

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
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2231 – North Littlehampton
600mm ø Bearing Pile & R.C. Cap Design
Calculations for Bebo Arch Bridge

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Appendix A 2231_SK001 Pile Cap Assumed Loads & Levels

Appendix B Borehole cross section & Ground Model

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Appendix K Pile Cap Reinforcement Drawing - 2231-002

Revision	Date	Details
0	19/03/21	Initial Issue for comment
A	05/08/21	Revised Cap Levels

1. Scope

Figure 1: Bebo arch spanning over water channel

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It is **strongly** recommended that dynamic probes are undertaken to determine rockhead levels due to the limited Site Investigation plus 2no. working load pile tests.

These calculations detail the bearing pile design to accommodate the full dead and imposed loads from the structure and are in accordance with Eurocodes and the requirements of BS EN 1997-1 (2013), British Standards plus current good practice guidance.

2. Documentation

Package containing:

- LP2128 Phase III Site Investigation Report - Leap Environmental Limited - dated 21/04/2020
- GEA-18426-14-69 Geo-Environmental Assessment - Merebrook Consulting - dated February 2014
- Preliminary/Tender layout drawings
 - A/PHILITTLE-MAIN.1/10-1 Rev T2 (MBL)
 - A/PHILITTLE-MAIN.1/20-1 Rev T3 (MBL)
 - 35944/1507/003 Rev P04 (PBA)
- Email dated 02/12/20 containing pile cap loads
- Email dated 15/12/20 containing required keyway dimensions
- 6217-255_E15.5mT/002 Rev 0 General Arrangement (Structural) - Plan View & Sections
- MB/C/02 Rev T1 draft - Northern Crossing and Bebo Construction Detail

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3. Specification & References

- i) BRE Special Digest 1 Concrete in Aggressive Ground - 3rd edition (2005).
- ii) BS 8002 (2015) – Code of Practice for Earth Retaining Structures, BSI, London.
- iii) BS 8004 (2015) – Code of Practice for Foundations, BSI, London.
- iv) BS EN 1536 (2015) – Execution of Special Geotechnical Work – Bored Piles.
- v) BS EN 1990 (2002) + A1 (2005) – Eurocode: Basis of structural design, BSI, London.
- i) NA to BS EN 1990 (2002) + A1 (2005) – UK National Annex to Eurocode: Basis of structural design, BSI, London.
- ii) BS EN 1992-1-1 (2004) – Eurocode 2: Design of Concrete Structures – Part 1-1: General rules and rules for Buildings, BSI, London.
- iii) NA to BS EN 1992-1-1 (2004) - UK National Annex to Eurocode 2: Design of Concrete Structures – Part 1-1: General rules and rules for Buildings, BSI, London.
- iv) BS EN 1997-1 (2013) – Eurocode 7: Geotechnical Design – Part 1 General Rules – BSI, London.
- v) NA to BS EN 1997 -1 (2013) – UK National Annex to Eurocode 7: Geotechnical Design – Part 1 General Rules – BSI, London.
- vi) Tomlinson MJ (2001) – Foundation Design and Construction - 7th Edition, Prentice Hall.
- vii) Piglet 5.1 User Manual
- viii) FPS (2004) Guidance note on the Design of Bored Piles in Chalk
- ix) CIRIA C574: Engineering in Chalk (2002)

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4. Ground Conditions

4.1 BGS map

The British Geological Survey (BGS) GeoIndex online geological mapping service indicates the site to be underlain by artificial deposits (Made Ground) overlying Raised Beach Deposits consisting of Sand and Gravel. These superficial deposits overly the New Pit Chalk Formation and various other Chalk formations including Lewes Nodular, Seaford, Hewhaven, Culvert and Portsdown. River Terrace Deposits consisting of Sand, Silt and Gravel are recorded to the north of the site and Raised Marine Deposits consisting of Clay, Silt, Sand and Gravel are recorded to the South of the site.

4.2 Ground investigation

Two phases of ground investigation on the site have been undertaken; Phase 3 Site Investigation Report (Zones 1 and 2) produced by Leap Environmental Ltd (Leap) in April 2020 and a Geo-Environmental Assessment produced by Merebrook Consulting (Merebrook) in February 2014. The site investigation in the vicinity of the proposed bridge is limited and there is a significant risk of variance in the founding Chalk bedrock levels.

The Phase 3 investigation by Leap comprised the following exploratory holes relevant to the pile design:

1. 2 No. cable percussion boreholes with groundwater monitoring wells.
2. 4 No. windowless boreholes drilled with a tracked rig.
3. 2 No. hand excavated trial pits.

The Geo-environmental Assessment by Merebrook comprised the following relevant exploratory holes:

1. 2 No. windowless boreholes.

There are limited exploratory holes directly adjacent to the proposed bebo arch bridge, however there is reasonable coverage of the ground conditions across the wetland area. The borehole locations and geological cross sections are summarised in Appendix B.

The area of the site proposed for the bebo arch bridge (referred to as Zone II in the Leap investigation) was noted to be at a significantly lower elevation with areas of open water. Email correspondence with Asset IS and MBL has indicated that the current ground level at the proposed bridge location is ~2mOD.

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The sequence of strata encountered in the exploratory holes is summarised in the tables below.

Borehole		BH103	BH105	WS101	WS102	WS103	WS104	HP102	HP103	MWS12	MWS11	Min	Max	Av.
By		Leap							Merebrook					
Ground level (mOD)		3.00	2.27	2.32	2.21	2.29	2.81	3.25*	3.25*	2.25*	2.25*	2.21	3.25	2.63
Depth to base or depth proven (m)	Made Ground	1.10	1.15	1.20	1.00	1.10	0.80	1.00	1.00	0.50	1.80	0.50	1.80	1.07
	Clay	3.30	7.00	2.00	1.80	4.70				0.70	3.20	0.70	7.00	3.25
	Sand						1.80					1.80	1.80	1.80
	Chalk	14.00	15.00		5.00	5.00	5.00			3.00		3.00	15.00	7.83
Thickness proven (m)	Made Ground	1.10	1.15	1.20	1.00	1.10	0.80	1.00	1.00	0.50	1.80	0.50	1.20	0.98
	Clay	2.20	5.85	0.80	0.80	3.60	0.00			0.20	1.40	0.00	5.85	1.92
	Sand						1.00					1.00	1.00	1.00
	Chalk	10.70	8.00		3.20	0.30	3.20			3.00		0.00	10.70	4.73
Level of base (mOD)	Made Ground	1.90	1.12	1.12	1.21	1.19	2.01	2.25	2.25	1.75	0.45	1.12	2.25	1.64
	Clay	-0.30	-4.73	0.32	0.41	-2.41				1.55	-0.95	-4.73	1.55	-0.86
	Sand						1.01					1.01	1.01	1.01
	Chalk	-11.00	-12.73		-2.79	-2.71	-2.19			-0.75	2.25	-12.73	-0.75	-5.36

*assumed ground level.

The ground conditions are discussed in more detail below with SPT plots provided in Appendix C.

Made Ground

The Made Ground generally consists of Silty Sandy Gravelly Clay with gravel of subangular and subrounded fine to coarse and cobbles of flint. Its thickness varies from 0.50 to 1.20m, average 1.07m.

4 No. SPT tests were undertaken within the Made Ground with N values varying between 1 and 10, average 6 indicative of soft to firm clay.

Superficial Deposits - Raised Marine Deposits

The Made Ground overlies superficial deposits which are likely to be Raised Marine Deposits. It is generally described as soft, occasionally firm, Gravelly Clay with gravel of subangular and subrounded fine to coarse and cobbles of flint. Its thickness varies considerably between 0.8m and 5.85m, average 1.92m.

The superficial deposits in WS104 and BH104 are described as slightly Gravelly Sand with 4no SPT N values between 4 & 17, average 12, indicative of medium dense Sand. All other exploratory holes in this area recorded Gravelly Clay.

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Hand penetrometer tests in WS103 record shear strengths of 30kPa and 155kPa - the unexpectedly high shear strength result could be as a result of Gravel at the test depth and will not be considered indicative of the soil shear strength.

For the purposes of the bearing pile design, the superficial deposits consisting of Gravelly Clay only will be considered going forwards.

13no. plasticity tests were carried out with the following range and average results:

- Moisture Content: 20% to 69%, average 50%
- Plastic Limit: 19% to 37%, average 28%
- Liquid Limit: 30% to 89%, average 59%
- Plasticity Index: 10% to 59%, average 31%

A single unconsolidated undrained multistage triaxial compression test was carried out on a sample taken at a depth of 4.2mbgl in BH105. The undrained shear strength at the approximate in site stress level was 9kPa. The measured bulk density as 1.79Mg/m³ equivalent to 17.5kN/m³.

Chalk

The superficial deposits overly bedrock consisting of Chalk. The top of the Chalk is generally described as weathered structureless moderate or medium to high density Chalk recovered as Silty Chalk Gravel with fine to coarse subangular to subrounded flint. Some exploratory holes record this as Dc and Dm grade Chalk. Its thickness, where proven, ranges between 3.5m and 5.5m, average 4.7m.

20no. SPT tests were undertaken within the structureless Chalk with SPT N values varying between 3 & 21, average 12.

4no. saturation moisture contents were undertaken on structureless Chalk samples. The measured bulk density varied between 2.04Mg/m³ and 2.19Mg/m³, average 2.12Mg/m³ equivalent to ~21kN/m³.

The structureless Chalk overlies Chalk generally described as structured high density Chalk recovered as Silty Chalk Gravel with sub-angular to sub-rounded flint. Its proven thickness varies between 2.5m and 6.5m.

9no. SPT tests were undertaken within the structured Chalk with SPT N values varying between 28 & 142 (extrapolated), average 68.

8no. saturation moisture contents were undertaken on structured Chalk samples. The measured bulk density varied between 2.01Mg/m³ and 2.36Mg/m³, average 2.16Mg/m³ equivalent to 21kN/m³.

No UCS or point load testing has been carried out on Chalk samples.

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Design of piles in chalk adopts the β method where ultimate shaft friction is a function of the effective stress profile within the ground. FPS (2004) Guidance note on the Design of Bored Piles in Chalk indicates that where low density chalk ($N < 10$) is present over any portion of the shaft, a value of $\beta = 0.45$ should be adopted. Where better quality medium density chalk is present over the full depth of the pile shaft or that portion that is within the chalk then a higher value of $\beta = 0.8$ may be adopted.

The shaft friction within the structureless Chalk layer will therefore adopt $\beta = 0.45$ whilst the shaft friction within the structured Chalk will adopt $\beta = 0.8$.

CIRIA C574 (2002) indicates that end bearing capacity may be taken as $200 \times \text{SPT } N$ for bored and CFA piles. However, due to the proposed close pile spacings, the end bearing will be limited to 5MPa.

Groundwater

Groundwater was encountered in 5 No. exploratory holes. The groundwater levels recorded during the investigation are summarised below including 6no. rounds of groundwater monitoring between January 2020 and March 2020.

Exploratory Hole	Strike Depth (m)	Strike Level (mOD)	Highest long term GW level (between Jan - March 2020) (mOD)
BH103 (Leap)	4.60	-1.60	NA
BH105 (Leap)	2.70	-0.43	NA
WS102 (Leap)	0.50	1.71	NA
WS103 (Leap)	1.10	1.19	1.92
WS104 (Leap)	1.20	1.61	1.61

The Leap Site Investigation notes that the Environmental Agency indicates the site to be located within a groundwater flooding zone with a very high susceptibility to groundwater flooding. The Merebrook SI notes that a significant amount of localised flooding was evident in the grass-covered areas and roadways. A flood plain lies directly to the north of the site.

4.3 Electrochemical data

6 No. water soluble sulphate and pH tests were undertaken on samples of the soils from the site with sulphate concentrations up to 400mg/l and a minimum pH of 8.0. In accordance with BRE SD1 (2001) in a dataset with less than 20 results the highest sulphate content and lowest pH will be adopted as design values.

The site is classified as having a design sulphate class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) classifications of AC-1.

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4.4 Geotechnical Design Parameters

The characteristic soil design parameters relevant to the bearing pile design are summarised as follows:

Stratum	Unit weight, γ (kN/m ³)	Undrained shear strength, c_u (kPa)	q_s (kPa)	Q_b max (kPa)
Made Ground	18	-	0	0
Raised Marine Deposits (soft Clay)	18	20	0	0
Structureless Chalk	20	NA	$0.45\sigma_v'$	200N
Structured Chalk	21	NA	$0.8\sigma_v'$	200N (limit 5000)

Groundwater will be modelled at +2mOD which is at approximate existing ground level.

Consideration will need to be given to the time of year that these works are carried out to reduce the risk of flooding and potential dewatering requirements for excavation and installation of the pile cap.

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5. Geotechnical Pile Design

5.1 Preamble

The new BEBO bridge will span a water course beneath an access road to a new housing developed situated across an area of wetlands. The bridge span width at base of arch level is 14.41m and will be supported on either side by a line of piles which will resist the applied permanent and variable actions from the bridge, fill and vehicle loads.

Both pile caps are 34.85m long. All piles have been designed for the same load cases assuming that the levels on either side of the bridge are the same. The bearing piles comprise of 124No x 600mm $\varnothing$ bored cast in-situ vertical piles.

The pile cap characteristic (SLS) actions have been provided by Asses IS with additional loads derived by BEL for the pile cap design section per m has summarised below:

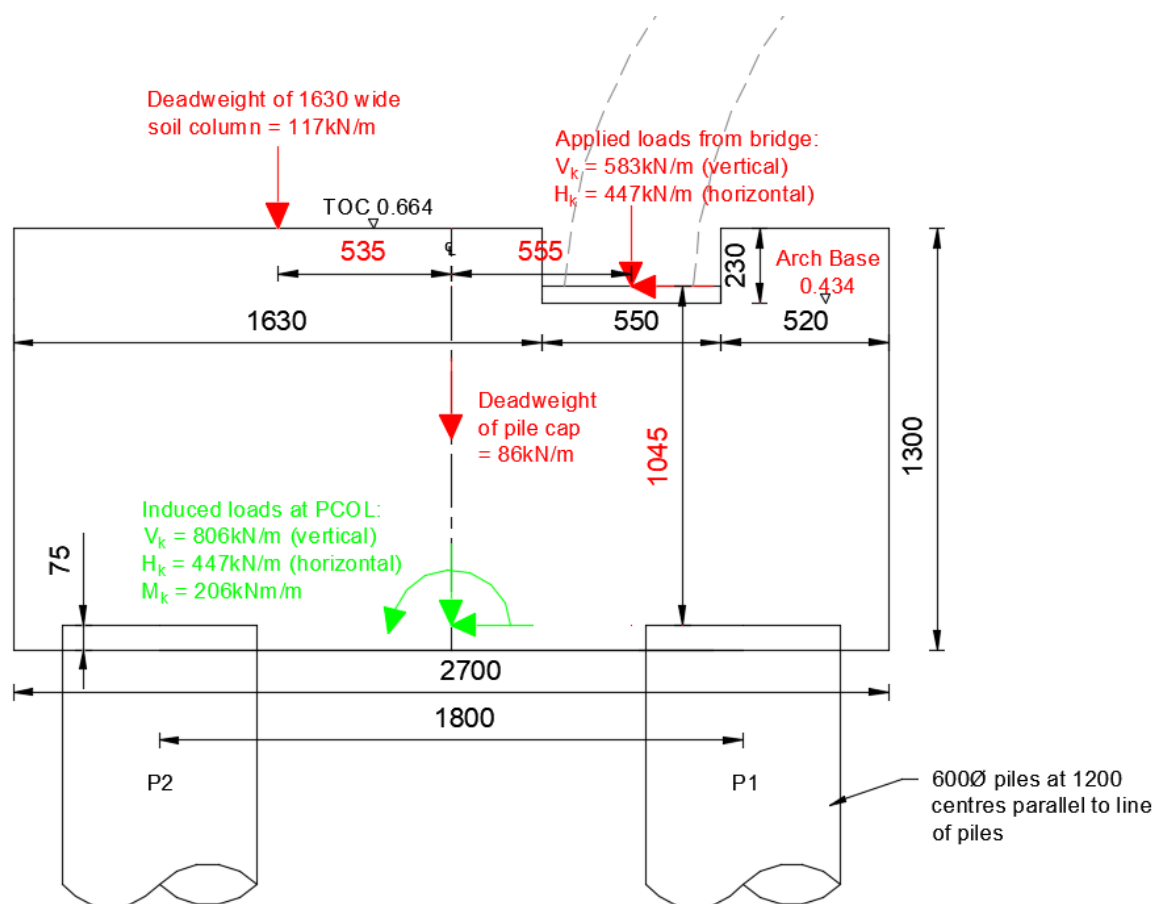


Figure 2: Pile cap loads

(Red are forces applied by the bridge / soil to the top of the pile cap, and green are the same forces transposed to the underside of the pile cap for use in the PIGLET Pile Group Analyses)

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Design actions have been determined from the BEBO bridge structure loads (vertical and horizontal), the dead weight of soil column above placed over the pile cap and the dead weight of the pile cap. The pile design has been undertaken in accordance with BS EN1997-1 (2013) and the appropriate UK National Annex plus BS8004 (2015).

