Contract No:	20147	Site Address: Gray's Inn Road, Panther House, WC1X 0AG, London		
Designed: WP		Checked: DMB	*Design Category Check:* 2	Page 1
Purpose of Design: Bearing Pile Design			GSS Ref.: 20147_PD01	

20147 – Panther House
Bearing Pile Design

Rev	Description	Date
C1	First Issue	05/03/2020
C2	Pile design revised to address pile P10	20/03/2020

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Purpose of Design: Bearing Pile Design			GSS Ref.: 20147_PD01

Design Risk Assessment

Risk Level					
Severity	**Likelihood of Exposure to Hazard**				
	Almost Certain	**Likely**	**Possible**	**Unlikely**	**Impossible**
Fatalities	**H**	**H**	**H**	**H**	**M**
Major	**H**	**H**	**H**	**M**	**L**
Minor	**H**	**M**	**M**	**L**	**L**
None anticipated	**L**	**L**	**L**	**L**	**L**

No.	Hazard Description	Risk Level Before Design Moderation (H / M / L)	Remedial Actions Taken	Risk Level After Design Moderation (H / M / L)	Significant Residual Risks Comments for, or Actions required by Others?
1	Risk of striking buried services.	H	Main contractor to identify existing services from site survey and to carry out CAT scan to physically identify the services on site before work commence.	M	Action Main Contractor
2	Piling works from suspended Slab	H	Existing Slab to be back propped to support the construction loads during piling works	M	GSS
3	Use of piling rig on site, potential unstable ground or soft spots may pose risk to machine overturning.	H	Piling rig to operate from the existing RC slab. Pile pockets to be broken out locally without oversizing. Suitable protection must be installed to protected operative from falling material and fall from heights.	M	GSS
4	Projecting reinforcement bars protruding from installed piles.	M	Pile reinforcement caps to be installed as the reinforcement bas will be projecting above basement slab.	L	Site foreman and piling supervisor to ensure H&S compliance.
5	Working in restricted headroom.	L	Ensure headroom provided, prior works, is agreed between GSS and Main Contractor.	L	N / A.
6	Access to pile for integrity testing.	L	Testing to be suitably programmed prior installation of basement slab.	L	GSS

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Designed: WP		Checked: DMB	*Design Category Check:* 2	Page 4
Purpose of Design: Bearing Pile Design			GSS Ref.: 20147_PD01

Construction Brief

This design is for the installation of a permanent pile required to support the proposed foundation forming part of the redeveloping scheme for the property above. Due to the restricted nature of the site a Super Kitten Mini Piling Rig will be used operating from the courtyard level.

Pile will be installed using the case and auger method whereby the temporary casings are installed to prevent the collapse of granular soils and ingress of groundwater into the pile bores. This method does not cause any vibration or disturbance to the surrounding structures or services. Site specific method statement will be carried out by a competent piling manager for this specific piling rig and method installation. Piling works shall not commence until the pile design and method statement have been approved.

This design is for

- 1No 300/340mm diameter bearing pile installed using drill and case method.

Design Information

- Eckersley O'Callaghan drawing 15078-S1.01 rev T2 Mark-up.

Site Investigation:

- Site Analytical Services Ltd. Ref. 1523911 from August 2015.

Pile Loads range:

- Compression load range= 450KN
- Tension load = 0KN
- Horizontal load = 15KN

Piling Platform Level (PPL)

The piling platform will be taken as the existing courtyard level.

PPL = 19.30mOD

Ground Conditions

According to the site investigation report the ground profile consists of Made Ground over Dense Gravel with underlaying Stiff to Very Stiff London Clay at depth.

Top of borehole level = 19.3mOD.

19.30mOD to 16.20mOD – Made Ground
16.20mOD to 13.80mOD – Dense Gravel
from 13.80mOD – Stiff to Very Stiff London Clay

Design Borehole Profile

19.30mOD to 15.60mOD	→	Piling mat & Basement Void – Ignore for pile capacity.
14.5mOD to 13.50mOD	→	Dense Gravel ($\Phi = 36^0$; γ=19KN/m^3) – Ignore for pile capacity.
from 13.500mOD	→	London Clay Cu = 75KPa increasing strength at 7.0KPa/m; γ=20KN/m^3

Water strike was identified at 5.5m below top of bore hole, 13.8mOD.

