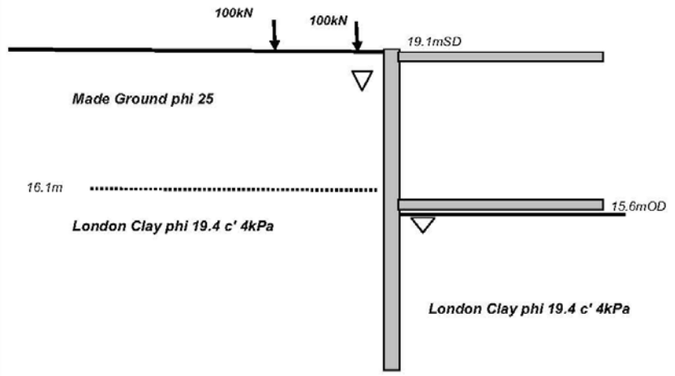


Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	multi-propped		
Maximum Moment	72	kNm/m	
Maximum Shear	67	kN/m	
Slab Load	123	kN/m	at basement
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	19 of 62	

Reference

Adjacent to Highway Wheel Loading - following Propped Temporary
ULS Factored Soil Strengths
Long term with accidental Water

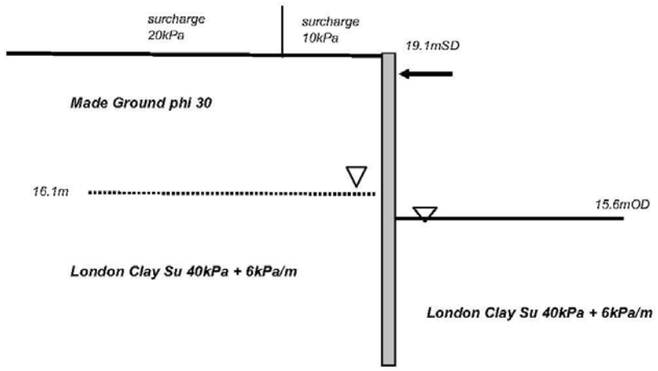


Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	multi-propped		
Maximum Moment	93	kNm/m	
Maximum Shear	80	kN/m	
Slab Load	2	kN/m	at ground floor
	154	kN/m	at basement
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	32 of 62	

Reference

Adjacent to Highway UDL Loading - Propped
SLS Unfactored Soil Strengths without overdig



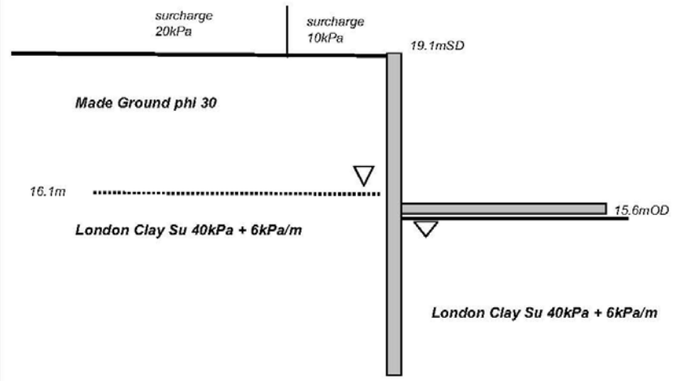
Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	2.43	Burland & Potts (see ULS Analysis)	
Maximum Moment	45	kNm/m	
Maximum Shear	31	kN/m	
Waling Load	33	kN/m	

Section 450mm at 600mm centres

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	33 of 62	

Reference

Adjacent to Highway UDL Loading - remove temp prop after casting basement
SLS Unfactored Soil Strengths



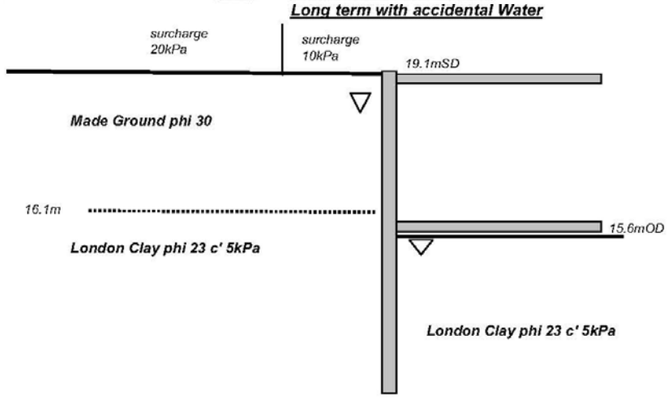
Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	3.08	Burland & Potts	
Maximum Moment	40	kNm/m	
Maximum Shear	41	kN/m	
Slab Load	77	kN/m	at basement
Calculated deflection	10	mm	at ground level

Section 450mm at 600mm centres

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	34 of 62	

Reference

Adjacent to Highway UDL Loading - following Temporary Propping
SLS Unfactored Soil Strengths
Long term with accidental Water