5.2 Pile Cap Actions

The following SLS, structural and geotechnical actions per metre on the pile cap have been provided by Asset IS:

Load Case	Bridge Action	SLS (kN/m)	DA1-C1 (kN/m) Set B - STR	DA1-C2 (kN/m) Set C - GEO
Max	Vertical Bridge Arch	583	788	621
	Horizontal Bridge Arch	447	604	479
Min	Vertical Bridge Arch	69	98	98
	Horizontal Bridge Arch	79	111	111
Max H, Min V	Vertical Bridge Arch	572	772	609
	Horizontal Bridge Arch	447	604	479

To ensure that the worst-case resultant pile actions are determined, 3 no. load cases have been considered with differing combinations of actions.

The dead weight of the pile cap and soil column above are treated as permanent unfavourable actions and are factored accordingly to determine the total Set B and Set C actions acting at the base of the pile cap which the piles will resist. Live loadings are insignificant. No further partial factors have been applied to the loads provided by BEBO Arch Solutions for the bridge structure forces on the pile cap. The following partial factors have been adopted to determine the total actions acting on the pile cap in accordance with guidance in BS EN 1990 (2002):

Action	DA1-C1 Set B - STR	DA1-C2 Set C - GEO
Permanent unfavourable	1.35	1.0
Permanent favourable	1.0	1.0
Variable unfavourable	1.5	1.3

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The following table summarises the total Set B and Set C actions acting at the centre of the base of the pile cap which the piles will resist, and which will be input into the PIGLET pile group analyses to determine the STR and GEO forces for the 'element' pile design.

Load Case	Total action on centroid of pile cap base	SLS (kN)	DA1-C1 Set B - STR (kN)	DA1-C2 Set C - GEO (kN)
Max	Vertical (kN/m)	$583 + 118 + 86 = 787$	$788 + (118 \times 1.35) + (86 \times 1.35) = 1062$	$621 + (118 \times 1.0) + (86 \times 1.0) = 825$
	Horizontal (kN/m)	447	604	479
	Moment (kNm/m)	$(447 \times 1.045) + (118 \times 0.535) - (583 \times 0.555) = 206$	$(604 \times 1.045) + (118 \times 0.535 \times 1.35) - (788 \times 0.555) = 279$	$(479 \times 1.045) + (118 \times 0.535 \times 1.0) - (621 \times 0.555) = 219$
Min	Vertical (kN/m)	$69 + 86 = 155$	214	184
	Horizontal (kN/m)	79	111	111
	Moment (kNm/m)	44	62	62
Max H, Min V	Vertical (kN/m)	$572 + 86 = 658$	858	694
	Horizontal (kN/m)	447	604	479
	Moment (kNm/m)	150	202	163

The 2D PIGLET pile group analyses are given in Appendix D and are summarised overleaf. The PIGLET analysis considers the general deformation of a 1.2m section of abutment foundation to SLS, STR and GEO actions at the centre of the pile cap base.

The simple (but conservative) correlation of vertical Shear Modulus 'G' = SPT 'N' MPa was adopted, with a 50% reduction for the horizontal shear modulus in accordance with the guidance in the Piglet manual. The assumed Young's Modulus for a 600mm ø concrete pile is 21,000MPa. The maximum predicted vertical and horizontal deflections of the abutment are 8mm and 30mm respectively.

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Load Case	Pile	SLS			ULS STR			ULS GEO		
		V (kN)	H (kN)	M (kNm)	V (kN)	H (kN)	M (kNm)	V (kN)	H (kN)	M (kNm)
Max	P1 - Inside	-4	269	304	-5	363	411	-13	288	326
	P2 - Outside	948	269	304	1280	363	411	1003	288	326
Min	P1 - Inside	5	47	52	3	67	75	-13	67	74
	P2 - Outside	181	47	52	253	67	75	233	67	74
Max H, Min V	P1 - Inside	-50	269	310	-84	363	418	-60	288	331
	P2 - Outside	840	269	310	1114	363	418	893	288	331

5.3 Axial Pile Capacity

The pile design has been carried out in accordance with BS EN 1997-1 (2004): Clause 2.4.7.3.4.2 which invokes Design Approach 1 which uses the following combinations are:

Combination 1: A1 + M1 + R1

Combination 2: A2 + (M1 or M2) + R4

For combination 2 the M1 factors are used for calculating the pile resistance and set M2 for calculating unfavourable actions such as negative skin friction.

When using this method, it is necessary to apply a model factor to the calculated base and shaft resistances. A model factor of 1.4 is applicable where working load pile tests are proposed.

5.3.1 Axial Pile Capacity Calculations

The pile capacity calculations are undertaken using the Oasys Pile software and included in Appendix E.

The axial design resistance of piles founding in cohesionless soil is calculated using the following formulae:

$$R_{sk} = \frac{\sum_i A_{s,i} q_{sk,i}}{\gamma_{RD}} \text{ where } q_{sk,i} = \beta \sigma'_v$$

$$R_{bk} = \frac{A_b q_{bk}}{\gamma_{RD}} \text{ where } q_{bk} = 5 \text{ MPa}$$

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Where,

R_{sk} = the characteristic value of the shaft resistance of the pile

σ_v' = effective overburden

γ_{RD} = the model factor taken as 1.4

Therefore, the calculated pile resistance, R_{cal} is the given by the following expression:

$$R_{cal} = \frac{R_{bk}}{\gamma_b} + \frac{R_{sk}}{\gamma_s}$$

Where γ_b and γ_s are partial factors which vary for combination 1 and 2 as defined in the National Annex to BS EN 1997 -1 (2004): Table A.NA.8 as follows:

Partial Resistance Factors for bored piles for STR and GEO limit states - Table A.NA.8				
Resistance	Symbol	Set		
		R1	R4 with explicit verification	R4 without explicit verification (ie no pile testing)
Base	γ_b	1.0	1.7	2.0
Shaft (comp)	γ_b	1.0	1.4	1.6
Total / combined (comp)	γ_t	1.0	1.7	2.0
Shaft (tension)	$\gamma_{s:t}$	1.0	1.7	2.0

The proposed testing regime consists of dynamic probing to prove rockhead & then 2no. working pile tests (one each side of the bridge) – adjacent working piles could act as reaction piles. The “R4 factors with explicit verification” can therefore be used.

Negative shaft friction has been allowed for within the Made Ground and superficial deposits due to the increase in proposed ground levels and these soft soils.

A minimum factor of safety of ~1.2 on shaft friction alone has been maintained.

The pile design calculations are given in Appendix E. The “outside” piles (P2) are required to be 15m below PPL, whilst the “inside” piles (P1) are required to be 11m below PPL. See the **draft GA** drawing and schedule in Appendix H.

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6. Structural Pile Design

6.1 Pile Concrete

All piles are to be formed of C32/40 concrete.

6.2 Concrete Aggressivity Assessment

The ground investigation report classifies the ground as DS-1 and AC-1 assuming mobile groundwater conditions. The design concrete class is therefore DC-1, however it is recommended that a minimum design concrete class of DC-2 is adopted.

6.3 Compression Capacity of the Concrete Section

The bearing piles are to be constructed using grade C32/40 concrete. The design compressive strength of the concrete for an unreinforced section is given by the following formula:

$$f_{c,d} = \frac{\alpha_{cc,pl} f_{ck}}{\gamma_c k_f}$$

Where,

f_{cd} = design compressive strength of concrete

$\alpha_{cc,pl}$ = coefficient taking into account long term effects of compressive load = 0.85

f_{ck} = characteristic compressive strength of concrete NB EC2 uses cylinder strength = 32MPa

γ_c = partial factor for concrete = 1.5

k_f = partial factor to be applied to cast-in-situ piles that do not have permanent casing = 1.1

Therefore, the design concrete strength:

$$f_{c,d} = \frac{0.85 \times 32}{1.5 \times 1.1} = 16.48 \text{ MPa}$$

And the characteristic design resistance for a 600mm diameter pile is therefore:

$$N_{Rd} = f_{c,d} \times A_c = 16.48 \times \pi \times \frac{(600)^2}{4} = 4661 \text{ kN} > 1280 \text{ kN} \therefore \text{OK}$$

6.4.3 Cover

In accordance with BS EN 1536 (2010) the minimum cover to pile steel (links) shall be 75mm.

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6.4.4 Bending and Shear reinforcement

The bending capacity calculations have been undertaken using the Oasys AdSec software that implements the guidance in BS EN 1992-1 (2004) and BS EN 1536 (2010). The output is included in Appendix F.

Shear reinforcement calculations have been undertaken using an in-house spreadsheet that also implements the guidance in BS EN 1992-1 (2004). The output is included in Appendix G.

The required cages are summarised below:

Pile diameter (mm)	Pile	Longitudinal steel	Shear reinforcement	Cage depth below PPL (m)
600	P1	(8 x B32)	450mm OD B16 at 160mm centres	11.0
600	P2	(8 x B32)	450mm OD B16 at 160mm centres	11.0

The above cages are the minimum that are considered necessary for the structural design and the piling contractor may increase the cage size to aid plunging during construction if necessary.

6.4.6 Anchorage

The minimum length of steel projecting above PCOL into the pile cap is calculated below in accordance with BS EN 1992-1 (2004).

$$l_0 = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_5 \cdot \alpha_6 \cdot l_{b,rqd} \geq l_{0,min}$$

The basic anchorage length of the rebar calculated from BS EN 1992-1 clause 8.4.3 with the expression:

$$l_{b,rqd} = \left(\phi / 4 \right) \left(\sigma_{sd} / f_{bd} \right)$$

Where:

ϕ = bar diameter

σ_{sd} = design stress of the bar at the position from where the anchorage is measured

f_{bd} = design ultimate bond stress = $2.25 \times \eta_1 \times \eta_2 \times f_{ctd}$

$$f_{ctd} = \frac{\alpha_{ct} \times f_{ctk,0.05}}{\gamma_c} = 1.0 \times 2.12 / 1.5 = 1.41 \text{ MPa (C32/40 concrete in cap) (BS EN 1992-1 Table 3.1)}$$

$$f_{bd} = 2.25 \times 1.0 \times 1.0 \times 1.41 = 3.18 \text{ MPa}$$

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile & RC Cap Design Calculations	Revision	A	Page	18 of 21

Hence:

$$32mm \text{ bar } l_{b,rqd} = \left(\frac{32}{4} \right) \left(\frac{435}{3.18} \right) = 1096mm, \text{ say } 1100mm$$

Design anchorage length is calculated in accordance with BS EN 1992-1 Clause 8.4.4:

$$l_{bd} = \alpha_1 \alpha_2 \alpha_3 \alpha_4 \alpha_5 l_{b,rqd}$$

In BS EN 1992-1 Table 8.2 all alpha values are equal to 1.0 for this case.

The design anchorage lengths for the bar diameters used is summarised in the below:

Reinforcement bar Diameter (mm)	Design Anchorage Length l_{bd} (mm)
32	1100

7. Pile Tests

Dynamic probing to prove rockhead should be undertaken and then 2no. working pile load tests (one each side of the bridge) tested to $1.5F_{rep}$. Adjacent working piles could act as reaction piles.

All testing should be carried out in accordance with SPERW 3rd edition.

8. Pile Cap Reinforcement

The detailed pile cap reinforcement design calculations are provided in Appendix J and a reinforcement drawing provided in Appendix K.

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Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
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9. Geotechnical Risk Assessment

In accordance with CDM 2015 regulations Byland Engineering Limited are responsible for the element design of the bearing piles only and are not the overall scheme designers. Risks relating to construction methods are assumed to be covered within the specialist and main contractor's method statements. The residual geotechnical risks considered relevant to the bearing pile design are detailed in the following table.

Risk	Mitigation
Working platform	Piling works should be undertaken during spring/summer months when the GWL is lower (TBC). The piling platform design is very important and will need to take special consideration of the high Groundwater levels. The piles should be installed from an appropriately designed granular working platform of suitable thickness to support the pressures applied to the ground by the piling rig. This is particularly important on this site where soft clay soils are present close to the surface and likely to influence the performance of the working platform.
Solution features within the Chalk	The boreholes do not indicate any areas of solution within the Chalk, however, the boreholes depths do not extend beyond the pile toe. Full CFA pile installation records should be taken. In the event that weak zones or voids are encountered within the Chalk then the piling should be stopped and the geotechnical designer contacted to review the ground conditions ASAP.
Ground conditions weaker than expected	The ground investigation indicates that the ground conditions are reasonably consistent across the site, however Chalk depth varies considerably. The ground conditions assumed in the design should be confirmed during probing and also during installation of the piles. If significant differences are encountered the designer should be contacted immediately. Full CFA pile installation records should be provided to the designer for review at the end of every week.
Ground conditions stronger than expected or obstructions	In the event that the ground conditions are stronger than assumed practical rig refusal in the chalk with a powerful CFA piling rig may be deemed satisfactory to resist the compression loadings but should be discussed and agreed with the Geotechnical Designer.
Positional tolerance	The piles should be installed in accordance with the guidance in SPERW (2017) which required a tolerance of +/- 75mm and a verticality of 1 in 75 or better.
"Smearing" of chalk strata	The groundwater level is indicated to be high and therefore the pile bores are likely to contain water. There is therefore a risk of smearing and remoulding of the chalk which may result in reduced shaft friction. It is recommended that care is taken not to over rotate the pile augers or continue rotating the augers particularly where higher density chalk is encountered at depth which may slow penetration. A large powerful modern CFA piling rig is recommended. A minimum target auger penetration of 1.0m per 10 No. auger revolutions should be targeted in accordance with SPERW (2017).
Plunging of cages	The pile cages are relatively long at up to 11.0m. There is a risk that the cages may refuse before reaching the design depth. Plasticiser should be added to the concrete mix as necessary to ensure that the pile concrete remains workable, or a cage vibrator may be used.

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Risk	Mitigation
Risk of cracking piles below PCOL during pile trimming	The piles are a relatively large diameter, however there is a risk that they may be damaged during pile trimming if excessive force or inappropriate plant is used. Pile trimming should be undertaken carefully using small plant and using de-bonding sleeves. All piles should be subject to integrity testing.
Pile performance	Working pile load tests to be undertaken during the early stages of the works to confirm the pile design and construction techniques / workmanship and before the piling rig leaves site.
Depth to Chalk	There is considerable variation in the depth to Chalk across the site. Dynamic probing or probing with the piling rig should be carried out early on to develop a better understanding of the bedrock profile.

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile & RC Cap Design Calculations	Revision	A	Page	21 of 21

10. Summary

These calculations detail the design of bearing piles to support a bebo bridge spanning across a water course through a wetlands area to provide access to a new housing development in North Littlehampton. The design is summarised below:

- A total of 116 No. CFA of SFA bearing piles either 11m long for the “inside” piles or 15m long for the “outside” piles. A piling General Arrangement drawing with schedule is provided in Appendix J. Pile coordination is to be done by others.
- PCOL is -0.561mOD. PPL has been assumed to be equal to TOC at 0.664mOD and should be confirmed prior to pile installation commencing. There are significant risks associated with the high groundwater level and the PPL may need to be raised to allow the piles to be installed safely.
- Pile reinforcement is summarised as follows:

Pile diameter (mm)	Longitudinal steel	Shear reinforcement	Cage depth below PPL (m)
600	(8 x B32)	450mm OD B16 at 160mm centres	11.0

- All reinforcing steel to be Grade B500B
- Piles to be formed of C32/40 concrete. It is recommended a minimum design chemical class for concrete of DC-2 is adopted for the concrete mix.
- The design anchorage lengths for the bar diameters used is summarised in the below:

Reinforcement bar Diameter (mm)	Design Anchorage Length l_{bd} (mm)
32	1100

- It is recommended that the reinforcement is extended to the underside of the top mat of reinforcement within the pile cap.
- Dynamic probing to prove rockhead & then 2no. working pile tests (one each side of the bridge) tested to $1.5F_{rep}$ – adjacent working piles could act as reaction piles.
- Full CFA pile installation records should be taken during pile installation and made available to the designer at the end of each week for review.
- Pile cap reinforcement requirements are provided on the drawing in Appendix K.