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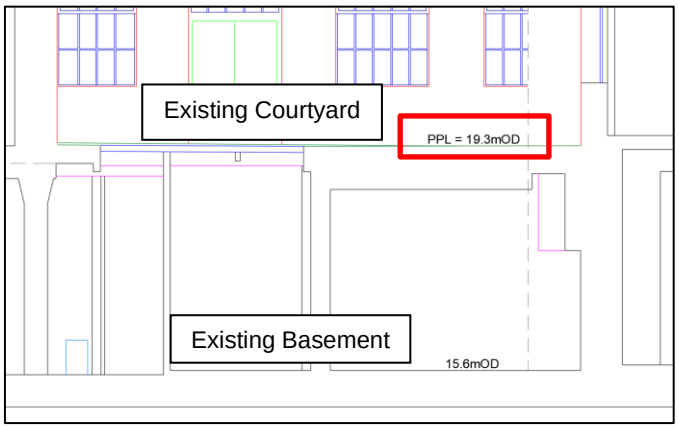
Piling Platform Level - PPL



Section extracted from Survey drawing 15-040-(13A&14) showing Section Through Courtyard and Basement

Design Parameters

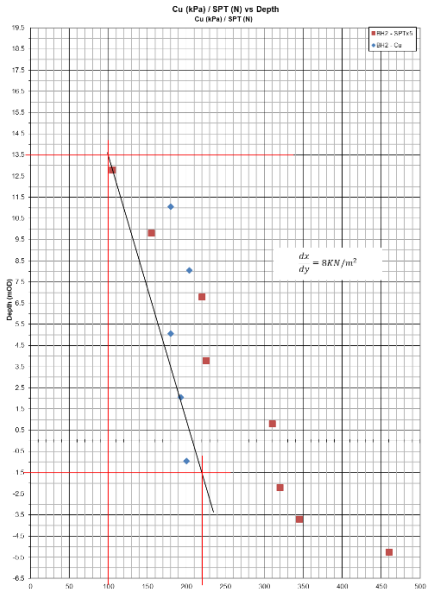
Piles will be installed using drill and case method and segmented augers.

- Pile Diameter = 300mm (nominal)
- FOS = 2.6 in compression and 3.0 in tension (based on LDSA Guidelines 2017)
- Alpha (adhesion factor in clay) = 0.5

The unit shaft friction is limited to 140KPa for Cohesive Soils.

Soil profile and parameters, seen above, have been used to design the bearing piles using a software package called CADS Bearing Pile designer. See software input and output attached.

Design Line



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Pile Fixity

Pile is considered to be restrained in both directions by the RC base slab. Pile stability and depth of reinforcement has been obtained using a computer package based on the Broms Method (1964). The proposed bearing pile is considered to be restrained at the top, hence the full design moment provided by Brom's Analysis has been halved to calculate the reinforcement required.

Pile Reinforcement Depth

The reinforcement required to resist the bending moment, generated due to shear force obtained from Brom's Analysis, has been calculated using Scale - Column Design method according to BS8110.

Pile COL and the required toe level resulting from Broms have been used to provide the overall cage length.

14.0mOD – 12.4moD = 1.6m, however provide an overall 6.0m cage, including top projection.

Design Parameters for Piles acting as Circular Columns

The reinforcement required to resist the bending moment generated due to shear force, obtained from Brom's Analysis, has been calculated using Scale - Column Design method according to BS8110.

Concrete = C28/35

Pile Diameter = 300mm

Concrete cover = 75mm

Cage reinforcement = 6.0m x 6H16 bars + H8 helicals provided at 150mm c/c

Pile Settlement

Pile settlement will be estimated using C_u values, given by the adopted soil profile, to calculate the Shear Modulus of the founding layer. See design sheet attached.

Settlement check follows Fleming's method; hence the Dense Gravel Strata is assumed to be a low friction zone, therefore ignored.

Estimated Settlement for 450KN Load

Founding layer = -1.50mOD
C_u = 220KPa at -1.50mOD
E = 33000MPa

Estimated pile settlement for a 450KN load = 1.8mm.