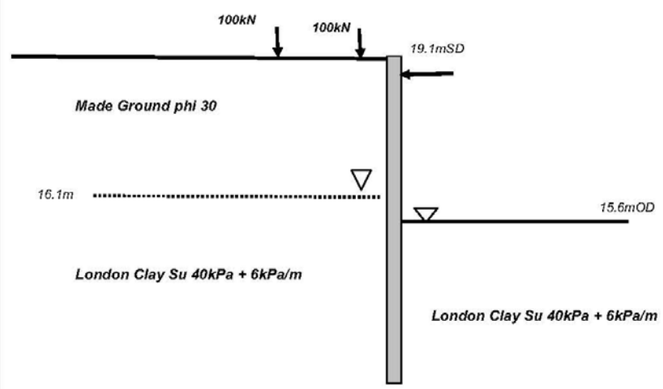


Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	multi-propped		
Maximum Moment	61	kNm/m	
Maximum Shear	67	kN/m	
Slab Load	2	kN/m	at ground floor
	125	kN/m	at basement
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	46 of 62	

Reference

Adjacent to Highway Wheel Loading - Propped
SLS Unfactored Soil Strengths without overdig

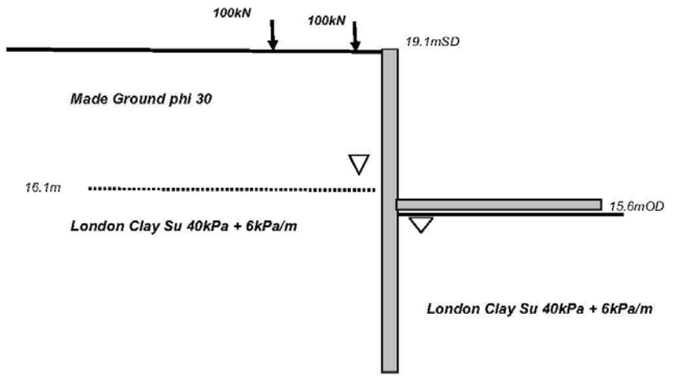


Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	2.41	Burland & Potts (see ULS Analysis)	
Maximum Moment	41	kNm/m	
Maximum Shear	37	kN/m	
Waling Load	40	kN/m	
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	47 of 62	

Reference

Adjacent to Highway Wheel Loading - remove Propping after casting basement
SLS Unfactored Soil Strengths

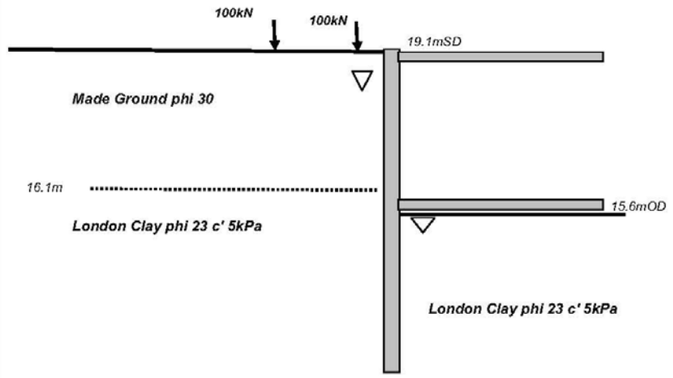


Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	multi-propped		
Maximum Moment	64	kNm/m	
Maximum Shear	53	kN/m	
Slab Load	95	kN/m	at basement
Calculated deflection	14	mm	at ground level
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall Adjacent to Highway
njb	12/09/14			RE1172 des 011	48 of 62	

Reference

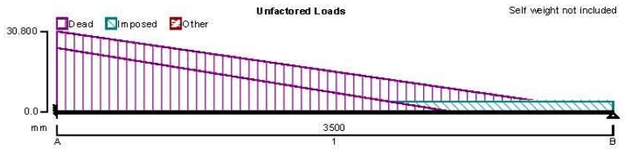
Adjacent to Highway Wheel Loading - following Propping
SLS Unfactored Soil Strengths
Long term with accidental Water

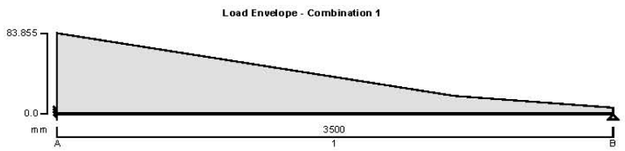


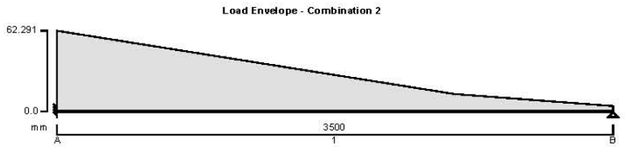
Excavation depth	15.6	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	13.1	m	
Pile Length	6.0	m	
Factor of Safety	multi-propped		
Maximum Moment	81	kNm/m	
Maximum Shear	74	kN/m	
Slab Load	2	kN/m	at ground floor
	141	kN/m	at basement
Section	450mm at 600mm centres		