Designer



Rachel Salter MEng CEng

Checker

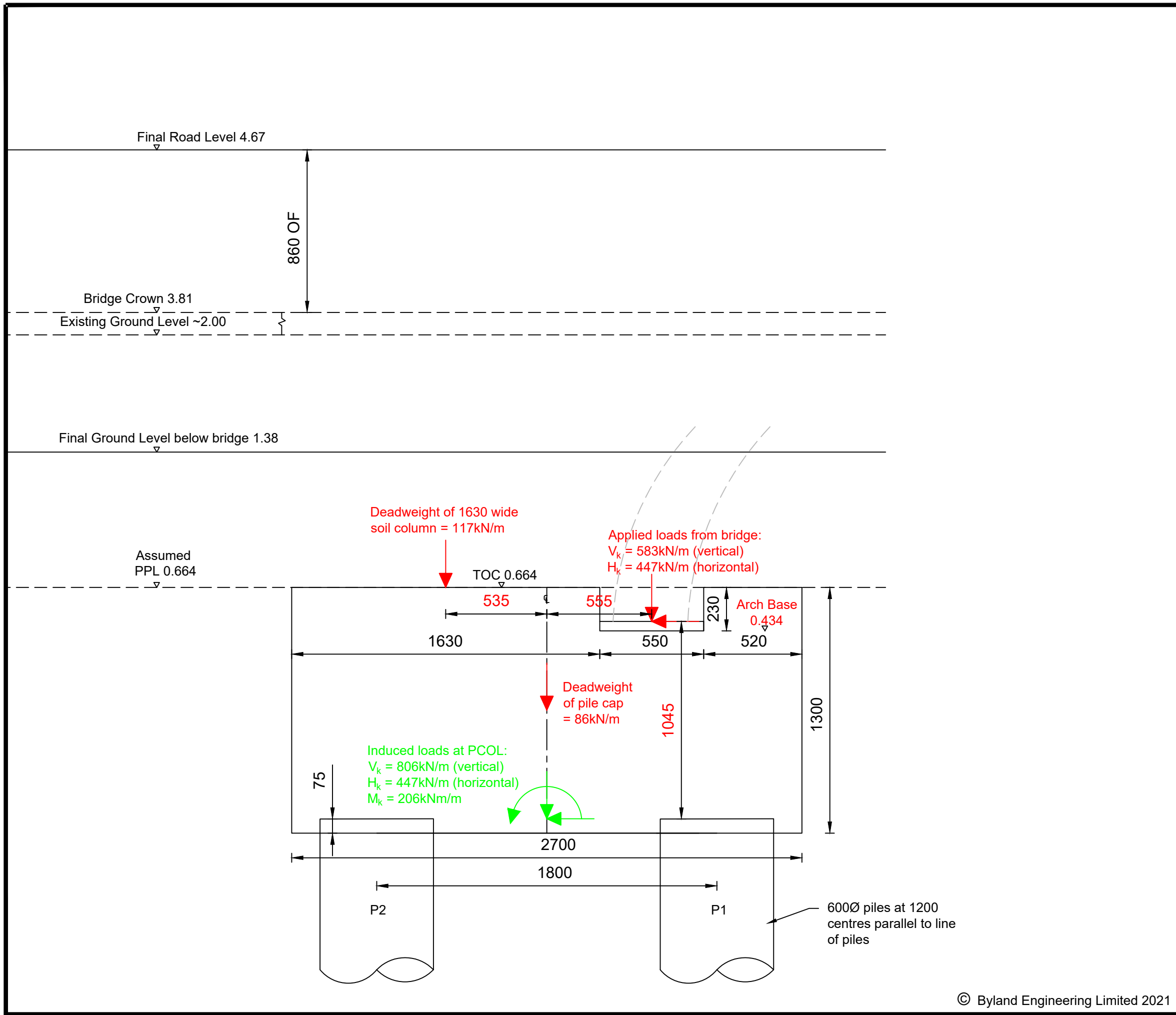


Jim Martin BSc CEng FICE FGS

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile Design Calculations	Revision	A	Page	1 of 11

Appendix A

2231_SK001 Pile Cap Assumed Loads & Levels



NOTES :

General

All dimensions mm UNO

All elevations mOD UNO

Do not scale, use figured dimensions only

Maximum loads shown based on bebo bridge load cases LC53 & LC54 ie for an overfill (OF) of 1.0m at the crown.

Soil column dead weight acting on cap based on width of cap to left hand side of bridge only. This is likely to be conservative as the axial bridge loads provided are likely to account for some of this load.

B	Cap Levels Revised	RS	JM	04/08/21
A	Pile cap depth increased to 1300mm	RS	JM	01/03/21
REV.	AMENDMENTS	DRAWN	CHECK	DATE



Client:

Van Elle

Project :

North Littlehampton

Title :

Pile Cap Loading - SLS

Drawing Status :

FOR COMMENT

	INITIALS	DATE	SCALE	DRAWING NUMBER
DRAWN	RS	17/02/21	1:20	2231_SK001
CHECKED	JM	17/02/21		
DATE : February 2021			ORIGINAL SHEET SIZE	REVISION : B

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
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Appendix B

Borehole Cross Section & Ground Model

Job No. 2231

Job Name North Littlehampton

Originator ef

Date 22/01/2021

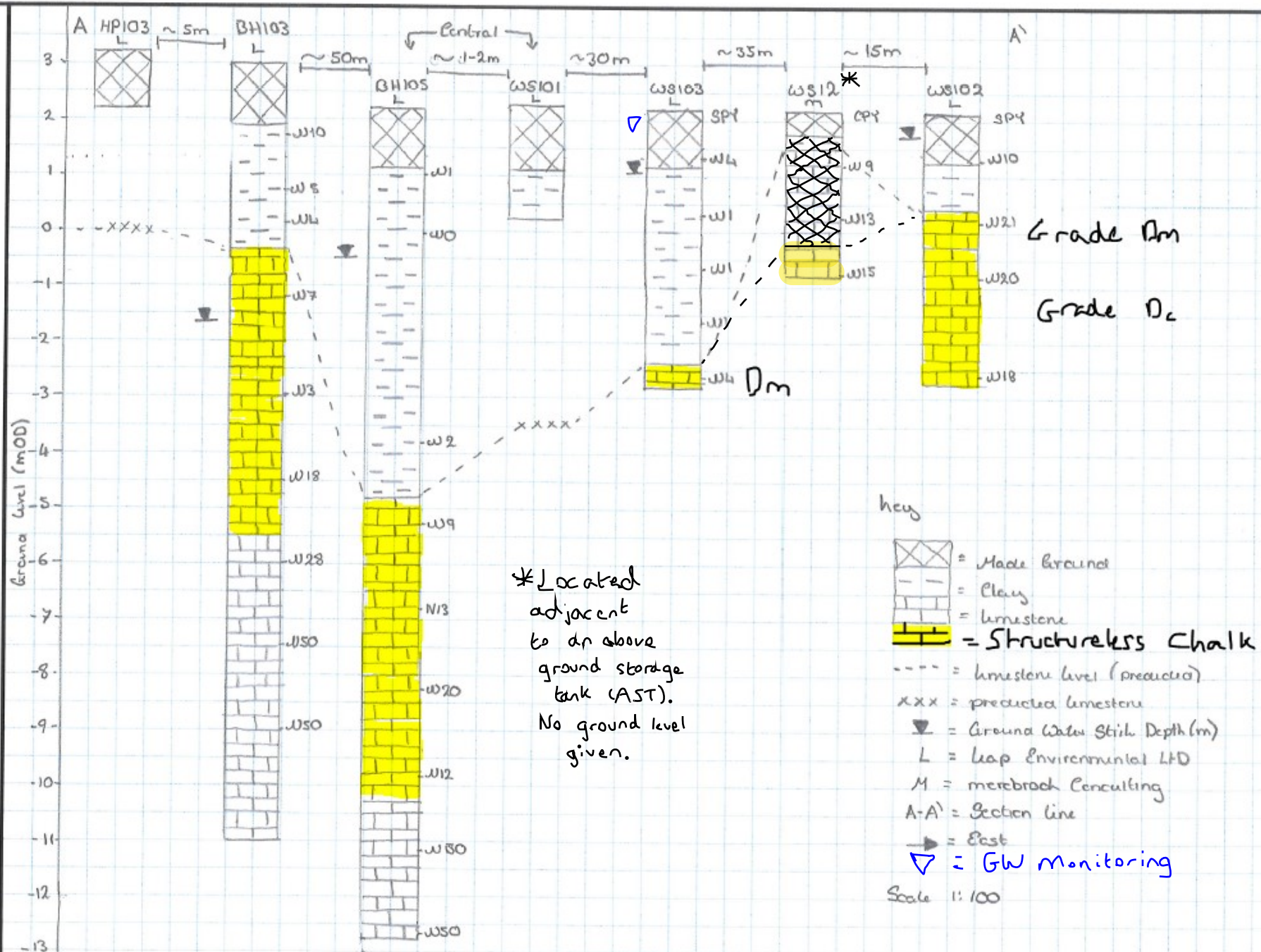
Section Exploratory holes

Checker

Date

Revision

Page



Job No. 2231

Originator RS

Date 26/01/21

Job Name North Littlehampton

Checker

Date

Section Ground model

Revision 0

Page 1

Reduced
Level
(mOD)

3 -

2 - GL = 1.38

1 -

0 -

-1 -

-2 -

-3 - 3.60

-4 -

-5 -

-6 -

-7 -

-8 - 8.60

-9 -

-10 -

-11 -

-12 -

-13 -

-14 -

-15 -

-16 -

-17 -

Made Ground $q_s = 0$ $\gamma = 18 \text{ kN/m}^3$

Soft Clay
 $q_s = 0$
 $\gamma = 18 \text{ kN/m}^3$
 $c_u = 20 \text{ kPa}$ ($\bar{N} = 2$)
 $E = 4000 \text{ kPa}$
 $G = 2000 \text{ kPa}$

Structureless Chalk based on a GL of +1.38mOD

$$\bar{c}_{sf} = \beta \bar{\sigma}_v = 0.45 \bar{\sigma}_v$$

$\bar{N} = 12$ (varies between 3 and 21)
 $\gamma = 17 \text{ kN/m}^3$

Structured Chalk

$$\bar{c}_{sf} = 0.8 \bar{\sigma}_v$$

$q_b = 200 \text{ N}$
 $\bar{N} = 68 \rightarrow \text{use } N = 50 \rightarrow q_b = 10 \text{ MPa}$
 $\rightarrow \text{limit } q_b \text{ to } 5 \text{ MPa}$
 $\gamma = 19 \text{ kN/m}^3$

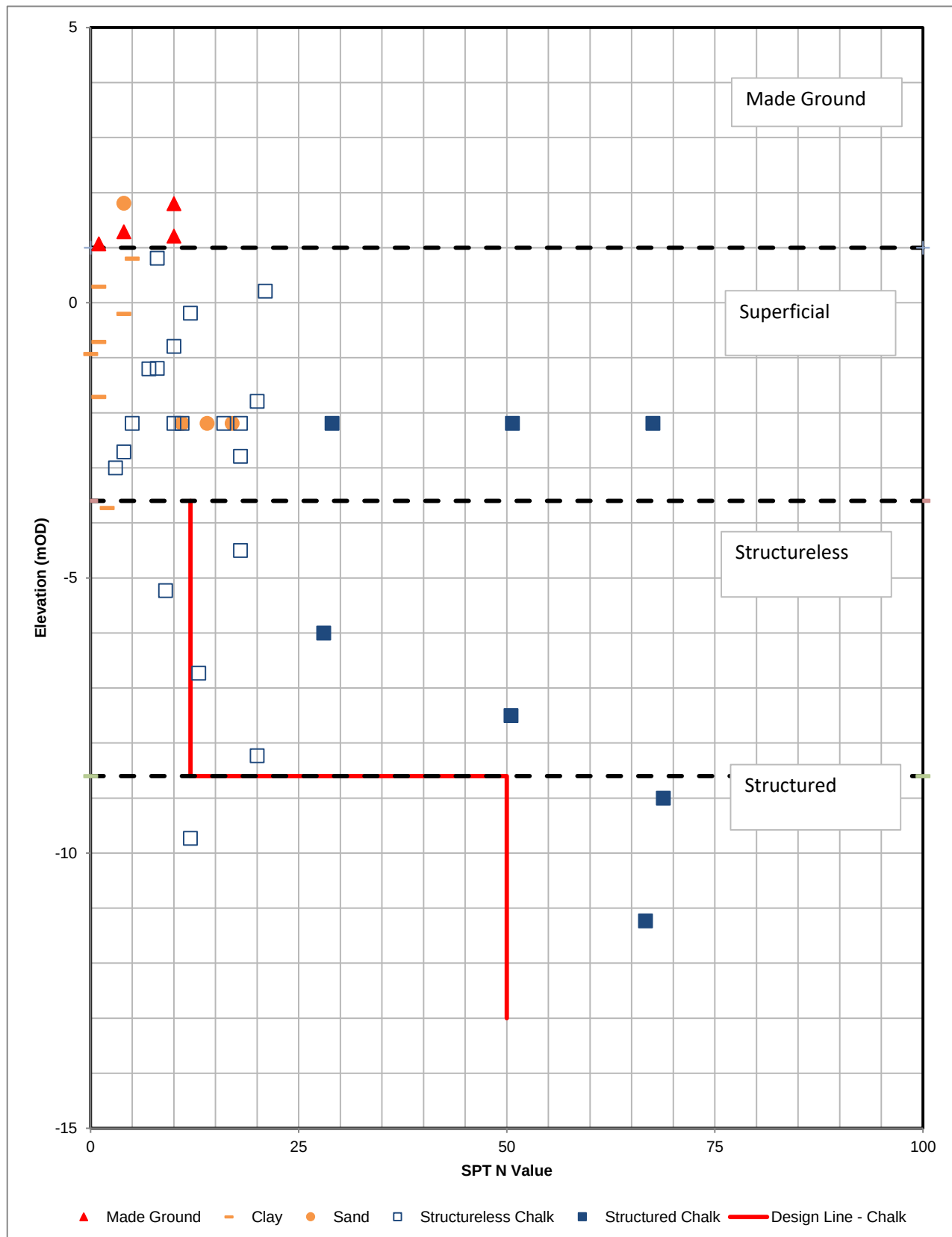
Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile Design Calculations	Revision	A	Page	3 of 11