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CADS Output – Pile Capacity

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CADS Bearing Pile Designer Version 1.09 Geotechnical analysis and design of bearing piles	Project 20147 File Name "\\geo-dc\DOCUMENTS\~F
Gray's Inn Road, Pnather House, WC1X 0AG, London PD01 - Bearing Pile Design	Engineer WP Date 20/03/2020

Pile type and size

Pile length	21.50
Pile type	Bored
Pile diameter	300

Soils and ground water data

Ground Water level 13.80

Top Level m	Description	Soil Type	Density kN/m3	Phi Deg	C Base kN/m2	C Inc kN/m3	SPT Base	SPT Inc. (/m)	Auto Value
19.30	Ignored	Granular by Phi	5.00	0					Auto
14.50	Dense Gravel	Granular by Phi	19.00	0					Auto
13.50	London Clay	Undrained	20.00		100	8.0			Auto

Calculation options

Factors of safety			
Compression check 1	Overall FOS	2.60	
Compression check 2	Shaft resist. FOS	1.00	
	End resistance FOS	3.00	
Tension check	Overall FOS	3.00	
Soil strength partial factors			
Factor on strength of granular soils		1.00	
Factor on strength of other soil types		1.00	
Unit strength capacity limits			
Max. unit shaft resist.	Granular soils	100	kN/m2
	Cohesive soils	140	kN/m2
	Chalk soils	150	kN/m2
Max. unit end bearing	Granular - Augered	5000	kN/m2
	Granular - Driven	10000	kN/m2
	Cohesive soils	10000	kN/m2
	Chalk soils	10000	kN/m2
Negative and zero skin friction zones			
Depth of soils over which NSF is applied		0	m
Additional depth for zero shaft resistance		0	m
Percentage of skin friction in NSF calc.		100	%

Results summary

Ultimate end bearing resistance	144	kN
Ultimate shaft resistance	1204	kN
Design compression	518	kN
Design tension	410	kN

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Tabular presentation of calculation output

Calc Level m	Vert Total kN/m2	Water kN/m2	Vert Stress kN/m2	Phi deg	C'/Cu kN/m2	SPT	Unit Shaft kN/m2	Ult. Shaft kN	Unit End kN/m2	Ult. End kN	Design Comp. kN	Design Tension kN
19.30	0	0	0	0	0	0	0	0	0	0	0	0
19.00	1	0	1	0	0	0	0	0	0	0	0	0
18.50	4	0	4	0	0	0	0	0	0	0	0	0
18.00	6	0	6	0	0	0	0	0	0	0	0	1
17.50	9	0	9	0	0	0	0	0	0	0	0	1
17.00	12	0	12	0	0	0	0	0	0	0	0	1
16.50	14	0	14	0	0	0	0	0	0	0	0	2
16.00	17	0	17	0	0	0	0	0	0	0	0	2
15.50	19	0	19	0	0	0	0	0	0	0	0	2
15.00	22	0	22	0	0	0	0	0	0	0	0	3
14.50	24	0	24	0	0	0	0	0	0	0	0	3
14.50	24	0	24	0	0	0	0	0	0	0	0	3
14.00	34	0	34	0	0	0	0	0	0	0	0	3
13.80	37	0	37	0	0	0	0	0	0	0	0	3
13.80	37	0	37	0	0	0	0	0	0	0	0	3
13.50	43	3	40	0	0	0	0	0	0	0	0	3
13.50	43	3	40	0	100	0	50	0	900	64	21	3
13.00	53	8	45	0	104	0	52	24	936	66	35	12
12.50	63	13	50	0	108	0	54	49	972	69	45	20
12.00	73	18	55	0	112	0	56	75	1008	71	56	29
11.50	83	23	60	0	116	0	58	102	1044	74	68	38
11.00	93	27	66	0	120	0	60	130	1080	76	79	47
10.50	103	32	71	0	124	0	62	158	1116	79	91	57
10.00	113	37	76	0	128	0	64	188	1152	81	104	67
9.50	123	42	81	0	132	0	66	219	1188	84	116	78
9.00	133	47	86	0	136	0	68	250	1224	87	130	88
8.50	143	52	91	0	140	0	70	283	1260	89	143	99
8.00	153	57	96	0	144	0	72	316	1296	92	157	111
7.50	163	62	101	0	148	0	74	351	1332	94	171	122
7.00	173	67	106	0	152	0	76	386	1368	97	186	134
6.50	183	72	111	0	156	0	78	422	1404	99	201	147
6.00	193	77	116	0	160	0	80	459	1440	102	216	159
5.50	203	81	122	0	164	0	82	498	1476	104	232	172
5.00	213	86	127	0	168	0	84	537	1512	107	248	185
4.50	223	91	132	0	172	0	86	577	1548	109	264	199
4.00	233	96	137	0	176	0	88	618	1584	112	281	213
3.50	243	101	142	0	180	0	90	660	1620	115	298	227
3.00	253	106	147	0	184	0	92	703	1656	117	315	241
2.50	263	111	152	0	188	0	94	746	1692	120	333	256
2.00	273	116	157	0	192	0	96	791	1728	122	351	271
1.50	283	121	162	0	196	0	98	837	1764	125	370	287
1.00	293	126	167	0	200	0	100	884	1800	127	389	302
.50	303	130	173	0	204	0	102	931	1836	130	408	318
.00	313	135	178	0	208	0	104	980	1872	132	428	335
-.50	323	140	183	0	212	0	106	1029	1908	135	448	351
-1.00	333	145	188	0	216	0	108	1080	1944	137	468	368
-1.50	343	150	193	0	220	0	110	1131	1980	140	489	386