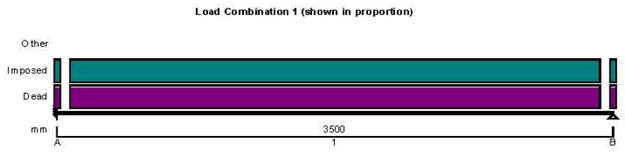
RC BEAM ANALYSIS & DESIGN BS8110

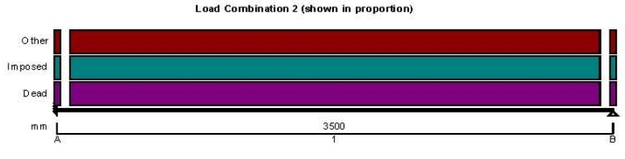
TEDDS calculation version 2.1.12

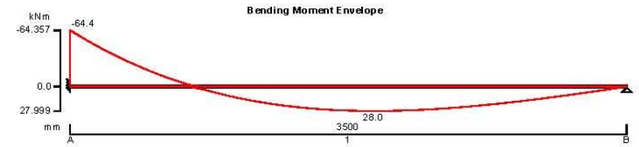


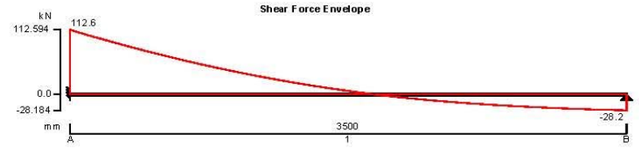












Support conditions

Support A	Vertically restrained	
	Rotationally restrained	
Support B	Vertically restrained	
	Rotationally free	

Applied loading

Soil	Dead full VDL 30.8 kN/m to 0 kN/m
Surcharge	Imposed full UDL 4 kN/m
Hydro	Dead partial VDL 24.525 kN/m at 0 mm to 0 kN/m at 2500 mm

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
		Other × 0.00
	Span 1	Dead × 1.40
		Imposed × 1.60
		Other × 0.00
	Support B	Dead × 1.40
		Imposed × 1.60
		Other × 0.00
Load combination 2	Support A	Dead × 1.05
		Imposed × 1.05
		Other × 1.05
	Span 1	Dead × 1.05
		Imposed × 1.05
		Other × 1.05
	Support B	Dead × 1.05

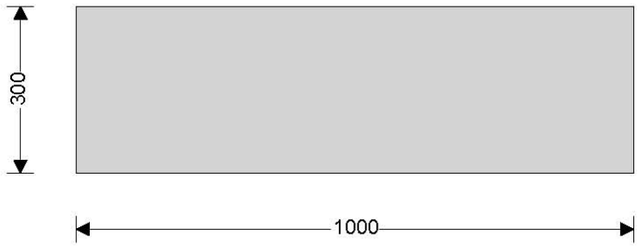
Imposed × 1.05
Other × 1.05

Analysis results

Maximum moment support A	M_{A_max} = **-64** kNm	M_{A_red} = **-64** kNm
Maximum moment span 1 at 1909 mm	M_{s1_max} = **28** kNm	M_{s1_red} = **28** kNm
Maximum moment support B	M_{B_max} = **0** kNm	M_{B_red} = **0** kNm
Maximum shear support A	V_{A_max} = **113** kN	V_{A_red} = **113** kN
Maximum shear support A span 1 at 239 mm	$V_{A\_s1\_max}$ = **93** kN	$V_{A\_s1\_red}$ = **93** kN
Maximum shear support B	V_{B_max} = **-28** kN	V_{B_red} = **-28** kN
Maximum shear support B span 1 at 3254 mm	$V_{B\_s1\_max}$ = **-26** kN	$V_{B\_s1\_red}$ = **-26** kN
Maximum reaction at support A	R_A = **113** kN	
Unfactored dead load reaction at support A	R_{A_Dead} = **70** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **9** kN	
Maximum reaction at support B	R_B = **28** kN	
Unfactored dead load reaction at support B	R_{B_Dead} = **14** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **5** kN	

Rectangular section details

Section width	b = **1000** mm
Section depth	h = **300** mm



Concrete details

Concrete strength class	**C32/40**
Characteristic compressive cube strength	f_{cu} = **40** N/mm^2
Modulus of elasticity of concrete	E_c = 20kN/mm^2 + 200 × f_{cu} = **28000** N/mm^2
Maximum aggregate size	h_{agg} = **10** mm

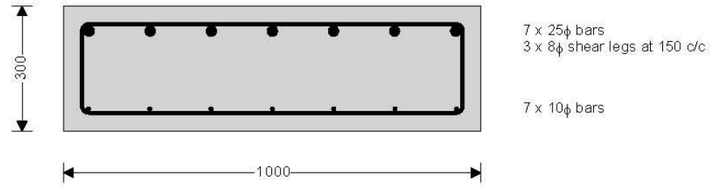
Reinforcement details

Characteristic yield strength of reinforcement	f_y = **500** N/mm^2
Characteristic yield strength of shear reinforcement	f_{yv} = **500** N/mm^2

Nominal cover to reinforcement

Nominal cover to top reinforcement	c_{nom_t} = **40** mm
Nominal cover to bottom reinforcement	c_{nom_b} = **40** mm
Nominal cover to side reinforcement	c_{nom_s} = **40** mm

Support A



Rectangular section in flexure (cl.3.4.4)