Appendix C

SPT vs depth & elevation

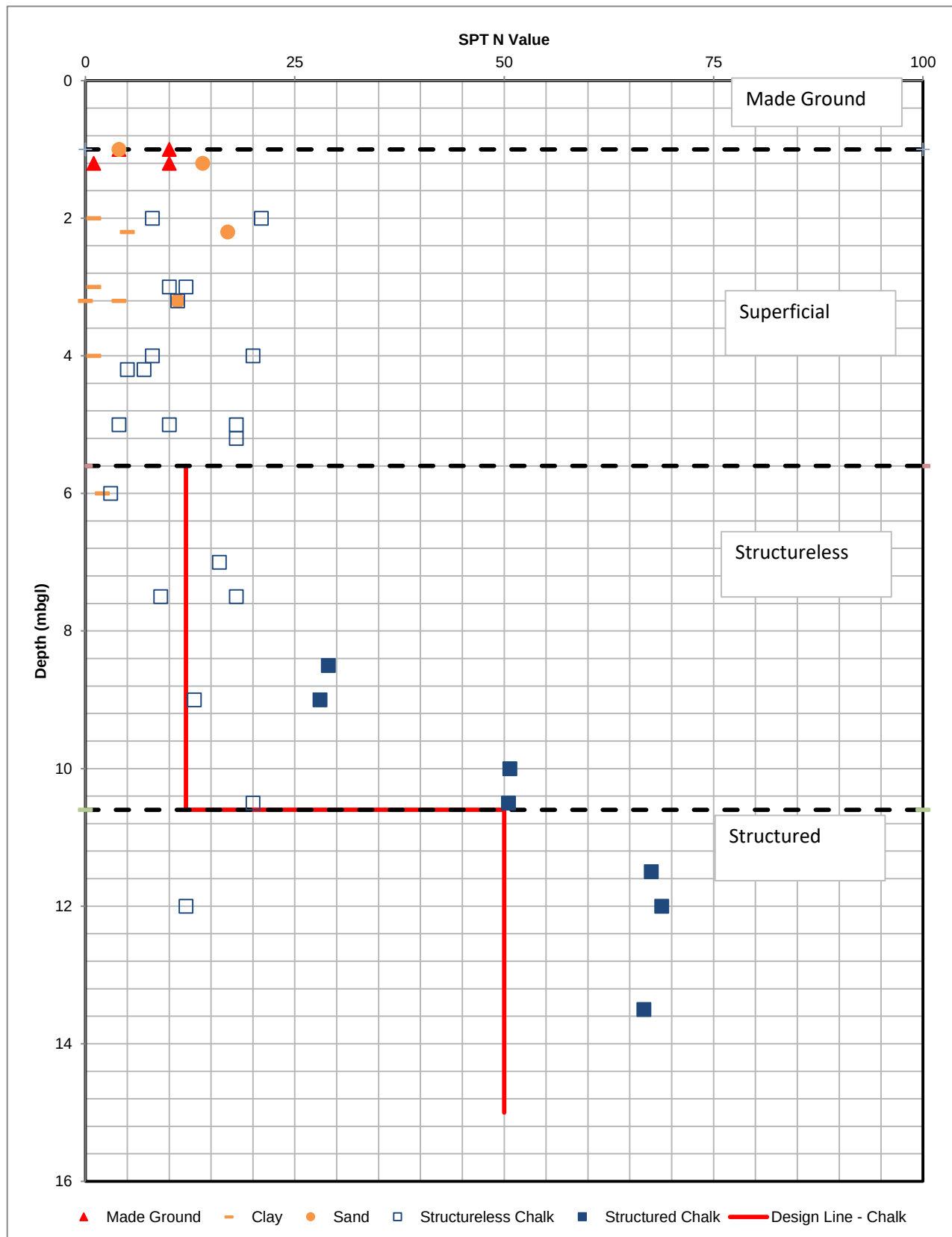
PROJECT North Littlehampton

SECTION Profile of SPT N Value versus Elevation



PROJECT North Littlehampton

SECTION Profile of SPT N Value versus Elevation



Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile Design Calculations	Revision	A	Page	4 of 11

Appendix D

2D Piglet Pile Group Analysis

Input data for PIGLET

Version No:

5.1

May 2004

Company name (licensee)

Byland Engineering (UK)

Title:

North Littlehampton - SLS - Rev A

Scope of problem

2

1 for vertical loading only, 2 for x:z plane only, 3 for all 6 degrees of freedom

Soil details:

Axial: Surface shear modulus, $G(0)$
Axial: Shear modulus gradient, dG/dz
Axial: Shear modulus below base, G_b
Lateral: Surface shear modulus, $G(0)$
Lateral: Shear modulus gradient, dG/dz
Poisson's ratio (all loading modes)

4.00E+03
0.00E+00
4.00E+03
2.00E+03
0.00E+00
0.25

Symbols

G_{oa}
 Gm_a $G_o + G_m L = 4.00E+03$
 G_b Set to less than $G_o + G_m L$ for continuous profile
 G_{ol}
 Gm_l
 ν

Pile details:

Free-standing length
Young's modulus: Free-standing part (axial)
Young's modulus: Embedded part (axial)
Young's modulus: Free-standing part (lateral)
Young's modulus: Embedded part (lateral)
Piles pinned (0) or fixed (1) to pile cap

0
2.10E+07
2.10E+07
2.10E+07
2.10E+07
1

L_f
 E_{paf}
 E_{pa}
 E_{plf}
 E_{pl}
 N_{fix}

Loading cases

	V (w)	H (u) x	M (θ) x to z	H (v) y	M (θ) y to z	T (ϕ) x to y	Loading Type
1	9.44E+02	5.37E+02	248				1
2	1.86E+02	9.40E+01	53				1
3	7.90E+02	5.37E+02	180				
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Pile group geometry:

	Shaft Diameter	Base Diameter	x co-ord.	y co-ord	Embedded Length	Rake x to z $\psi(x)$	Rake y to z $\psi(y)$	Profile switches x:z	y:z
1	6.00E-01	6.00E-01	-9.00E-01	0.00E+00	1.10E+01	0.00E+00	0.00E+00	2	
2	6.00E-01	6.00E-01	9.00E-01	1.00E-13	1.60E+01	0.00E+00	0.00E+00	2	
3									
4									
5									
6									

Output from PIGLET

Company name (licensee):

Byland Engineering (UK)

Checksum

84013607.65

Title:

North Littlehampton - SLS - Rev A

Scope of problem

Vertical and horizontal loading in x:z plane only

Total number of piles

2

Number of load cases

3

Pile head fixity

Piles built into pile cap

Results from each load case (sequentially)

Load case number:

1

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
944	537	248

Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.00834805	0.02980939	0.00293374

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	-3.9916983	268.5	-304.3924
2	947.991638	268.500031	-304.39246

Bending moment and deflection profiles (x:z plane)

Pile No.	1								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-304.3924	-92.398323	20.1975346	66.2231674	68.7627029	72.8676682	60.1706467	33.7599068	
Deflection	0.01908486	0.01637954	0.01299013	0.00994423	0.00786473	0.00494206	0.00242299	0.00066238	

Pile No.	2								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-304.39246	-92.398361	20.197506	66.2231674	68.7627106	72.8676682	60.1706543	33.7599106	
Deflection	0.01908486	0.01637954	0.01299013	0.00994423	0.00786473	0.00494206	0.00242299	0.00066238	

Load case number:

2

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
186	94	53

Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.00165392	0.00524655	0.00053069

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	5.27555943	47	-52.451988
2	180.724442	47.0000038	-52.451996

Bending moment and deflection profiles (x:z plane)

Pile No.	1								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-52.451988	-15.483962	4.05230474	11.9346571	12.2304745	12.8424177	10.5591459	5.91276598	

Deflection	0.00336447	0.00287778	0.0022761	0.00173839	0.00137274	0.00086147	0.00042191	0.00011524
Pile No.	2							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-52.451996	-15.483963	4.05230141	11.9346561	12.2304754	12.8424187	10.5591469	5.91276646
Deflection	0.00336447	0.00287778	0.0022761	0.00173839	0.00137274	0.00086147	0.00042191	0.00011524

Load case number: 3

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
790	537	180

Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.00691708	0.02961373	0.00281608

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	-49.546825	268.5	-310.09207
2	839.546814	268.500031	-310.09213

Bending moment and deflection profiles (x::z plane)

Pile No.	1							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-310.09207	-97.132103	16.6522617	63.8734741	67.4332047	72.269577	59.988987	33.7378807
Deflection	0.01892205	0.01630682	0.01297486	0.00996013	0.00789187	0.00496687	0.00243825	0.00066726

Pile No.	2							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-310.09213	-97.132111	16.6522484	63.8734741	67.4332123	72.2695847	59.9889908	33.7378845
Deflection	0.01892205	0.01630682	0.01297486	0.00996014	0.00789187	0.00496687	0.00243825	0.00066726

Output from PIGLET

Company name (licensee): Byland Engineering (UK)

Title: North Littlehampton - SLS - Rev A

Scope of problem	Vertical and horizontal loading in x:z plane only
Total number of piles	2
Number of load cases	3
Pile head fixity	Piles built into pile cap

Summary tables of results

Pile cap loads and deformations at origin ($x = y = z = 0$):

Load Case No.	Vertical Load	Horizontal Load (x)	Moment (x to z)
1	944	537	248
2	186	94	53
3	790	537	180

Load Case No.	Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
1	0.00834805	0.02980939	0.00293374
2	0.00165392	0.00524655	0.00053069
3	0.00691708	0.02961373	0.00281608

Pile forces and deflections at cap level:

Pile No.	Load Case No.	Axial Loads	Lateral Loads (x)	Moments (x to z)	Axial Deflection	Lateral Defn (x)
1	1	-3.9916983	268.5	-304.3924	0.00570769	0.02980939
	2	5.27555943	47	-52.451988	0.00117629	0.00524655
	3	-49.546825	268.5	-310.09207	0.00438261	0.02961373
2	1	947.991638	268.500031	-304.39246	0.01098842	0.02980939
	2	180.724442	47.0000038	-52.451996	0.00213154	0.00524655
	3	839.546814	268.500031	-310.09213	0.00945155	0.02961373

Input data for PIGLET

Version No:

5.1

May 2004

Company name (licensee)

Byland Engineering (UK)

Title:

North Littlehampton - ULS1 - Rev A

Scope of problem

2

1 for vertical loading only, 2 for x:z plane only, 3 for all 6 degrees of freedom

Soil details:

Axial: Surface shear modulus, $G(0)$
Axial: Shear modulus gradient, dG/dz
Axial: Shear modulus below base, G_b
Lateral: Surface shear modulus, $G(0)$
Lateral: Shear modulus gradient, dG/dz
Poisson's ratio (all loading modes)

4.00E+03
0.00E+00
4.00E+03
2.00E+03
0.00E+00
0.25

Symbols

G_{oa}
 Gm_a $G_o + G_m L = 4.00E+03$
 G_b Set to less than $G_o + G_m L$ for continuous profile
 G_{ol}
 Gm_l
 ν

Pile details:

Free-standing length
Young's modulus: Free-standing part (axial)
Young's modulus: Embedded part (axial)
Young's modulus: Free-standing part (lateral)
Young's modulus: Embedded part (lateral)
Piles pinned (0) or fixed (1) to pile cap

0
2.10E+07
2.10E+07
2.10E+07
2.10E+07
1

L_f
 E_{paf}
 E_{pa}
 E_{plf}
 E_{pl}
 N_{fix}

Loading cases

	V (w)	H (u) x	M (θ) x to z	H (v) y	M (θ) y to z	T (ϕ) x to y	Loading Type
1	1.28E+03	7.25E+02	335				1
2	2.56E+02	1.34E+02	75				1
3	1.03E+03	7.25E+02	243				
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Pile group geometry:

	Shaft Diameter	Base Diameter	x co-ord.	y co-ord	Embedded Length	Rake x to z $\psi(x)$	Rake y to z $\psi(y)$	Profile switches x:z	y:z
1	6.00E-01	6.00E-01	-9.00E-01	0.00E+00	1.10E+01	0.00E+00	0.00E+00	2	
2	6.00E-01	6.00E-01	9.00E-01	1.00E-13	1.60E+01	0.00E+00	0.00E+00	2	
3									
4									
5									
6									

Output from PIGLET

Company name (licensee):Byland Engineering (UK)

Checksum84014836.65

Title:North Littlehampton - ULS1 - Rev A

Scope of problemVertical and horizontal loading in x:z plane only

Total number of piles2

Number of load cases3

Pile head fixityPiles built into pile cap

Results from each load case (sequentially)

Load case number:1

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
1275	725	335
Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.01127544	0.04024585	0.00396106

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	-5.2184038	362.499969	-410.94644
2	1280.21838	362.5	-410.9465

Bending moment and deflection profiles (x:z plane)

Pile No.	1								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-410.94644	-124.73671	27.2757511	89.4122162	92.8387604	98.3793411	81.2363434	45.5790596	
Deflection	0.02576667	0.02211405	0.01753791	0.01342561	0.01061806	0.0066722	0.00327122	0.00089426	
Pile No.	2								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-410.9465	-124.73675	27.2757549	89.4122162	92.8387451	98.3793488	81.2363434	45.5790634	
Deflection	0.02576667	0.02211405	0.01753791	0.01342561	0.01061806	0.0066722	0.00327122	0.00089426	

Load case number:2

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
256	134	75
Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.00227066	0.00748522	0.00076018

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	3.45044446	67	-74.594582
2	252.549545	67.0000076	-74.594597

Bending moment and deflection profiles (x:z plane)

Pile No.	1								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-74.594582	-21.925541	5.88703918	17.0863705	17.4763145	18.3258915	15.058054	8.42952251	

Deflection	0.00480123	0.00410463	0.00324513	0.00247763	0.00195604	0.00122729	0.00060097	0.00016412
Pile No.	2							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-74.594597	-21.925547	5.88703203	17.0863667	17.4763145	18.3258934	15.0580549	8.42952347
Deflection	0.00480123	0.00410463	0.00324513	0.00247763	0.00195604	0.00122729	0.00060097	0.00016412

Load case number: 3

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
1030	725	243

Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.00898942	0.04001678	0.00382331

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	-84.0214	362.499969	-417.6192
2	1114.02136	362.5	-417.61926

Bending moment and deflection profiles (x:z plane)

Pile No.	1							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-417.6192	-130.27864	23.1252384	86.6613617	91.2822876	97.6791458	81.0236664	45.5532722
Deflection	0.02557606	0.02202891	0.01752004	0.01344422	0.01064983	0.00670124	0.0032891	0.00089997

Pile No.	2							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-417.61926	-130.27867	23.1252117	86.661377	91.2822723	97.6791534	81.0236664	45.5532761
Deflection	0.02557606	0.02202892	0.01752004	0.01344423	0.01064984	0.00670124	0.0032891	0.00089997

Output from PIGLET

Company name (licensee): Byland Engineering (UK)

Title: North Littlehampton - ULS1 - Rev A

Scope of problem	Vertical and horizontal loading in x:z plane only
Total number of piles	2
Number of load cases	3
Pile head fixity	Piles built into pile cap

Summary tables of results

Pile cap loads and deformations at origin ($x = y = z = 0$):

Load Case No.	Vertical Load	Horizontal Load (x)	Moment (x to z)
1	1275	725	335
2	256	134	75
3	1030	725	243

Load Case No.	Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
1	0.01127544	0.04024585	0.00396106
2	0.00227066	0.00748522	0.00076018
3	0.00898942	0.04001678	0.00382331

Pile forces and deflections at cap level:

Pile No.	Load Case No.	Axial Loads	Lateral Loads (x)	Moments (x to z)	Axial Deflection	Lateral Defn (x)
1	1	-5.2184038	362.499969	-410.94644	0.00771049	0.04024585
	2	3.45044446	67	-74.594582	0.0015865	0.00748522
	3	-84.0214	362.499969	-417.6192	0.00554843	0.04001678
2	1	1280.21838	362.5	-410.9465	0.01484039	0.04024585
	2	252.549545	67.0000076	-74.594597	0.00295482	0.00748522
	3	1114.02136	362.5	-417.61926	0.0124304	0.04001678

Input data for PIGLET

Version No:

5.1

May 2004

Company name (licensee)

Byland Engineering (UK)

Title:

North Littlehampton - ULS2 - Rev A

Scope of problem

2

1 for vertical loading only, 2 for x:z plane only, 3 for all 6 degrees of freedom

Soil details:

Axial: Surface shear modulus, $G(0)$
Axial: Shear modulus gradient, dG/dz
Axial: Shear modulus below base, G_b
Lateral: Surface shear modulus, $G(0)$
Lateral: Shear modulus gradient, dG/dz
Poisson's ratio (all loading modes)

4.00E+03
0.00E+00
4.00E+03
2.00E+03
0.00E+00
0.25

Symbols

G_{oa}
 Gm_a $G_o + G_m L = 4.00E+03$
 G_b Set to less than $G_o + G_m L$ for continuous profile
 G_{ol}
 Gm_l
 ν

Pile details:

Free-standing length
Young's modulus: Free-standing part (axial)
Young's modulus: Embedded part (axial)
Young's modulus: Free-standing part (lateral)
Young's modulus: Embedded part (lateral)
Piles pinned (0) or fixed (1) to pile cap