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Calc Level m	Vert Total kN/m2	Water kN/m2	Vert Stress kN/m2	Phi deg	C'/Cu kN/m2	SPT	Unit Shaft kN/m2	Ult. Shaft kN	Unit End kN/m2	Ult. End kN	Design Comp. kN	Design Tension kN
-2.00	353	155	198	0	224	0	112	1183	2016	143	510	403
-2.20	357	157	200	0	226	0	113	1204	2030	144	518	410

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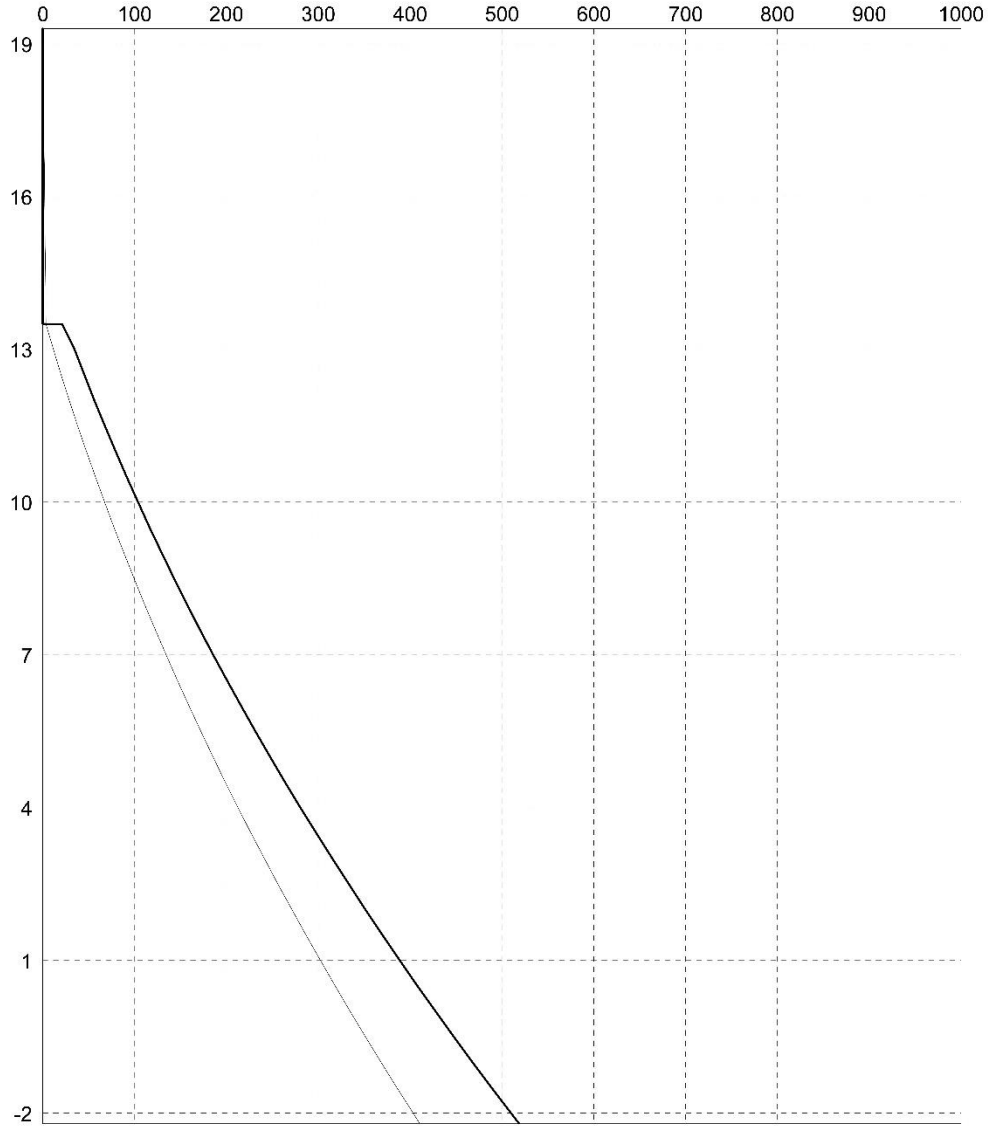
Graphical presentation of calculation output