Design bending moment	M = abs(M_{A_red}) = **64** kNm
Depth to tension reinforcement	d = h - c_{nom_t} - ϕ_v - ϕ_{top} / 2 = **239** mm
Redistribution ratio	β_b = min(1 - m_{rA}, 1) = **1.000**
	K = M / (b × d^2 × f_{cu}) = **0.028**
	K' = 0.156
	K' > K - No compression reinforcement is required
Lever arm	z = min(d × (0.5 + (0.25 - K / 0.9)$^{0.5}$), 0.95 × d) = **228** mm
Depth of neutral axis	x = (d - z) / 0.45 = **27** mm
Area of tension reinforcement required	$A_{s,req}$ = M / (0.87 × f_y × z) = **650** mm^2
Tension reinforcement provided	7 × 25ϕ bars
Area of tension reinforcement provided	$A_{s,prov}$ = **3436** mm^2
Minimum area of reinforcement	$A_{s,min}$ = 0.0013 × b × h = **390** mm^2
Maximum area of reinforcement	$A_{s,max}$ = 0.04 × b × h = **12000** mm^2
	PASS - Area of reinforcement provided is greater than area of reinforcement required

Rectangular section in shear

Design shear force span 1 at 239 mm	V = max($V_{A\_s1\_max}$, $V_{A\_s1\_red}$) = **93** kN
Design shear stress	v = V / (b × d) = **0.389** N/mm^2
Design concrete shear stress	v_c = 0.79 × min(3,[100 × $A_{s,prov}$ / (b × d)]$^{1/3}$) × max(1, (400 /d)$^{1/4}$) × (min(f_{cu}, 40) / 25)$^{1/3}$ / γ_m
	v_c = **0.948** N/mm^2
Allowable design shear stress	v_{max} = min(0.8 N/mm^2 × (f_{cu}/1 N/mm^2)$^{0.5}$, 5 N/mm^2) = **5.000** N/mm^2
	PASS - Design shear stress is less than maximum allowable
Value of v from Table 3.7	v < 0.5v_c
Design shear resistance required	v_s = max(v - v_c, 0.4 N/mm^2) = **0.400** N/mm^2
Area of shear reinforcement required	$A_{sv,req}$ = v_s × b / (0.87 × f_{yv}) = **920** mm^2/m
Shear reinforcement provided	3 × 8ϕ legs at 150 c/c
Area of shear reinforcement provided	$A_{sv,prov}$ = **1005** mm^2/m
	PASS - Area of shear reinforcement provided exceeds minimum required
Maximum longitudinal spacing	$s_{v,max}$ = 0.75 × d = **180** mm
	PASS - Longitudinal spacing of shear reinforcement provided is less than maximum

Spacing of reinforcement (cl 3.12.11)

Actual distance between bars in tension	s = (b - 2 × (c_{nom_s} + ϕ_v + ϕ_{top}/2)) /(N_{top} - 1) - ϕ_{top} = **122** mm

Minimum distance between bars in tension (cl 3.12.11.1)

Minimum distance between bars in tension	s_{min} = h_{agg} + 5 mm = **15** mm
	PASS - Satisfies the minimum spacing criteria

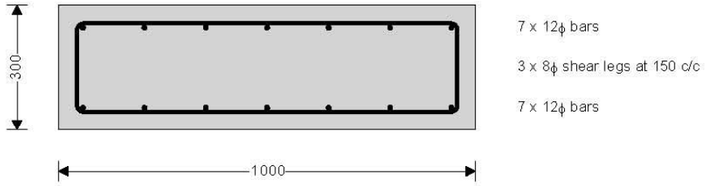
Maximum distance between bars in tension (cl 3.12.11.2)

Design service stress: $f_s = (2 \times f_y \times A_{s,req}) / (3 \times A_{s,prov} \times \beta_b)$ = **63.1** N/mm²

Maximum distance between bars in tension: s_{max} = min(47000 N/mm / f_s, 300 mm) = **300** mm

PASS - Satisfies the maximum spacing criteria

Support B



Rectangular section in shear

Design shear force span 1 at 3254 mm: V = abs(min($V_{B\_s1\_max}$, $V_{B\_s1\_red}$)) = **26** kN

Design shear stress: $v = V / (b \times d)$ = **0.107** N/mm²

Design concrete shear stress: $v_c = 0.79 \times \min(3, [100 \times A_{s,prov} / (b \times d)]^{1/3}) \times \max(1, (400/d)^{1/4}) \times (\min(f_{cu}, 40) / 25)^{1/3} / \gamma_m$

v_c = **0.572** N/mm²

Allowable design shear stress: v_{max} = min(0.8 N/mm² × (f_{cu}/1 N/mm²)$^{0.5}$, 5 N/mm²) = **5.000** N/mm²

PASS - Design shear stress is less than maximum allowable

Value of v from Table 3.7: $v < 0.5v_c$

Design shear resistance required: v_s = max(v - v_c, 0.4 N/mm²) = **0.400** N/mm²

Area of shear reinforcement required: $A_{sv,req} = v_s \times b / (0.87 \times f_{yv})$ = **920** mm²/m