0
2.10E+07
2.10E+07
2.10E+07
2.10E+07
1

L_f
 E_{paf}
 E_{pa}
 E_{plf}
 E_{pl}
 N_{fix}

Loading cases

	V (w)	H (u) x	M (θ) x to z	H (v) y	M (θ) y to z	T (ϕ) x to y	Loading Type
1	9.90E+02	5.75E+02	262				1
2	2.20E+02	1.34E+02	75				1
3	8.33E+02	5.75E+02	195				
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Pile group geometry:

	Shaft Diameter	Base Diameter	x co-ord.	y co-ord	Embedded Length	Rake x to z $\psi(x)$	Rake y to z $\psi(y)$	Profile switches x:z	y:z
1	6.00E-01	6.00E-01	-9.00E-01	0.00E+00	1.10E+01	0.00E+00	0.00E+00	2	
2	6.00E-01	6.00E-01	9.00E-01	1.00E-13	1.60E+01	0.00E+00	0.00E+00	2	
3									
4									
5									
6									

Output from PIGLET

Company name (licensee):

Byland Engineering (UK)

Checksum

84013897.65

Title:

North Littlehampton - ULS2 - Rev A

Scope of problem

Vertical and horizontal loading in x:z plane only

Total number of piles

2

Number of load cases

3

Pile head fixity

Piles built into pile cap

Results from each load case (sequentially)

Load case number:

1

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
990	575	262
Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.00874221	0.03192101	0.00314266

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	-12.631338	287.499969	-325.86807
2	1002.63129	287.5	-325.86813

Bending moment and deflection profiles (x:z plane)

Pile No.	1								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-325.86807	-98.883446	21.6666813	70.9357986	73.6435471	78.0307617	64.4305725	36.1491203	
Deflection	0.0204372	0.01753943	0.01390952	0.01064774	0.00842096	0.0052915	0.00259427	0.0007092	
Pile No.	2								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-325.86813	-98.883484	21.6666698	70.9357986	73.6435547	78.0307693	64.4305801	36.1491241	
Deflection	0.0204372	0.01753943	0.01390953	0.01064774	0.00842096	0.0052915	0.00259427	0.0007092	

Load case number:

2

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
220	134	75
Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.00192685	0.00752024	0.00078124

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	-13.415986	66.9999924	-73.574371
2	233.415985	67	-73.574387

Bending moment and deflection profiles (x:z plane)

Pile No.	1								
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236	
Moment	-73.574371	-21.078224	6.52161741	17.5069466	17.7142849	18.4329433	15.0905685	8.43346405	

Deflection	0.00483037	0.00411765	0.00324786	0.00247478	0.00195118	0.00122285	0.00059824	0.00016325
Pile No.	2							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-73.574387	-21.078236	6.52161026	17.5069466	17.7142849	18.4329433	15.0905695	8.433465
Deflection	0.00483037	0.00411765	0.00324786	0.00247478	0.00195118	0.00122285	0.00059824	0.00016325

Load case number: 3

Pile cap loads and deformations

Vertical Load	Horizontal Load (x)	Moment (x to z)
833	575	195
Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
0.007282	0.03173335	0.00302981

Pile head loads and moments

Pile No.	Axial Loads	Lateral Loads (x)	Moments (x to z)
1	-59.983181	287.5	-331.33478
2	892.983093	287.500031	-331.33484

Bending moment and deflection profiles (x::z plane)

Pile No.	1							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-331.33478	-103.42371	18.2663555	68.6821671	72.3684158	77.4571304	64.25634	36.1279984
Deflection	0.02028105	0.01746968	0.01389488	0.01066299	0.00844699	0.0053153	0.00260892	0.00071387
Pile No.	2							
Depth	0	1.00611746	2.01223493	3.01835251	4.02446985	5.0305872	6.03670502	7.04282236
Moment	-331.33484	-103.42373	18.2663422	68.6821671	72.3684082	77.4571381	64.2563477	36.1280022
Deflection	0.02028105	0.01746969	0.01389489	0.010663	0.00844699	0.0053153	0.00260892	0.00071387

Output from PIGLET

Company name (licensee): Byland Engineering (UK)

Title: North Littlehampton - ULS2 - Rev A

Scope of problem	Vertical and horizontal loading in x:z plane only
Total number of piles	2
Number of load cases	3
Pile head fixity	Piles built into pile cap

Summary tables of results

Pile cap loads and deformations at origin (x = y = z = 0):

Load Case No.	Vertical Load	Horizontal Load (x)	Moment (x to z)
1	990	575	262
2	220	134	75
3	833	575	195

Load Case No.	Vertical Deflection	Horizontal Defn (x)	Rotation (x to z)
1	0.00874221	0.03192101	0.00314266
2	0.00192685	0.00752024	0.00078124
3	0.007282	0.03173335	0.00302981

Pile forces and deflections at cap level:

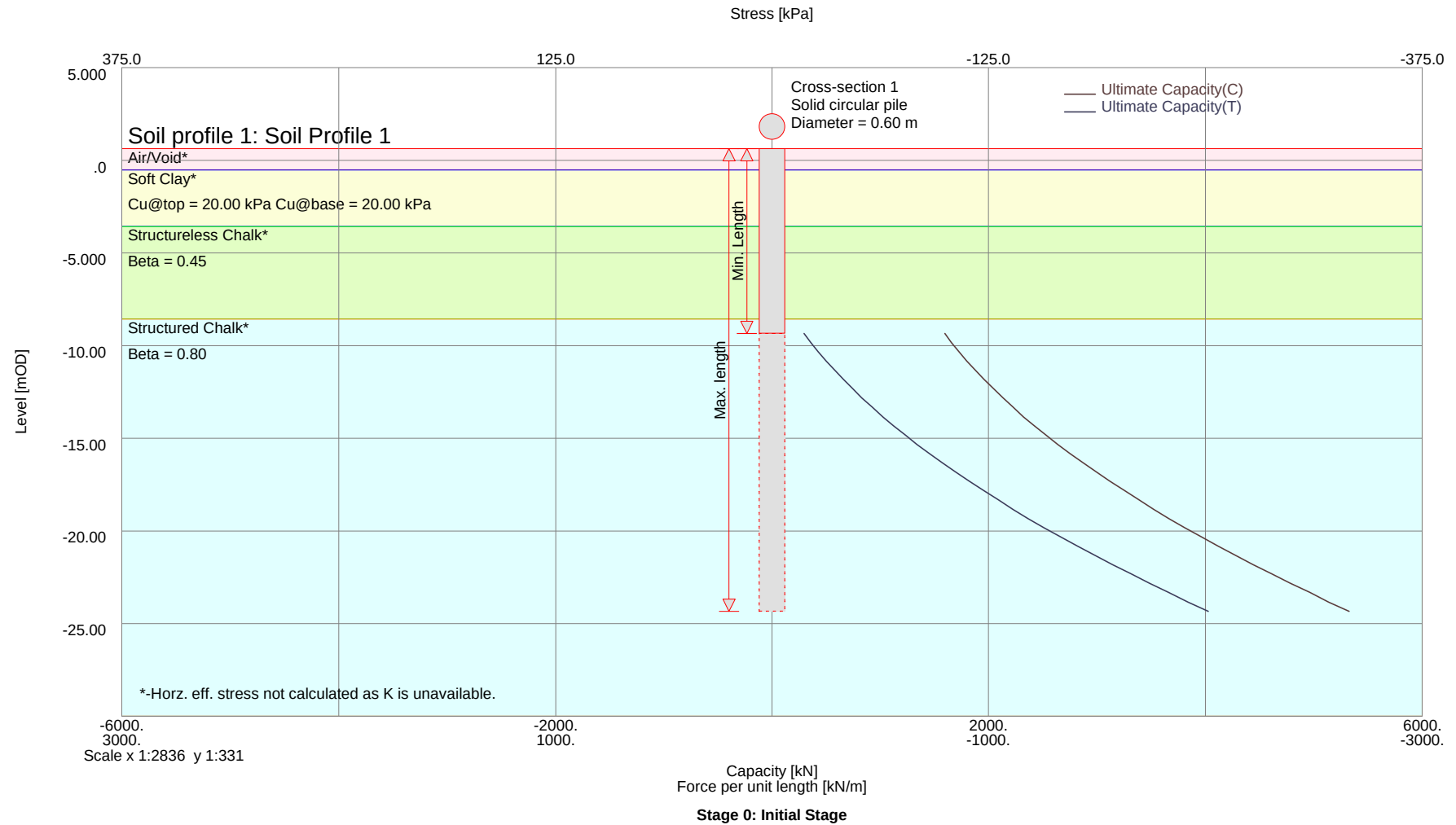
Pile No.	Load Case No.	Axial Loads	Lateral Loads (x)	Moments (x to z)	Axial Deflection	Lateral Defn (x)
1	1	-12.631338	287.499969	-325.86807	0.00591382	0.03192101
1	2	-13.415986	66.9999924	-73.574371	0.00122373	0.00752024
1	3	-59.983181	287.5	-331.33478	0.00455516	0.03173335
2	1	1002.63129	287.5	-325.86813	0.01157061	0.03192101
2	2	233.415985	67	-73.574387	0.00262996	0.00752024
2	3	892.983093	287.500031	-331.33484	0.01000883	0.03173335

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile Design Calculations	Revision	A	Page	5 of 11

Appendix E

Oasys 'PILE' Input / Output

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date	Checked Date



Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date	Checked Date

Analysis Options

Design approach:	DA1(C1 + C2)
Pile type:	CFA
Model factor:	1.40
Partial factor on negative skin friction - Set A1:	1.00
Partial factor on negative skin friction - Set A2:	1.00
Serviceability verified by load tests (preliminary/working) carried out on more than 1% of constructed piles to loads not less than 1.5 times the representative load for which they are designed?	Yes
Resistance verified by a maintained load test taken to the calculated, unfactored, ultimate resistance?	No
Is BS8004 SLS check enabled?	Yes
Shaft only FoS (Compression):	1.20
Shaft only FoS (Tension):	0.00
Is pile capacity limited by pile material compressive strength?	No
Pile material compressive strength calculation type	Grade based
Limiting pile material compressive strength[kPa]	0.000000
Datum type	Elevation based
Effective stress profile	Calculated

Pile Properties

Pile type	Solid
Material type	User-defined
Pile cross-section	Circular
Under-ream	No
Calculation profile	Range
Minimum pile length	10.000 m
Maximum pile length	25.000 m
Increment size	0.50000

Cross-section	Number of cross sections	Top Diameter [m]	Second Diameter location [m]	Second Diameter [m]	Third Diameter location [m]	Third Diameter [m]
Cross-section 1	1	0.60000				

Undrained Materials - General Data

No. Material description	Bulk unit weight [kN/m³]	Cu material factor	Top Cu [kPa]	Base Cu [kPa]
1 Soft Clay	18.000	NA	20.000	20.000

Undrained Materials - Skin Friction Data

No. Material description	Skin friction computation	Alpha	q _s Top [kPa]	q _s Base [kPa]	q _s Spec. Value [kPa]
1 Soft Clay	Alpha specified	1.0000	NA	NA	No NA

Undrained Materials - End Bearing Data

No. Material description	End bearing computation	Nc	q _b Top [kPa]	q _b Base [kPa]	q _b Spec. Value [kPa]
1 Soft Clay	qb specified	NA	0.0	0.0	No NA

* - Will be calculated by the program.

Undrained Materials - Material Factors (Code Based)

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No.	Material description	End bearing computation	Nc	Qb	Qb, lim
				Top [kPa]	Base Spec. Value [kPa]
No.	Material description	Qs factors	Nc factors	Qb factors	
		M1 M2	M1 M2	M1 M2	
1	Soft Clay	N.A. N.A.	N.A. N.A.	1.0000 1.0000	

Drained Materials - General Data

No.	Material description	Bulk unit weight [kN/m³]	Tan(d) material factor
1	Structureless Chalk	20.000	NA
2	Structured Chalk	21.000	NA

Drained Materials - Friction Data

No.	Material description	Skin friction computation	Beta	Delta (d)	Coefficient of earth pressure K	Qs	Qs, lim
				[deg]		Top [kPa]	Base Spec. Value [kPa]
1	Structureless Chalk	Beta specified	0.45000	NA	NA	NA	NA No NA
2	Structured Chalk	Beta specified	0.80000	NA	NA	NA	NA No NA

Drained Materials - End Bearing Data

No.	Material description	End bearing computation	Nq	Phi'	PhiD	Phicv'	Id	Qb	Qb, lim	Nq-Phi curves
				[deg]	[deg]	[deg]		Top [kPa]	Base Spec. Value [kPa]	
1	Structureless Chalk	qb specified	NA	NA	NA	NA	NA	0.0	0.0	No NA NA
2	Structured Chalk	qb specified	NA	NA	NA	NA	NA	5000.0	5000.0	No NA NA

Drained Materials - Material Factors (Code Based)

No.	Material description	Qs factors	Nq factors	Qb factors
		M1 M2	M1 M2	M1 M2
1	Structureless Chalk	N.A. N.A.	N.A. N.A.	1.0000 1.0000
2	Structured Chalk	N.A. N.A.	N.A. N.A.	1.0000 1.0000

STAGE SPECIFIC DATA

Stage 0 : Initial Stage

Groundwater

No.	Level	Pressure	Unit weight of water
	[m]	[kPa]	[kN/m³]
1	2.0000	0.0	10.000

Soil Profiles

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date	Checked Date

No.	Level	Pressure	Unit weight of water
	[m]	[kPa]	[kN/m³]

Soil Profile 1: Soil Profile 1

No.	Level	Material description	Contributes to negative skin friction
	[mOD]		

1	0.66000	Air/Void	No
2	-0.56000	Soft Clay	Yes
3	-3.60000	Structureless Chalk	No
4	-8.60000	Structured Chalk	No

Soil Profile - Groundwater Map

No.	Soil Profile	Groundwater
1	Soil Profile 1	Groundwater Profile 1

CAPACITY RESULTS

Partial Resistance Factors Used:

DA1 C1

Shaft resistance factor for set R1 (Compression):	1.00
Base resistance factor for set R1:	1.00
Shaft resistance factor for set R1 (Tension):	1.00

DA1 C2

Shaft resistance factor for set R4 (Compression):	1.40
Base resistance factor for set R4:	1.70
Shaft resistance factor for set R4 (Tension):	1.70

Model factor:	1.40
---------------	------

Stress Profiles

Soil Profile 1: Soil Profile 1

Level	*	Density	Undrained Cohesion	Nq	Total vertical stress	Porewater pressure	Effective vertical stress	Effective horizontal stress*	Cumulative skin friction per unit perimeter
[mOD]		[kN/m³]	[kPa]		[kPa]	[kPa]	[kPa]	[kPa]	[kN/m]
2.0000	-	10.000	0.0	0.0	0.0	0.0	0.0	NA	0.0
0.66000	H	10.000	0.0	0.0	13.400	13.400	0.0	NA	0.0
0.66000	H	10.000	0.0	0.0	13.400	13.400	0.0	NA	0.0
-0.56000	-	10.000	0.0	0.0	25.600	25.600	0.0	NA	0.0
-0.56000	-	18.000	20.000	N.A.	25.600	25.600	0.0	NA	0.0
-3.6000	-	18.000	20.000	N.A.	80.320	56.000	24.320	NA	-60.800
-3.6000	-	20.000	0.0	N.A.	80.320	56.000	24.320	NA	-60.800
-8.6000	-	20.000	0.0	N.A.	180.32	106.00	74.320	NA	50.170
-8.6000	-	21.000	0.0	N.A.	180.32	106.00	74.320	NA	50.170
-9.3400	T	21.000	0.0	N.A.	195.86	113.40	82.460	NA	96.577
-9.8400	T	21.000	0.0	N.A.	206.36	118.40	87.960	NA	130.66
-10.340	T	21.000	0.0	N.A.	216.86	123.40	93.460	NA	166.94
-10.840	T	21.000	0.0	N.A.	227.36	128.40	98.960	NA	205.43
-11.340	T	21.000	0.0	N.A.	237.86	133.40	104.46	NA	246.11
-11.840	T	21.000	0.0	N.A.	248.36	138.40	109.96	NA	289.00
-12.340	T	21.000	0.0	N.A.	258.86	143.40	115.46	NA	334.08
-12.840	T	21.000	0.0	N.A.	269.36	148.40	120.96	NA	381.36
-13.340	T	21.000	0.0	N.A.	279.86	153.40	126.46	NA	430.85
-13.840	T	21.000	0.0	N.A.	290.36	158.40	131.96	NA	482.53
-14.340	T	21.000	0.0	N.A.	300.86	163.40	137.46	NA	536.42
-14.840	T	21.000	0.0	N.A.	311.36	168.40	142.96	NA	592.50
-15.340	T	21.000	0.0	N.A.	321.86	173.40	148.46	NA	650.78
-15.840	T	21.000	0.0	N.A.	332.36	178.40	153.96	NA	711.27
-16.340	T	21.000	0.0	N.A.	342.86	183.40	159.46	NA	773.95