Design compression capacity - Shown by thick line
Design tension capacity - Shown by thin line



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Scale Output – Cage Depth Required

```
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PD01 - Bearing Pile Design                        Made by:  WP
Reinforcement Cage Depth                             Date:  20/03/20
                                                   Ref No:  20147
_____________________________________________________________________

                                                   Office:  6255

Location: Laterally loaded pile analysed by Brom's method
```

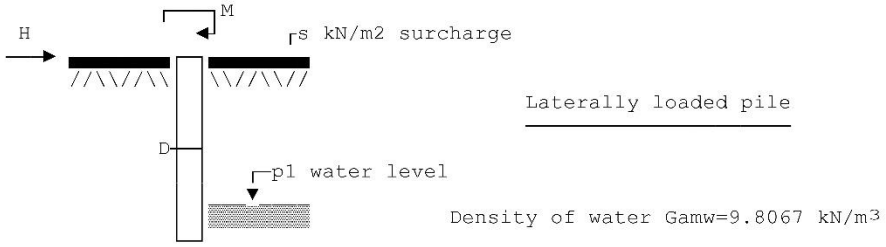


```
Water level (-ve values)          p1=13.800 m

Increment of calculation          d1=0.05 m
F.O.S applied to lateral pressure fos=3
Number of soil strata             N=2

• Soil data for stratum 1 of 2
Top level of stratum              TL(1)=14.000 m
Bulk density                      Gam(1)=19 kN/m3
Angle of internal friction        Phi(1)=36°
Cohesive shear strength           Cu(1)=0 kN/m2

• Soil data for stratum 2 of 2
Top level of stratum              TL(2)=13.500 m
Bulk density                      Gam(2)=20 kN/m3
Angle of internal friction        Phi(2)=0°
Cohesive shear strength           Cu(2)=75 kN/m2

Unfactored vertical surcharge     s=1 kN/m2
Unfactored lateral load at top    H=15 kN
Unfactored moment applied to top  M=1 kNm
Pile dia. resisting lateral load  D=0.300 m
```

Summary

Level of max moment (m)	Level of bottom of cage (m)	Unfactored max moment (kNm)
13.2	12.4	9.6064

Level (m)	Pressure (kN/m2)	Shear (kN)	Moment (kNm)
14	3.8518	15	1
13.95	7.5111	14.915	1.7481
13.9	11.17	14.775	2.4906
13.85	14.83	14.58	3.2247
13.8	18.489	14.33	3.9476
13.75	20.259	14.039	4.6569
13.7	22.03	13.722	5.3511

Design Moment
9.6 / 2 = 4.8KNm x 1.45 = 7.0KNm

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Gray's Inn Road, WC1X 0AG, London
PD01 - Bearing Pile Design
Reinforcement Cage Depth

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13.65	23.801	13.378	6.0287
13.6	25.571	13.008	6.6885
13.55	27.342	12.611	7.3291
13.5	29.112	12.188	7.9491
13.45	156.94	10.792	8.5316
13.4	166.67	8.3652	9.0112
13.35	176.39	5.7923	9.3657
13.3	186.11	3.0736	9.588
13.25	195.83	0.20897	9.6707
13.2	205.56	0	9.6064
13.15	215.28	-3.1563	9.5281
13.1	225	-6.4583	9.2884
13.05	225	-9.8333	8.8811
13	225	-13.208	8.3051
12.95	225	-16.583	7.5603
12.9	225	-19.958	6.6467
12.85	225	-23.333	5.5644
12.8	225	-26.708	4.3134
12.75	225	-23.333	3.0624
12.7	225	-19.958	1.9801
12.65	225	-16.583	1.0665
12.6	225	-13.208	0.32173
12.55	225	-9.8333	-0.25432
12.5	225	-6.4583	-0.66161
12.45	225	-3.0833	-0.90015
12.4	225	0.29167	-0.96994