Shear reinforcement provided: 3 × 8ϕ legs at 150 c/c

Area of shear reinforcement provided: $A_{sv,prov}$ = **1005** mm²/m

PASS - Area of shear reinforcement provided exceeds minimum required

Maximum longitudinal spacing: $s_{v,max} = 0.75 \times d$ = **185** mm

PASS - Longitudinal spacing of shear reinforcement provided is less than maximum

Pringuer-James Consulting Engineers

10 Beulah Road, Wimbledon London SW19 3SB
Phone : 0208 940 4159
Email : Mail@pjce.com

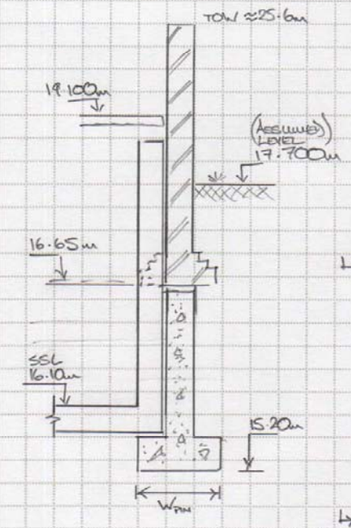
Sheet No : BW.01
Date : SEPT '14
By : C.C.

Job No. : L-1706
Item : BOUNDARY DETAILS - PROPOSED UNDERPINNING

TITLE : 227A GRAYS INN ROAD

LOCATION	CALCULATIONS	OPTIONS

Typical Underpinning Foundation to Eastern Boundary



Consider loads to boundary wall

330 Brick Wall — Gk: 22.0 kN/m³ × 0.33 = 7.26 kN/m²

330 Conc Underpin: 25.0 kN/m³ × 0.33 = 8.25 kN/m²

↳ Line Load at proposed footing level

W_D = (8.95m × 7.26 kN/m²) + (1.45m × 8.25 kN/m²)
= 64.98 + 11.963
= 76.94 kN/m @ Base

Referring to HEI Geotechnical Report Ref MRS/12138 (dated) 02/06/14

↳ Allowable Bearing Capacity

Let C = 38 kN/m²
N_c = 5.0
FOS = 3.0

∴ q_{des} = 96.7 kN/m²

↳ Width of footing (W_{PIN}) Req'd

$W_{PIN} \geq \frac{76.94}{96.70}$

≥ 0.796m

(Min width to be greater than or equal to existing footing below boundary wall).

* A Factor of Safety of 3.0 has been adopted thus ensuring that the potential settlements below the footing are kept within tolerable limits.

PROJECT	227A Grays Inn Road				R&E Geotechnical Consultants
TITLE	Propped Wall Adjacent to 55 Argyle Street				Design Cover Sheet
Reference No. RE1172 des 021	Revision No. 0	Date of Previous Design (if revision)			1 of 50
Activity	Initials	Signature		Date	
Design By				14/09/14	
Verified By					

Design Input

Existing basement 3.45m depth; basement founded at about 3.8m depth; excavation for proposed development 5m
Herts & Essex Site Investigation report ref MRS/12138 dated 2nd June 2014
& Draft logs BHD & E August 14
Su profile presented on sheet 50

Design to BS8002 / CIRIA C580
ULS analysis, to check depth, with unplanned overdig and factored soil strengths
SLS analysis with unfactored strengths and without overdig to checked factored SLS moments and shears

Two approaches are considered; firstly the existing basement is represented by two surcharges; this should be more onerous than reality as it still has some lateral load from basement. Secondly the starting level is taken as the basement level; passive soil above is modelled as a surcharge that is removed during excavation; ko taken as 2.5 at basement decreasing with depth.

450mm diameter at 600mm centres
Wall Propped at Capping Beam during Excavation

Design Output

Summary of analysis is presented on sheets:
Basement reprented by -ve surcharges *Sheets 3, 4, 26 & 27* *gives greater moments*
Starting level basement of No 55 *Sheets 14, 15, 37 & 38*

For calculated deflection look at SLS analysis sheets 26 to 47 only; methods give similar deflections

For retained height 5m, temporary propped Wall
Pile Length 10m
Reinforcement 9B25 B8at200

Temporary Propping Force
ULS 112 kN/m (-ve surcharges give the higher values)
SLS 75 kN/m unfactored

Sequence is based on removing temporary prop after casting ground floor slab

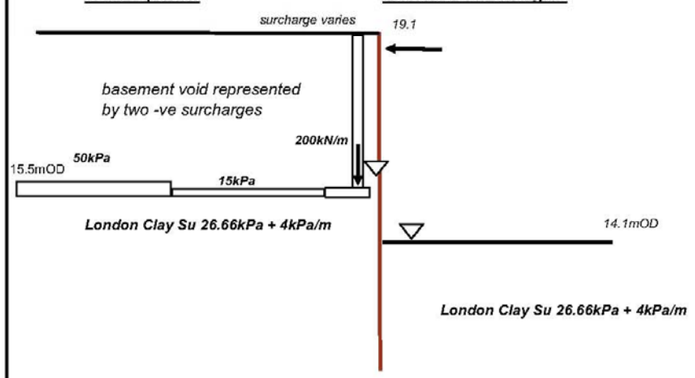
Revision	By	Date	Ver	Date	Description

RE1172 des 021.xls

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	2 of 50	

Reference

Soil Properties **Factored Soil Strengths**



Made Ground

Bulk Density = 18 kN/m3
Submerged Density = 19 kN/m3
Shear Strength phi = 25 c' = 0
Earth Pressure Coefficients ka = 0.352
ko = 0.55
kp = 3.369
Elastic Modulus = 5,000kPa + 4,000kPa/m