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date	Checked Date

Level	*	Density	Undrained Cohesion	Nq	Total vertical stress	Porewater pressure	Effective vertical stress	Effective horizontal stress*	Cumulative skin friction per unit
-16.840	T	21.000	0.0	N.A.	353.36	188.40	164.96	NA	838.84
-17.340	T	21.000	0.0	N.A.	363.86	193.40	170.46	NA	905.92
-17.840	T	21.000	0.0	N.A.	374.36	198.40	175.96	NA	975.20
-18.340	T	21.000	0.0	N.A.	384.86	203.40	181.46	NA	1046.7
-18.840	T	21.000	0.0	N.A.	395.36	208.40	186.96	NA	1120.4
-19.340	T	21.000	0.0	N.A.	405.86	213.40	192.46	NA	1196.3
-19.840	T	21.000	0.0	N.A.	416.36	218.40	197.96	NA	1274.3
-20.340	T	21.000	0.0	N.A.	426.86	223.40	203.46	NA	1354.6
-20.840	T	21.000	0.0	N.A.	437.36	228.40	208.96	NA	1437.1
-21.340	T	21.000	0.0	N.A.	447.86	233.40	214.46	NA	1521.8
-21.840	T	21.000	0.0	N.A.	458.36	238.40	219.96	NA	1608.7
-22.340	T	21.000	0.0	N.A.	468.86	243.40	225.46	NA	1697.8
-22.840	T	21.000	0.0	N.A.	479.36	248.40	230.96	NA	1789.0
-23.340	T	21.000	0.0	N.A.	489.86	253.40	236.46	NA	1882.5
-23.840	T	21.000	0.0	N.A.	500.36	258.40	241.96	NA	1978.2
-24.340	T	21.000	0.0	N.A.	510.86	263.40	247.46	NA	2076.1

* Annotation:

H: Pile head location

T: Pile toe locations corresponding to different pile lengths

* Effective horizontal stress not calculated for "Total Stress" materials and for Beta Method.

Cross-section 1 results:

Uniform pile with top shaft diameter = 0.60 m

Results - Compression

Soil Profile 1: Soil Profile 1

Level	Pile length	Ultimate base capacity (Q _b)	Cumulative external Friction (Q _s)	Average external Friction (q _s)	Negative skin friction (Q _{nsf})	Net ultimate resistance
[mOD]	[m]	[kN]	[kN]	[kN/m]	[kN]	[kN]
-9.3400	10.000	1413.7	296.65	29.665	114.61	1595.8
-9.8400	10.500	1413.7	360.90	34.371	114.61	1660.0
-10.340	11.000	1413.7	429.29	39.026	114.61	1728.4
-10.840	11.500	1413.7	501.83	43.637	114.61	1800.9
-11.340	12.000	1413.7	578.52	48.210	114.61	1877.6
-11.840	12.500	1413.7	659.35	52.748	114.61	1958.5
-12.340	13.000	1413.7	744.33	57.256	114.61	2043.4
-12.840	13.500	1413.7	833.46	61.738	114.61	2132.6
-13.340	14.000	1413.7	926.74	66.195	114.61	2225.8
-13.840	14.500	1413.7	1024.2	70.632	114.61	2323.3
-14.340	15.000	1413.7	1125.7	75.048	114.61	2424.8
-14.840	15.500	1413.7	1231.4	79.448	114.61	2530.6
-15.340	16.000	1413.7	1341.3	83.832	114.61	2640.4
-15.840	16.500	1413.7	1455.3	88.201	114.61	2754.4
-16.340	17.000	1413.7	1573.5	92.557	114.61	2872.6
-16.840	17.500	1413.7	1695.8	96.901	114.61	2994.9
-17.340	18.000	1413.7	1822.2	101.23	114.61	3121.3
-17.840	18.500	1413.7	1952.8	105.56	114.61	3251.9
-18.340	19.000	1413.7	2087.6	109.87	114.61	3386.7
-18.840	19.500	1413.7	2226.5	114.18	114.61	3525.6
-19.340	20.000	1413.7	2369.5	118.47	114.61	3668.6
-19.840	20.500	1413.7	2516.7	122.76	114.61	3815.8
-20.340	21.000	1413.7	2668.0	127.05	114.61	3967.1
-20.840	21.500	1413.7	2823.5	131.33	114.61	4122.6
-21.340	22.000	1413.7	2983.1	135.60	114.61	4282.2
-21.840	22.500	1413.7	3146.9	139.86	114.61	4446.0
-22.340	23.000	1413.7	3314.8	144.12	114.61	4613.9
-22.840	23.500	1413.7	3486.9	148.38	114.61	4786.0
-23.340	24.000	1413.7	3663.1	152.63	114.61	4962.2
-23.840	24.500	1413.7	3843.4	156.88	114.61	5142.6
-24.340	25.000	1413.7	4028.0	161.12	114.61	5327.1

Level	Pile length	Design resistance	Combination with least resistance	Factored load*
-------	-------------	-------------------	-----------------------------------	----------------

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date	Checked Date

					#						
		DA1-C1	DA1-C2	BS8004-SLS		DA1-C1	DA1-C2	BS8004-SLS			
[mOD]	[m]	[kN]	[kN]	[kN]	[kN]		[kN]		[kN]	[kN]	[kN]
-9.3400	10.000	1221.7	745.35	247.21	3	114.61(C)	160.45(C)	114.61(C)			
-9.8400	10.500	1267.6	778.13	300.75	3	114.61(C)	160.45(C)	114.61(C)			
-10.340	11.000	1316.4	813.02	357.74	3	114.61(C)	160.45(C)	114.61(C)			
-10.840	11.500	1368.2	850.03	418.19	3	114.61(C)	160.45(C)	114.61(C)			
-11.340	12.000	1423.0	889.16	482.10	3	114.61(C)	160.45(C)	114.61(C)			
-11.840	12.500	1480.8	930.40	549.46	3	114.61(C)	160.45(C)	114.61(C)			
-12.340	13.000	1541.5	973.76	620.28	3	114.61(C)	160.45(C)	114.61(C)			
-12.840	13.500	1605.1	1019.2	694.55	3	114.61(C)	160.45(C)	114.61(C)			
-13.340	14.000	1671.8	1066.8	772.28	3	114.61(C)	160.45(C)	114.61(C)			
-13.840	14.500	1741.3	1116.5	853.47	3	114.61(C)	160.45(C)	114.61(C)			
-14.340	15.000	1813.9	1168.3	938.11	3	114.61(C)	160.45(C)	114.61(C)			
-14.840	15.500	1889.4	1222.3	1026.2	3	114.61(C)	160.45(C)	114.61(C)			
-15.340	16.000	1967.9	1278.3	1117.8	3	114.61(C)	160.45(C)	114.61(C)			
-15.840	16.500	2049.3	1336.5	1212.8	3	114.61(C)	160.45(C)	114.61(C)			
-16.340	17.000	2133.7	1396.8	1311.2	3	114.61(C)	160.45(C)	114.61(C)			
-16.840	17.500	2221.1	1459.2	1413.1	3	114.61(C)	160.45(C)	114.61(C)			
-17.340	18.000	2311.4	1523.7	1518.5	3	114.61(C)	160.45(C)	114.61(C)			
-17.840	18.500	2404.7	1590.3	1627.4	2	114.61(C)	160.45(C)	114.61(C)			
-18.340	19.000	2500.9	1659.1	1739.6	2	114.61(C)	160.45(C)	114.61(C)			
-18.840	19.500	2600.1	1729.9	1855.4	2	114.61(C)	160.45(C)	114.61(C)			
-19.340	20.000	2702.3	1802.9	1974.6	2	114.61(C)	160.45(C)	114.61(C)			
-19.840	20.500	2807.4	1878.0	2097.2	2	114.61(C)	160.45(C)	114.61(C)			
-20.340	21.000	2915.5	1955.2	2223.3	2	114.61(C)	160.45(C)	114.61(C)			
-20.840	21.500	3026.6	2034.6	2352.9	2	114.61(C)	160.45(C)	114.61(C)			
-21.340	22.000	3140.6	2116.0	2485.9	2	114.61(C)	160.45(C)	114.61(C)			
-21.840	22.500	3257.6	2199.6	2622.4	2	114.61(C)	160.45(C)	114.61(C)			
-22.340	23.000	3377.5	2285.2	2762.3	2	114.61(C)	160.45(C)	114.61(C)			
-22.840	23.500	3500.4	2373.0	2905.7	2	114.61(C)	160.45(C)	114.61(C)			
-23.340	24.000	3626.3	2462.9	3052.6	2	114.61(C)	160.45(C)	114.61(C)			
-23.840	24.500	3755.1	2554.9	3202.9	2	114.61(C)	160.45(C)	114.61(C)			
-24.340	25.000	3886.9	2649.1	3356.6	2	114.61(C)	160.45(C)	114.61(C)			

Limiting criteria :

1 : DA1 C1

2 : DA1 C2

3 : BS8004:2015 SLS

*(C)-> Compression load, (T)-> Tension load

Note: Design resistance does not include any consideration of negative skin friction.

Nq Calculation Details

Soil Profile 1: Soil Profile 1 - Material Factor Set - 1

There are no pile toe levels in any drained material(with Berezantzev/Bolton option) in the given soil profile.

Soil Profile 1: Soil Profile 1 - Material Factor Set - 2

There are no pile toe levels in any drained material(with Berezantzev/Bolton option) in the given soil profile.

Results - Tension

Soil Profile 1: Soil Profile 1

Level	Pile length	Cumulative external Friction (Q _s)	Average external Friction (q _s)	Net ultimate resistance
[mOD]	[m]	[kN]	[kN/m]	[kN]
-9.3400	10.000	296.65	29.665	296.65
-9.8400	10.500	360.90	34.371	360.90
-10.340	11.000	429.29	39.026	429.29
-10.840	11.500	501.83	43.637	501.83
-11.340	12.000	578.52	48.210	578.52
-11.840	12.500	659.35	52.748	659.35

North Littlehampton
600mm diameter pile
Working Pile Test

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date	Checked Date

Level	Pile length	Cumulative external Friction (Q _s)	Average external Friction (q _s)	Net ultimate resistance
-12.340	13.000	744.33	57.256	744.33
-12.840	13.500	833.46	61.738	833.46
-13.340	14.000	926.74	66.195	926.74
-13.840	14.500	1024.2	70.632	1024.2
-14.340	15.000	1125.7	75.048	1125.7
-14.840	15.500	1231.4	79.448	1231.4
-15.340	16.000	1341.3	83.832	1341.3
-15.840	16.500	1455.3	88.201	1455.3
-16.340	17.000	1573.5	92.557	1573.5
-16.840	17.500	1695.8	96.901	1695.8
-17.340	18.000	1822.2	101.23	1822.2
-17.840	18.500	1952.8	105.56	1952.8
-18.340	19.000	2087.6	109.87	2087.6
-18.840	19.500	2226.5	114.18	2226.5
-19.340	20.000	2369.5	118.47	2369.5
-19.840	20.500	2516.7	122.76	2516.7
-20.340	21.000	2668.0	127.05	2668.0
-20.840	21.500	2823.5	131.33	2823.5
-21.340	22.000	2983.1	135.60	2983.1
-21.840	22.500	3146.9	139.86	3146.9
-22.340	23.000	3314.8	144.12	3314.8
-22.840	23.500	3486.9	148.38	3486.9
-23.340	24.000	3663.1	152.63	3663.1
-23.840	24.500	3843.4	156.88	3843.4
-24.340	25.000	4028.0	161.12	4028.0

Level	Pile length	Design resistance			Combination with least resistance	Factored load*		
					#			
		DA1-C1	DA1-C2	BS8004-SLS		DA1-C1	DA1-C2	BS8004-SLS
[mOD]	[m]	[kN]	[kN]		[kN]	[kN]		
-9.3400	10.000	211.89	124.64		2	N.A.	N.A.	114.61(C)
-9.8400	10.500	257.78	151.64		2	N.A.	N.A.	114.61(C)
-10.340	11.000	306.64	180.37		2	N.A.	N.A.	114.61(C)
-10.840	11.500	358.45	210.85		2	N.A.	N.A.	114.61(C)
-11.340	12.000	413.23	243.07		2	N.A.	N.A.	114.61(C)
-11.840	12.500	470.97	277.04		2	N.A.	N.A.	114.61(C)
-12.340	13.000	531.67	312.74		2	N.A.	N.A.	114.61(C)
-12.840	13.500	595.33	350.19		2	N.A.	N.A.	114.61(C)
-13.340	14.000	661.95	389.39		2	N.A.	N.A.	114.61(C)
-13.840	14.500	731.54	430.32		2	N.A.	N.A.	114.61(C)
-14.340	15.000	804.09	472.99		2	N.A.	N.A.	114.61(C)
-14.840	15.500	879.60	517.41		2	N.A.	N.A.	114.61(C)
-15.340	16.000	958.08	563.57		2	N.A.	N.A.	114.61(C)
-15.840	16.500	1039.5	611.48		2	N.A.	N.A.	114.61(C)
-16.340	17.000	1123.9	661.12		2	N.A.	N.A.	114.61(C)
-16.840	17.500	1211.3	712.51		2	N.A.	N.A.	114.61(C)
-17.340	18.000	1301.6	765.64		2	N.A.	N.A.	114.61(C)
-17.840	18.500	1394.9	820.51		2	N.A.	N.A.	114.61(C)
-18.340	19.000	1491.1	877.13		2	N.A.	N.A.	114.61(C)
-18.840	19.500	1590.3	935.49		2	N.A.	N.A.	114.61(C)
-19.340	20.000	1692.5	995.59		2	N.A.	N.A.	114.61(C)
-19.840	20.500	1797.6	1057.4		2	N.A.	N.A.	114.61(C)
-20.340	21.000	1905.7	1121.0		2	N.A.	N.A.	114.61(C)
-20.840	21.500	2016.8	1186.3		2	N.A.	N.A.	114.61(C)
-21.340	22.000	2130.8	1253.4		2	N.A.	N.A.	114.61(C)
-21.840	22.500	2247.8	1322.2		2	N.A.	N.A.	114.61(C)
-22.340	23.000	2367.7	1392.8		2	N.A.	N.A.	114.61(C)
-22.840	23.500	2490.6	1465.1		2	N.A.	N.A.	114.61(C)
-23.340	24.000	2616.5	1539.1		2	N.A.	N.A.	114.61(C)
-23.840	24.500	2745.3	1614.9		2	N.A.	N.A.	114.61(C)
-24.340	25.000	2877.1	1692.4		2	N.A.	N.A.	114.61(C)

Note - The weight of the pile has not been included in the factored load.

Limiting criteria :

1 : DA1 C1 [Shaft Tension]

2 : DA1 C2 [Shaft Tension]

3 : BS8004:2015 SLS Check [Shaft Tension]

*(C)-> Compression load, (T)-> Tension load

Note: Design resistance does not include any consideration of negative skin friction.