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Scale Output – Pile Cage Reinforcement

```
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PD01 - Bearing Pile Design                              Made by:  WP
Reinforcement Cage                                        Date:  20/03/20
                                                        Ref No:  20147
_____________________________________________________________________

                                                       Office:  6255   1

Location: Small column. High-yield steel. High moment. Low axial load.

Design of circular section under bending and axial load
_______________________________________________

Design to BS8110(1997), partial safety factor for steel gammaS=1.15
```

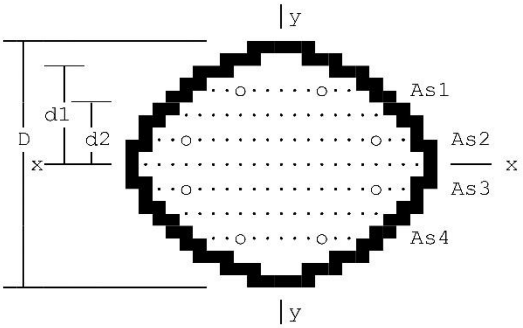

Calculations for reinforcement are in accordance with BS 8110 Solution is obtained by trial-and-adjustment procedure with check calculations printed out beneath. The concrete section is split into eight strips of equal depth. Eight steel bars arranged as shown are assumed, giving four steel areas.

```
Design axial load                  N=1 kN
Design moment                      M=7.0 kNm
Section diameter                   D=300 mm
Size of links                      dia1=8 mm
Characteristic concrete strength   fcu=35 N/mm2
Characteristic steel strength      fy=500 N/mm2
Nominal cover to all steel         c=75 mm
force on strip                     f=A*et/(et-eb)*fu*(1-0.333*e1/et)
                                     /1E3=45.739 kN
force on strip          f=A*fu*(1-0.333*(1-fb/fu)*(e1-eb)/(et-eb))/1E3
                         =79.176 kN
SUMMARY ( fcu=35 N/mm2 : fy=500 N/mm2 )
_____________________________________

(Note: 'microstrain' indicates true strain multiplied by 1,000,000.)
Diameter of section                300 mm
Cover to all reinforcement         75 mm
Size of main bars                  16 mm
Number of main bars                6
Area of steel provided             1206.4 mm2
Percentage of steel provided       1.7067 %
Size of links provided             8 mm
Comp.strain at outer conc.fibre    3500 microstrain
Tensile strain at steel area As1   2987.5 microstrain
Tensile strain at steel area As4   10394 microstrain
Depth of concrete in compression   51.517 mm
                        Specified   Calculated   Excess (%)
Axial load in kN            1          -415.12
Resistance moment in kNm    7           12.916       84.5    satisfactory

                                                          No 94
```

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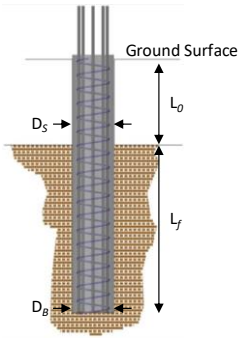
Pile Settlement Check – 450KN

GSS Piling Limited RESTRICTED ACCESS PILING SPECIALISTS Geostructural Solutions Ltd Construction Specialists	Client:		Job No.		20147	
	Project:	Gray's inn Road, Panther House, WC1X 0AG				
	Section:	Estimation of pile settlement for 300mm Pile Founding Level at -1.5mOD from COL @ 14.00mOD.	By:	WP	Date:	20/03/20
			Chk:	DMB	Date:	20/03/20

Prediction of pile ultimate capacity using the method outlined by Fleming in Geotechnique 42, No 3 pages 411-425

Pile Data

Pile Number			
Pile shaft diameter	Ds	300	mm
Pile base diameter	Db	300	mm
Pile length with no friction	Lo	1	m
Pile length with friction	Lf	14.5	m
Effective Lf length factor	Ke	0.45	
Shaft flexibility factor	Ms	0.0010	
Soil modulus below pile base	Eb	33000	kN/m²
Concrete modulus	Ec	**3.00E+07**	kN/m²
Ultimate shaft capacity	Us	1131	kN
Ultimate shaft friction	qus	83	kN/m²
Estimated Ultimate End bearing	Ub	140	kN
Ultimate end bearing pressure	qub	1980.6	kN/m²