Undrained London Clay

Bulk Density = 20 kN/m3
Submerged Density = 20 kN/m3
Shear Strength Su = 26.66kPa + 4kPa/m
Earth Pressure Coefficients ka = 1 kac = 2.389
ko = 1.25
kp = 1 kpc = 2.39
Elastic Modulus = 26,000kPa + 4,000kPa/m depth

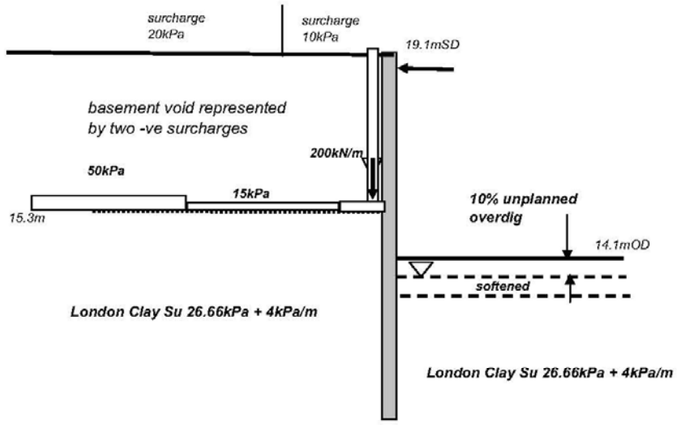
Drained London Clay

Bulk Density = 20 kN/m3
Submerged Density = 20 kN/m3
Shear Strength phi = 19.4 c' 4 kPa
Earth Pressure Coefficients ka = 0.445 kac = 1.577
ko = 1.25
kp = 2.505 kpc = 4.274
Elastic Modulus = 20,000kPa + 3,200kPa/m depth

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	3 of 50	

Reference

Adjacent to 55 Argyle Street - Basement represented by -ve surcharges
ULS Factored Soil Strengths and unplanned overdig

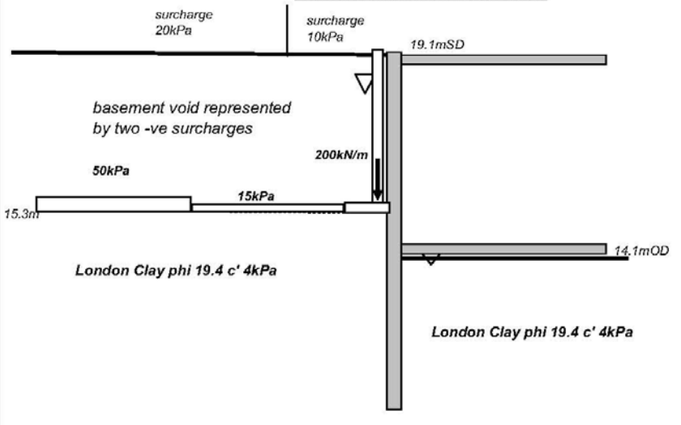


Excavation depth	14.1	mOD	planned dig
	13.6	mOD	unplanned overdig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	1.33	> 1.0 for factored strengths and overdig	
Maximum Moment	332	kNm/m	
Maximum Shear	149	kN/m	
Waling Load	112	kN/m	
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	4 of 50	

Reference

Adjacent to 55 Argyle Street - Basement represented by -ve surcharges
ULS Factored Soil Strengths
Long term with accidental Water

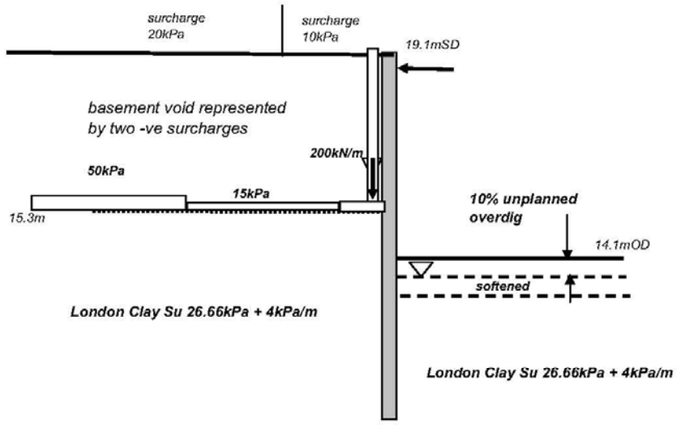


Excavation depth	14.1	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	multi-propped		
Maximum Moment	333	kNm/m	
Maximum Shear	145	kN/m	
Slab Load	101	kN/m	at ground floor
	195	kN/m	at basement
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	3 of 50	

Reference

Adjacent to 55 Argyle Street - Basement represented by -ve surcharges
ULS Factored Soil Strengths and unplanned overdig