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile Design Calculations	Revision	A	Page	6 of 11

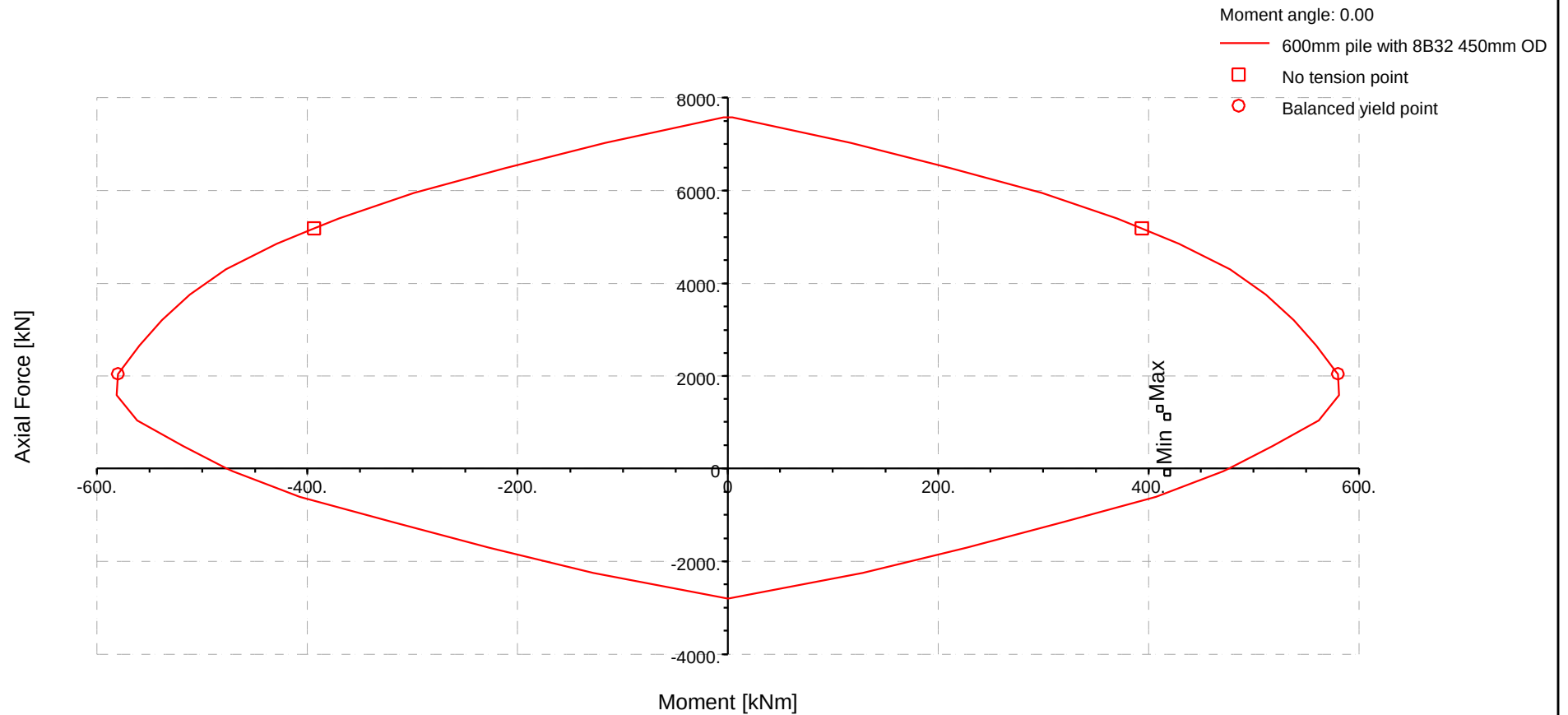
Appendix F

Adsec Input / Output

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by	Date	Checked
RS	03-Mar-2021	

600mm pile with 8B32 450mm OD cage

EC2 (GB) : Section 1



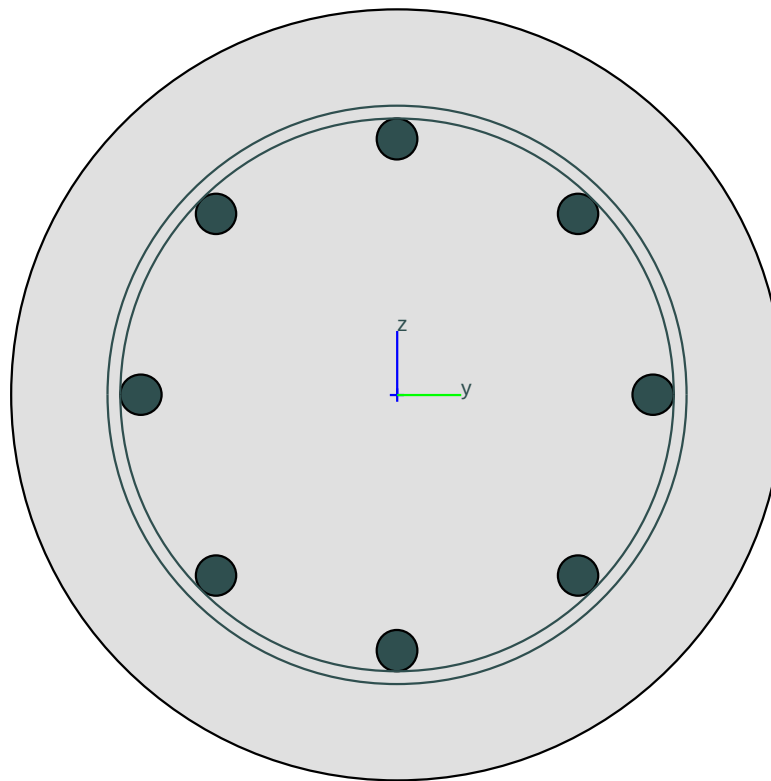
Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date 03-Mar-2021	Checked

Key

2.28% reinforcement

No Results

+ Reference Point



Section 1

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date 03-Mar-2021	Checked

Title & Specification

Job number 2231
Job title North Littlehampton
Subtitle 600mm diameter pile
Calc. heading
File Z:\Projects\2231 - North Littlehampton\Technical\Adsec\600mm diameter - 8B32.ads
Notes (none)
Code of Practice BS EN 1992-1-1:2004 [United Kingdom]
Bending Axes Biaxial
Number of sections 1
Number of ULS cases 3
Number of SLS cases 0

Section : Definition

1 : Section 1

Name Section 1
Type Concrete
Material C32/40
Origin Centre
Dimensions
Diameter 600.0mm
Section Area 282700.mm²
Reinforcement Area 6434.mm²
Reinforcement 2.276%

Section : Nodes

1 : Section 1

Node	Y [mm]	Z [mm]
1	0.0	301.3
2	67.04	293.7
3	130.7	271.4
4	187.8	235.5
5	235.5	187.8
6	271.4	130.7
7	293.7	67.04
8	301.3	-13.17E-6
9	293.7	-67.04
10	271.4	-130.7
11	235.5	-187.8
12	187.8	-235.5
13	130.7	-271.4
14	67.04	-293.7
15	-26.34E-6	-301.3
16	-67.04	-293.7
17	-130.7	-271.4
18	-187.8	-235.5
19	-235.5	-187.8
20	-271.4	-130.7
21	-293.7	-67.04
22	-301.3	3.593E-6
23	-293.7	67.04
24	-271.4	130.7
25	-235.5	187.8
26	-187.8	235.5
27	-130.7	271.4

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date 03-Mar-2021	Checked

Node	Y [mm]	Z [mm]
28	-67.04	293.7

Section : Cover & Links

1 : Section 1

Cover	75.00mm
Link Size	10.00mm
Link Material	500B

Section : Bars

1 : Section 1

Bar	Y	Z	Diameter	Area	Effective	Type	Material	Prestress	Prestress
Appl. loads					Area			Force	Strain
include/exclude									
prestress									
	[mm]	[mm]	[mm]	[mm ²]	[mm ²]			[kN]	
1	199.0	0.0	32.00	804.2	804.2	Steel	500B		
2	140.7	140.7	32.00	804.2	804.2	Steel	500B		
3	12.97E-6	199.0	32.00	804.2	804.2	Steel	500B		
4	-140.7	140.7	32.00	804.2	804.2	Steel	500B		
5	-199.0	25.94E-6	32.00	804.2	804.2	Steel	500B		
6	-140.7	-140.7	32.00	804.2	804.2	Steel	500B		
7	-10.60E-6	-199.0	32.00	804.2	804.2	Steel	500B		
8	140.7	-140.7	32.00	804.2	804.2	Steel	500B		

Section : Elastic Properties

1 : Section 1

Effective properties of the section, ignoring reinforcement.

Geometric Centroid	y	0.0mm
	z	0.0mm
Area		282700.mm ²
Second Moments of Area	I _{yy}	6.362E+9mm ⁴
	I _{zz}	6.362E+9mm ⁴
	I _{yz}	0.0mm ⁴
Principal Second Moments of Area	I _{uu}	6.362E+9mm ⁴
	I _{zz}	6.362E+9mm ⁴
	Angle	0.0°
Shear Area Factor	k _y	0.8571
	k _z	0.8571
Torsion Constant		12.72E+9mm ⁴
Section Modulus	Z _y	21.21E+6mm ³
	Z _z	21.21E+6mm ³
Plastic Modulus	Z _{py}	36.00E+6mm ³
	Z _{pz}	36.00E+6mm ³
Radius of Gyration	R _y	150.0mm
	R _z	150.0mm

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date 03-Mar-2021	Checked

Bar	Y	Z	Diameter	Area	Effective	Type	Material	Prestress	Prestress
Appl. loads					Area			Force	Strain
include/exclude									
Properties of gross section, including reinforcement.									
Geometric Centroid		y			0.0mm				
		z			1.848E-6mm				
EA					10.50E+6kN				
EI		EI _{yy}			233400.kNm ²				
		EI _{zz}			233400.kNm ²				
		EI _{yz}			-242.6E-6kNm ²				
Principal EI		EI _{uu}			233400.kNm ²				
		EI _{zz}			233400.kNm ²				
		Angle			-45.00°				
Material : Concrete									
1 : C32/40									
Name		C32/40							
		(Standard)							
Cylinder Strength	f _{ck}	32.00N/mm ²							
Tensile Strength	f _{ctm}	3.024N/mm ²							
Weight		Normal							
		Weight							
Density	ρ	2.400t/m ³							
Elastic Modulus	E	33350.N/mm ²							
Poisson's Ratio	ν	0.2000							
Coeff. Thermal Expansion	α	10.00E-6/°C							
Partial Safety Factor	γ _c	1.500							
Maximum Strain		0.003500							
Plateau Strain		0.002000							
ULS Compression Curve		Parabola rectangle							
ULS Tension Curve		No-tension							
SLS Compression Curve		FIB Model Code							
SLS Tension Curve		Interpolated							
Design strength factor	α _{cc}	0.8500							
Aggregate Size		20.00mm							
Material : Rebar									
1 : 500B									

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date 03-Mar-2021	Checked

Bar	Y	Z	Diameter	Area	Effective	Type	Material	Prestress	Prestress
Appl. loads					Area			Force	Strain
include/exclude									
Type					Steel rebar				
Strength		f_{yk}			500.0N/mm ²				
Elastic Modulus		E			200000.N/mm ²				
Hardening Modulus		E_h			0.0N/mm ²				
Density		ρ			7.850t/m ³				
Poisson's Ratio		ν			0.3000				
Coeff. Thermal Expansion		α			12.00E-6/°C				
Ductility					Normal	Modified			
Partial Safety Factor		γ_s			1.150				
		γ_{se}			1.000				
Maximum Strain		ϵ_{uk}			0.05000	Modified			
Maximum Strain		ϵ_{ud}			0.04500	Modified			
Stress/Strain Curve					Elastic-plastic				

Loading

Reference Point

All loading acts through the Reference Point.
All strain planes are defined relative to the Reference Point.

Definition		Geometric Centroid
Reference Point Coordinates	y	0.0mm
	z	0.0mm

Applied loads

Load Case	N	M_{yy}	M_{zz}	Note
	[kN]	[kNm]	[kNm]	
1	1280.	411.0	0.0	
2	1114.	418.0	0.0	
3	-84.00	418.0	0.0	

Ultimate Charts

N/M Coordinates

600mm pile with 8B32 450mm OD cage

Moment angle: 0.00

	M	N	Notes
	[kNm]	[kN]	
1	-577.9	2119.	
2	-580.1	2048.	Balanced yield point
3	-581.5	1573.	
4	-561.5	1027.	
5	-518.0	481.1	
6	-476.8	0.7294	
7	-471.1	-64.59	
8	-407.0	-610.5	
9	-318.5	-1156.	
10	-227.5	-1702.	
11	-128.2	-2248.	
12	-0.8790	-2794.	

Job No.	Sheet No.	Rev.
2231		
Drg. Ref.		
Made by RS	Date 03-Mar-2021	Checked

M N
[kNm] [kN] Notes

13	0.8725	-2794.	
14	128.2	-2248.	
15	227.5	-1702.	
16	318.5	-1156.	
17	407.0	-610.5	
18	471.1	-64.59	
19	476.8	0.7305	
20	518.0	481.1	
21	561.5	1027.	
22	581.5	1573.	
23	580.1	2048.	Balanced yield point
24	577.9	2119.	
25	559.5	2665.	
26	538.1	3210.	
27	511.9	3756.	
28	477.4	4302.	
29	429.0	4848.	
30	393.4	5189.	No tension point
31	370.0	5394.	
32	298.8	5940.	
33	212.1	6485.	
34	117.3	7031.	
35	4.593	7576.	
36	-4.587	7576.	
37	-117.3	7031.	
38	-212.1	6485.	
39	-298.8	5940.	
40	-370.0	5394.	
41	-393.4	5189.	No tension point
42	-429.0	4848.	
43	-477.4	4302.	
44	-511.9	3756.	
45	-538.1	3210.	
46	-559.5	2665.	
47	-577.9	2119.	

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
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Appendix G

EC2 Shear Calculations

Byland

Job No.	2231	Page	1	of	2
Job Name	North Littlehampton	Made By	RS	Date	04/08/2021
Section	600mm diameter	Check By	JM	Date	04/08/2021
Clark & Birjandi	Bending Resistance				
	M_d = design moment (lateral action effect)		418		kNm/pile
	F_{cd} = design vertical action		1280		kN
	h = pile diameter		600		mm
	d_c = cover to reinforcement		75		mm
	$h_s = h - 2d - 2tl$ (tl=link/helical diameter)		418		mm
	h_s/h =		0.70		
	Use chart 14	F_{cd}/h^2	3.56		N/mm ²
		M/h^3	1.94		N/mm ²
	Estimated steel area = $100A_{sc}/A_c$ =		1.80		%
	A_{sc} =		5089		mm ²
	Number of bars =		8		
	Approximate bar diameter required =		28.5		mm
	Refer to Adsec Analysis for EC 1992-1-1 Analysis				
	Hence 8 B 32 bars provided				
		A_{sc}	6,434		mm ²
	Shear Resistance				
	$v = V/b_v d$				
	V_d = design shear (lateral action effect)		363		kN
	r = pile radius		300		mm
	r_s = radius to centre of main bar		193		mm
	r_{sv} = radius to shear steel		217		mm
	$\sin \alpha = (2/\pi) \times r_s/r$		0.41		
	α		0.422		rads
	d = effective depth of section = $r (1 + \sin \alpha)$		423		mm
	$\cos \alpha$		0.91		
	$A = (\pi/2 + \alpha + \sin \alpha \cos \alpha)$		2.37		
	b_v = breadth of section = $r (A/(1 + \sin \alpha))$		504		mm

Byland

Job No.	2231	Page	2	of	2
Job Name	North Littlehampton	Made By	RS	Date	04/08/2021
Section	600mm diameter	Check By	JM	Date	04/08/2021
BS EN 1992 eq 6.8	Closed Circular Links $V_{Rd,s} = 0.85 \cdot (A_{sw}/s) \cdot Z \cdot F_{ywd} \cdot \cot \theta$ $s < 0.75 \cdot d = 317 \text{ mm}$ $\text{Let } s = 160 \text{ mm}$ $Z = 0.77 \cdot d = 326 \text{ mm}$ $f_{ywd} = f_{yk} / \gamma_s = 435 \text{ N/mm}^2$ $\cot \theta = 1.25 \text{ (tension)}$ $A_{sw} = s \cdot V_{Rd,s} / 0.85 \cdot f_{ywd} \cdot Z \cdot \cot \theta = 385.9 \text{ mm}^2$ Therefore, bar size = 15.7 mm Link diameter 16 mm Therefore, provide B16 circular link at 160mm centres Spiral (Helical) Links $p \text{ (pitch)} = 160$ $\lambda_2 = ((p / 2\pi r_{sv})^2 + 1)^{-0.5} = 0.993$ $V_{Rd,s} = 0.85 \cdot \lambda_2 (A_{sw}/s) \cdot Z \cdot F_{ywd} \cdot \cot \theta$ $A_{sw} = s \cdot V_{Rd,s} / 0.85 \cdot \lambda_2 \cdot f_{ywd} \cdot Z \cdot \cot \theta = 388.58$ Therefore, bar size = 15.7 mm Therefore, provide B16 helical at 160mm centres				
Orr et al					
BS EN 1992 eq 6.9	check : $V_d < V_{Rd,max} = \alpha_{cw} \cdot b_v \cdot Z \cdot v_1 \cdot f_{cd} = 818.7 \text{ kN}$ $\alpha_{cw} = 1$ $b_v = 504 \text{ mm}$ $z = 0.77 d = 326$ $v_1 = 0.54 (1 - 0.5 \cos \alpha) = 0.293683$ $f_{cd} = f_{ck} \cdot \alpha_{cc} \cdot \gamma_c = 18.1 \text{ N/mm}^2$ Therefore, $V_{Rd,max} >> V_d$. OK				

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
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Appendix H

Pile GA Layout & Schedule drawing - 2231-001



Pile Schedule



	INITIALS	DATE	SCALE		DRAWING NUMBER
DRAWN	RS	19/03/21	AS SHOWN		2231-001
CHECKED	JM	19/03/21			
DATE : March 2021			ORIGINAL SHEET SIZE	A1	REVISION : A

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile Design Calculations	Revision	A	Page	9 of 11

Appendix I

Bebo Bridge Loadings email

From: Sean Pattimore <Sean.Pattimore@assetint.co.uk>
Sent: 02 December 2020 15:28
To: Keith Nation <Keith.Nation@van-elle.co.uk>
Cc: Richard McTavish <Richard.McTavish@assetint.co.uk>; Kang Lim Koh <Kang.LimKoh@assetint.co.uk>
Subject: SP194895 - North Littlehampton

Hi Keith,

Sorry this has not come sooner we have had a bit of a back log design wise. Please see below foundation reactions from the arch and attached link for AIP and Soils: <https://we.tl/t-BBCXr2U2zU>

I have considered LM1 and LM2, no SV vehicles. I've modelled up to 2.0 m overfill over the crown, but don't think this will actually be the case.