K = 251005.2 KN/m²/m

Test Data

Load at head	(kN)																		
Head Settlement	(mm)																		
Elastic Settlement	(mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

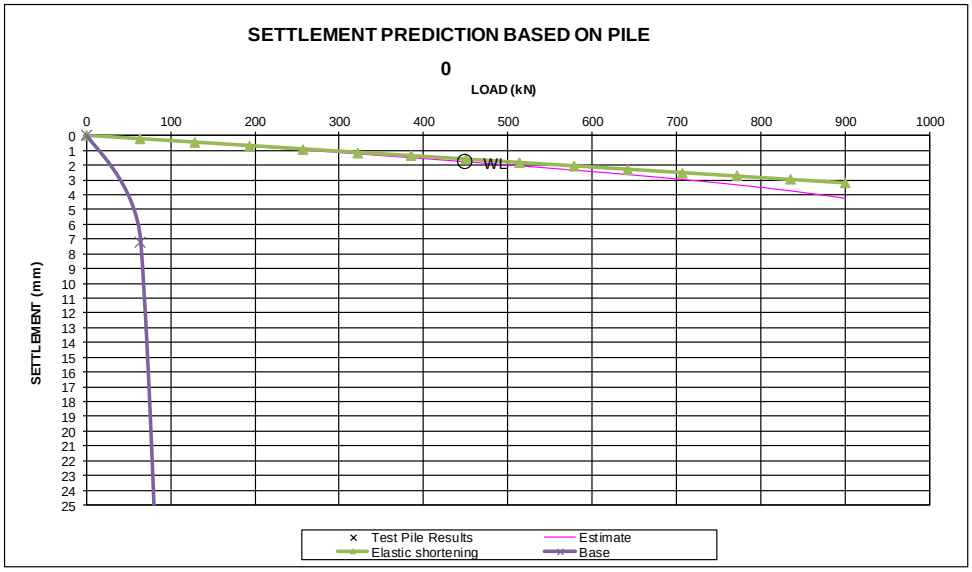
Predicted Settlement

Load descriptor WL — Settlement required for load of 450 kN — Predicted settlement at head = 1.8 mm

Projected Data

Load at head	(kN)	0	64	129	193	257	321	386	450	514	579	643	707	771	836	900	
Rigid Pile Settleme	(mm)	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.1	
Elastic settlement	(mm)	0.0	0.2	0.5	0.7	0.9	1.1	1.4	**1.6**	1.8	2.1	2.3	2.5	2.7	3.0	3.2	
Total settlement	(mm)	0.0	0.2	0.5	0.7	1.0	1.3	1.5	**1.8**	2.1	2.4	2.7	3.0	3.4	3.8	4.3	
Base settlement	(mm)	0	7.204	95.455	95.45	95.455	95.455	95.455	95.455	95.455	95.455	95.455	95.455	95.455	95.455	95.455	

(For "Load at Head" applied at base)



Rev	Description	Date
C1	First Issue	05/03/2020
C2	Pile design revised to address pile P10	20/03/2020

Design Summary – Bearing Piles

- PPL 19.300mOD;
- Pile to be 300/340mm diameter drill and case;
- Concrete = C28/35 – with a sulphate classification of DS-2;
- Cage reinforcement to be 6.0m x 6H16+H8@150mm c/c as per schedule;
- Cage OD to be 150mm.
- Pile to be integrity tested.

Pile Schedule

GSS Piling Limited
RESTRICTED ACCESS PILING SPECIALISTS

Rev	Date	Description
0	058/03/20	First Issue
A	20/03/20	Pile Schedule revised to addres pile P10 only

Project: Gray's Inn Road - Pnather House
Job No. 20147

Bearing Piles

Hide Hide

Pile No.	Compressioin Load (KN)	Horizontal	CUT-OFF LEVEL (mOD)	Pile Diameter (mm)	PPL (mOD)	Pile Depth (m)	Top of Cage below PPL (m)	Debond length (m)	Top of Concrete below PPL (m)	Toe Level Compression (mOD)	ADOPTED TOE (mOD)	Top Reinforcement Cage	Theoretical Concrete Volume (m^3)
P10	450	15	14.000	300	19.300	21.0	4.5	0.4	5.0	-1.5	-1.5	6.0m x 6H16+H8 @ 150mm c/c	1.5
						21m							1.5