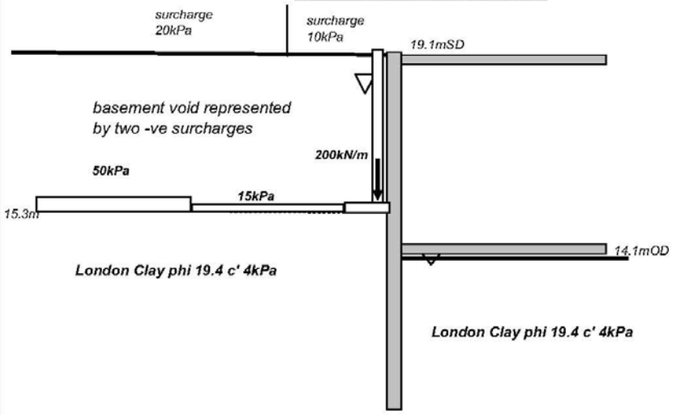


Excavation depth	14.1	mOD	planned dig
	13.6	mOD	unplanned overdig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	1.33	> 1.0 for factored strengths and overdig	
Maximum Moment	332	kNm/m	
Maximum Shear	149	kN/m	
Waling Load	112	kN/m	
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	4 of 50	

Reference

Adjacent to 55 Argyle Street - Basement represented by -ve surcharges
ULS Factored Soil Strengths
Long term with accidental Water

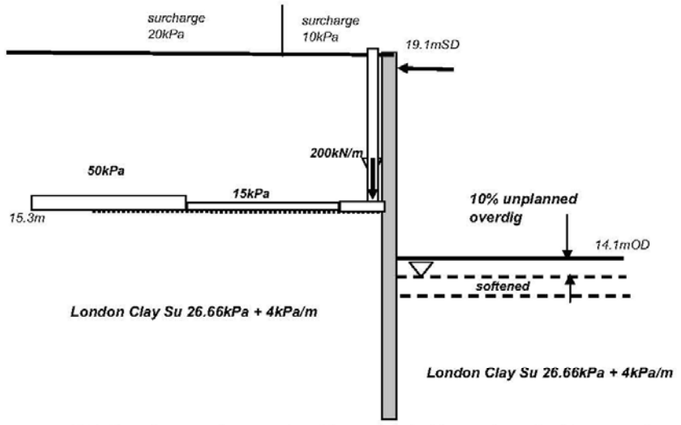


Excavation depth	14.1	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	multi-propped		
Maximum Moment	333	kNm/m	
Maximum Shear	145	kN/m	
Slab Load	101	kN/m	at ground floor
	195	kN/m	at basement
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	14 of 50	

Reference

Adjacent to 55 Argyle Street - Alternative; basement level starting level
ULS Factored Soil Strengths and unplanned overdig



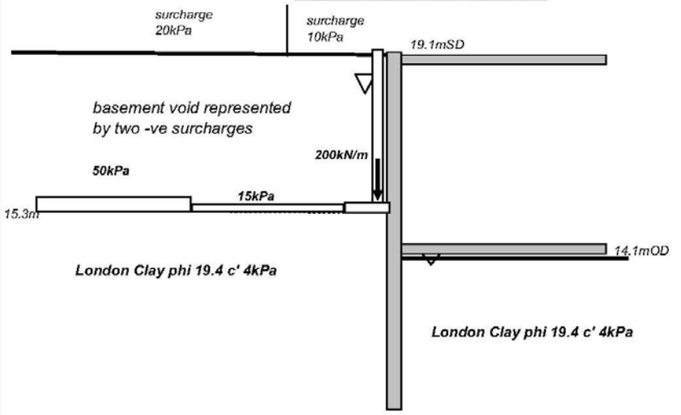
Soil above basement on passive side represented by surcharge that is removed

Excavation depth	14.1	mOD	planned dig
	13.6	mOD	unplanned overdig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	1.47	> 1.0 for factored strengths and overdig	
Maximum Moment	262	kNm/m	
Maximum Shear	127	kN/m	
Waling Load	77	kN/m	
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	15 of 50	

Reference

Adjacent to 55 Argyle Street - Alternative; basement level starting level
ULS Factored Soil Strengths
Long term with accidental Water



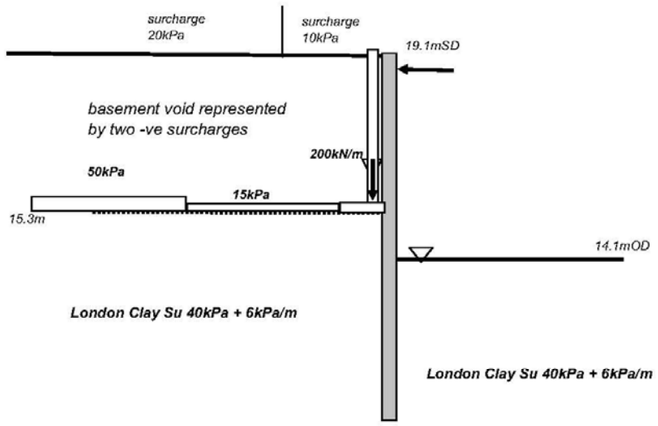
Soil above basement on passive side represented by surcharge that is removed

Excavation depth	14.1	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	multi-propped		
Maximum Moment	240	kNm/m	
Maximum Shear	159	kN/m	
Slab Load	75	kN/m	at ground floor
	288	kN/m	at basement
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	26 of 50	