NOTES:
Cage OD = 150mm
Concrete = C28/35 - 20mm aggregate
Concrete Cover = 75mm
Laps to be 40D

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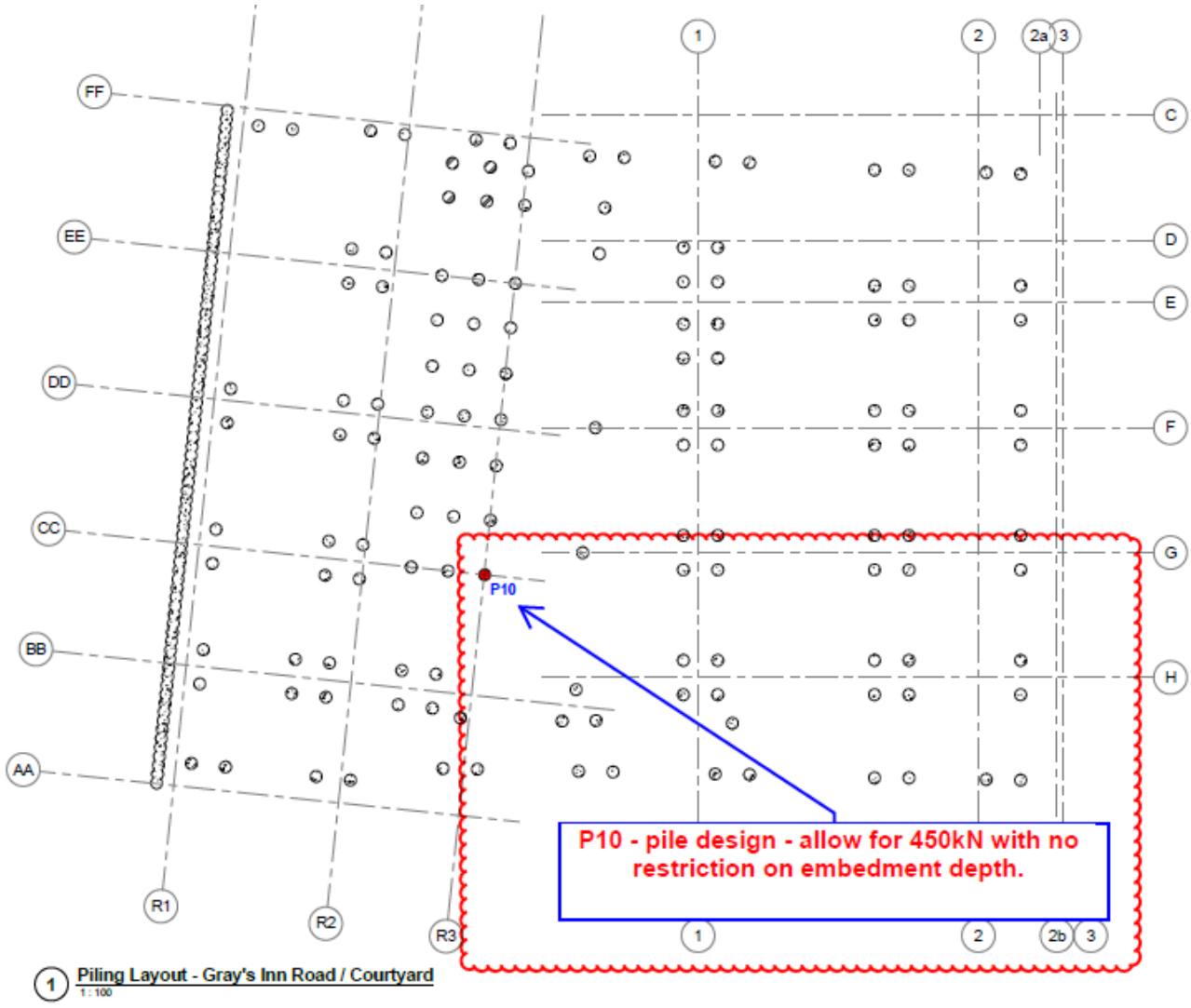
Pile Layout and Loads



Pile layout extracted from Eckersley O'Callaghan drawing 15078-S1.01 rev T2

Rev	Description	Date
C1	First Issue	05/03/2020
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