Reference

Adjacent to 55 Argyle Street - Basement represented by -ve surcharges
SLS Unfactored Soil Strengths without overdig

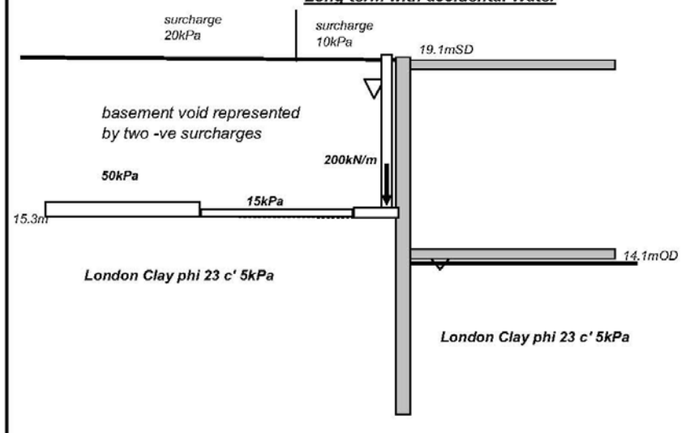


Excavation depth	14.1	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	2.21		Burland & Potts (see ULS Analysis)
Maximum Moment	202	kNm/m	
Maximum Shear	118	kN/m	
Waling Load	75	kN/m	
Maximum Deflection	11	mm	at 15mOD
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	27 of 50	

Reference

Adjacent to 55 Argyle Street - Basement represented by -ve surcharges
SLS Unfactored Soil Strengths
Long term with accidental Water

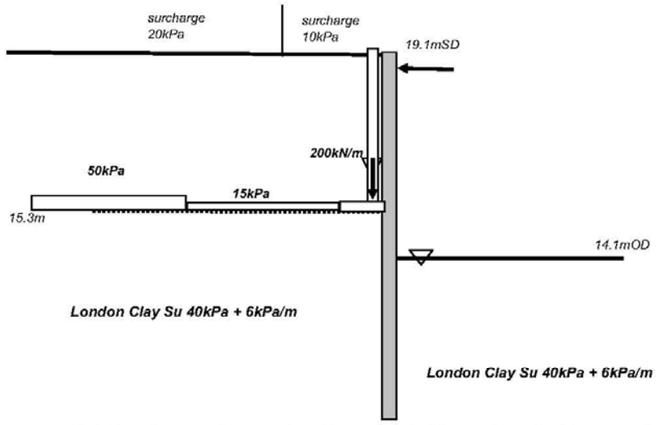


Excavation depth	14.1	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	multi-propped		
Maximum Moment	196	kNm/m	
Maximum Shear	132	kN/m	
Slab Load	69 219	kN/m kN/m	at ground floor at basement
Maximum Deflection	11	mm	at 13mOD
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	37 of 50	

Reference

Adjacent to 55 Argyle Street - Alternative; basement level starting level
SLS Unfactored Soil Strengths without overdig



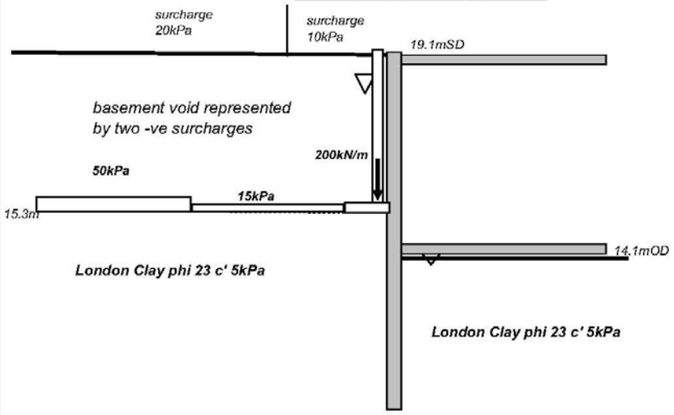
Soil above basement on passive side represented by surcharge that is removed

Excavation depth	14.1	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	2.46	Burland & Potts (see ULS Analysis)	
Maximum Moment	181	kNm/m	
Maximum Shear	100	kN/m	
Waling Load	54	kN/m	
Maximum Deflection	9	mm	at 14mOD
Section	450mm at 600mm centres		

R&E Geotechnical Consultants						227A Grays Inn Road
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Propped Wall adjacent to 55 Argyle Street
njb	14/09/14			RE1172 des 021	38 of 50	

Reference

Adjacent to 55 Argyle Street - Alternative; basement level starting level
SLS Unfactored Soil Strengths
Long term with accidental Water



Soil above basement on passive side represented by surcharge that is removed

Excavation depth	14.1	mOD	planned dig
Retained Level	19.1	mOD	
PPL	19.1	mOD	
Toe depth	9.1	m	
Pile Length	10.0	m	
Factor of Safety	multi-propped		
Maximum Moment	176	kNm/m	
Maximum Shear	140	kN/m	
Slab Load	56 253	kN/m kN/m	at ground floor at basement
Maximum Deflection	12	mm	at 12mOD
Section	450mm at 600mm centres		