Note the external rise of the structure from base to crown is $R_{tot} = 3.376$ m, for the geotechnical engineer to consider earth loads on the foundation / pile cap.

E15.5mT/-		unfactored		ULS Set A EQU		ULS Set B STR		ULS Set C GEO	
4		H	V	H	V	H	V	H	V
Load Case ID		[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]
LC2	Arch Installation	78.5	68.9	82.5	72.3	111.3	97.6	111.3	97.6
LC10-LC39	Backfill Process	Generally not governing (contact BEBOI for final design check)							
LC40	0.6 m OF Permanent Loads	182.1	310.6	191.2	326.1	245.8	419.3	182.1	310.6
LC41	0.6 m OF + LM2 Centric	279.1	420.1	322.1	473.9	376.7	567.1	293.6	436.5
LC42	0.6 m OF + LM2 Eccentric	266.6	423.8	305.3	479.0	359.9	572.2	279.3	440.8
LC43	0.6 m OF + LM1 Centric	425.9	554.1	520.3	654.8	575.0	748.0	462.5	590.6
LC44	0.6 m OF + LM1 Eccentric	382.4	556.0	461.6	657.4	516.2	750.5	412.5	592.8
LC50	1.0 m OF Permanent Loads	236.5	330.0	248.3	346.5	319.2	445.6	236.5	330.0
LC51	1.0 m OF + LM2 Centric	323.6	435.5	366.0	488.9	436.9	587.9	336.7	451.3
LC52	1.0 m OF + LM2 Eccentric	304.9	436.2	340.6	489.8	411.6	588.8	315.1	452.1
LC53	1.0 m OF + LM1 Centric	447.4	572.2	533.1	673.4	604.0	772.4	479.0	608.5
LC54	1.0 m OF + LM1 Eccentric	403.5	583.3	473.8	688.5	544.7	787.5	428.6	621.3
LC60	2.0 m OF Permanent Loads	353.5	498.9	371.1	523.8	477.2	673.5	353.5	498.9
LC61	2.0 m OF + LM2 Centric	407.4	573.2	444.0	624.1	550.0	773.8	415.5	584.3
LC62	2.0 m OF + LM2 Eccentric	398.9	573.5	432.4	624.6	538.4	774.3	405.7	584.7
LC63	2.0 m OF + LM1 Centric	510.4	695.8	582.9	789.7	689.0	939.3	533.9	725.3
LC64	2.0 m OF + LM1 Eccentric	492.3	717.1	558.6	818.4	664.6	968.1	513.2	749.8

Partial factors applied are:

Partial Factors (upper values [sup] govern foundation designs)

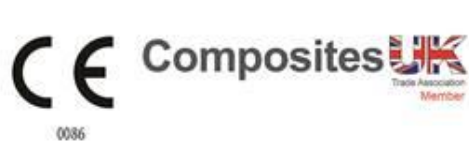
	EQU (Set A)	STR (Set B)	GEO (Set C)
	Sup	Sup	Sup
G Arch	1.05	1.35	1.00
G Fill	1.05	1.35	1.00
Q LL	1.35	1.35	1.15

Kind Regards,

Sean Pattimore
Concrete Products Manager



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Please title your email: Asset International Structures – Privacy Lead

Email: info@assetint.co.uk

Address: Asset International Structures, Suite 5 Brecon House, Llantarnam Industrial Park, Llantarnam, Torfaen, NP44 3AB

Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
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Appendix J

Pile Cap Reinforcement Calculations

DALES CALCS LTD

Civil and Structural
Engineering Consultants

Project: North Littlehampton

Job No 21010

Calc Sheet No
(1)

Part of Structure: Pile Cap

Date 18/03/2021

Calc By RT

STRUCTURAL CALCULATION
FOR.

R.C. PILE CAP AT.
NORTH LITTLEHAMPTON.

R. Thero . BSc. PhD CEng MISTRUCTE

Dales Calcs Ltd

21010-CA-001.

DALES CALCS LTD

Civil and Structural
Engineering Consultants

Project: North Littlehampton

Job No 21010

Calc Sheet No

(ii)

Part of Structure: Pile Cap

Date 18/03/2021

Calc By RT

Introduction

Brief

To prepare structural calculations and reinforced concrete details for the proposed pile cap for Von Elle and North Littlehampton

References

1. Drawings 2231-SK001A, 2231-SK002A, 2231-009 by Byland Engineering Limited
2. Drawings 35944/1507/003 P04 and 39878/4001/008 B by Peterbrett
3. Manual for the design of concrete building structures to Eurocode 2
4. Tekla TEAD Design and Analysis Package
5. Concrete C32/40

DALES CALCS LTD

Civil and Structural Engineering Consultants

Project: North Littlehampton

Job No 21010

Calc Sheet No 1

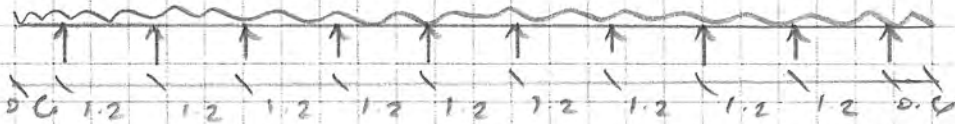
Part of Structure: Pile Cap

Date 18/03/2021

Calc. By RT

Longitudinal Analysis

Vertical loading 1043 kN/m



Consider a nominal 10 pile continuous pile cap.

Refer to TEDDS analysis PCI-PC3.

$$M_v = 188 \text{ kNm} \quad V$$

Pile cap effective section 2700×1070

$$\frac{M}{bd^2 f_{ck}} = \frac{188 \times 10^6}{2700 \times 955^2 \times 32} = 0.0024$$

$$\Rightarrow Z = 0.98 \times 1070 = 1048$$

$$A_s = \frac{188 \times 10^6}{0.87 \times 500 \times 1048} = 412 \text{ mm}^2$$

$$A_{s \text{ min}} = 0.0015 bh = 0.0015 \times 2700 \times 1300 = 5265 \text{ mm}^2$$

$$\text{Provide 14 H25's} = 6872 \text{ mm}^2$$

Horizontal loading = 604 kN/m.

$$\text{By ratio } M_H = \frac{604}{1043} \times 188 = 109 \text{ kNm}$$

$$\frac{M}{bd^2 f_{ck}} = \frac{109 \times 10^6}{1070 \times 2610^2 \times 32} = 0.0004$$

$$A_s = \frac{109 \times 10^6}{0.87 \times 500 \times 0.98 \times 2610} = 98 \text{ mm}^2$$

$$\text{Provide 4 H25's} = 1963 \text{ mm}^2$$

From TEDDS analysis

Vertical shear = 628 kN

$$v_{ed} = \frac{628 \times 10^3}{2700 \times 955} = 0.243 \text{ N/mm}^2$$

$$\frac{100 A_s}{b d} = \frac{100 \times 6872}{2700 \times 955} = 0.266 \Rightarrow v_{red} = 0.35 > 0.243 \text{ OK}$$

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Project: North Littlehampton

Job No 21010

Calc Sheet No 2

Part of Structure: Pile Cap

Date 18/03/2021

Calc. By RT.

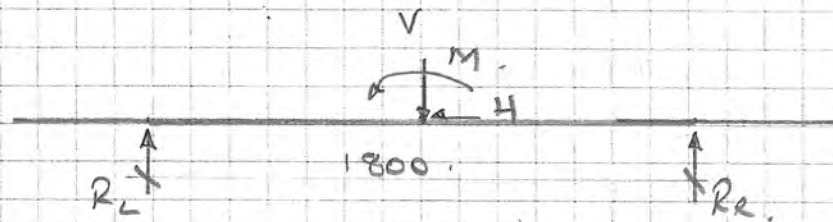
Longitudinal Analysis (cont)

Shear check $V_{Ed} > V_{Ed}$ $\therefore$ No links required.

Provide 14 H25's Top + Bottom.

Transverse Analysis

Idealised section.



Loading per 1.2 m.

$$V = 1.2 \times 1043 = 1252 \text{ kN}$$

$$H = 1.2 \times 604 = 725 \text{ kN}$$

$$M = 1.2 \times 269 = 323 \text{ kNm}$$

$$R_L \times 1.8 = 1252 \times 0.9 + 323 \Rightarrow R_L = 805.4 \text{ kN}$$

$$R_R = 1252 - 805.4 \Rightarrow R_R = 446.6 \text{ kN}$$

$$M_v = 805.4 \times 0.9 = 724.9 \text{ kNm}$$

$$\frac{M}{bd^2 f_{cm}} = \frac{724.9 \times 10^6}{1200 \times 980^2 \times 32} = 0.0196 \Rightarrow Z = 0.98$$

$$A_s = \frac{724.9 \times 10^6}{0.87 \times 500 \times 0.98 \times 980} = 1735 \text{ mm}^2 / 1.2 \text{ m}$$

$$6 \text{ H25's} = 2945 \text{ mm}^2 > 1735 \text{ O.K.}$$

$$\text{Shear at face of pile} = 805.4 - \frac{730}{2700} \times 116 \times 1.2 - \frac{730}{1630} \times 139 \times 1.2 = 690 \text{ kN}$$

$$\text{Reduction factor For load close to support} = \beta = \alpha / 2d \\ = 1455 / (2 \times 980) = 0.59$$

$$V_{Ed} = 0.59 \times 690 \times 10^3 = 0.346 \text{ N/mm}^2$$

$$V_{Ed} = 0.35 > 0.346 \therefore \text{No links required.}$$

Provide H25's @ 200 Top + Bottom.

Torsion check.

$$\text{Beam Torsion} = 323 / 2 = 161.5 \text{ kNm}$$

See TEDDS TI-72. No torsion reinforcement req'd

DALES CALCS LTD

Civil and Structural
Engineering Consultants

Project: North Littlehampton

Job No 21010

Calc Sheet No
3

Part of Structure: Pile Cap.

Date 19/02/2021

Calc By ET

Top Revers

Treat top rears as a horizontal corbel.

See TEDS TR1-TR3.

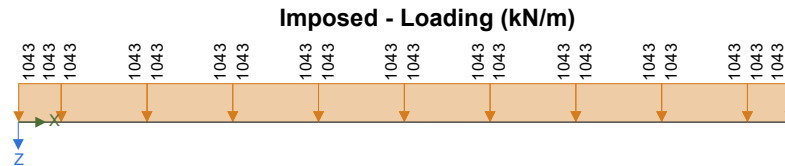
Provide 4 H16 legs @ 200%.

Project North Littlehampton				Job no. 21010	
Calcs for Pile Cap				Start page no./Revision PC 1	
Calcs by RT	Calcs date 18/03/2021	Checked by	Checked date	Approved by	Approved date

ANALYSIS

Tedds calculation version 1.0.35

Loading

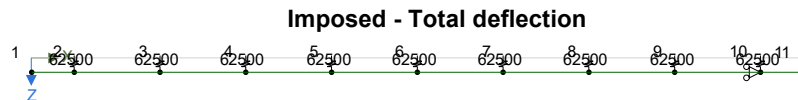


Element Loads

Element	Load case	Load Type	Orientation	Description
1	Imposed	UDL	GlobalZ	1043 kN/m
2	Imposed	UDL	GlobalZ	1043 kN/m
3	Imposed	UDL	GlobalZ	1043 kN/m
4	Imposed	UDL	GlobalZ	1043 kN/m
5	Imposed	UDL	GlobalZ	1043 kN/m
6	Imposed	UDL	GlobalZ	1043 kN/m
7	Imposed	UDL	GlobalZ	1043 kN/m
8	Imposed	UDL	GlobalZ	1043 kN/m
9	Imposed	UDL	GlobalZ	1043 kN/m
10	Imposed	UDL	GlobalZ	1043 kN/m

Results

Total deflection



Node deflections

Load case: Imposed

Node	Deflection		Rotation (°)	Co-ordinate system
	X (mm)	Z (mm)		
1	0	20.1	-0.00156	
2	0	20	-0.00133	
3	0	20	-0.00093	
4	0	20	-0.00059	
5	0	20	-0.00028	
6	0	20	0	
7	0	20	0.00028	
8	0	20	0.00059	
9	0	20	0.00093	
10	0	20	0.00133	
11	0	20.1	0.00156	

Total base reactions

Load case/combination	Force	
	FX (kN)	FZ (kN)
Imposed	0	11251.9

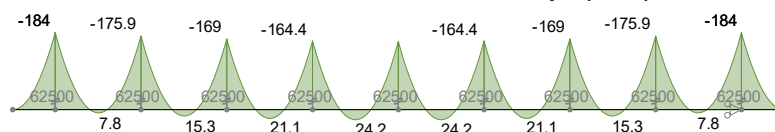
Element end forces

Load case: Imposed

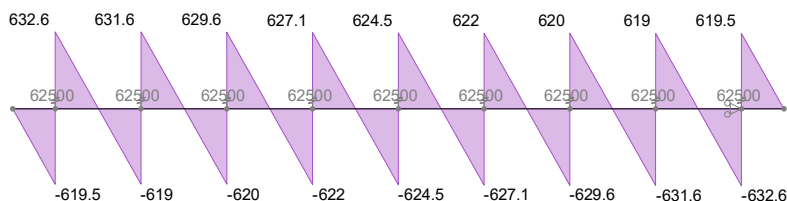
Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	0.594	1	0	0	0
		2	0	-619.5	-184
2	1.2	2	0	-632.6	184
		3	0	-619	-175.9
3	1.2	3	0	-631.6	175.9
		4	0	-620	-169
4	1.2	4	0	-629.6	169
		5	0	-622	-164.4
5	1.2	5	0	-627.1	164.4
		6	0	-624.5	-162.7
6	1.2	6	0	-624.5	162.7
		7	0	-627.1	-164.4
7	1.2	7	0	-622	164.4
		8	0	-629.6	-169
8	1.2	8	0	-620	169
		9	0	-631.6	-175.9
9	1.2	9	0	-619	175.9
		10	0	-632.6	-184
10	0.594	10	0	-619.5	184
		11	0	0	0

Forces

All load cases - Moment envelope (kNm)



All load cases - Shear envelope (kN)



Project North Littlehampton				Job no. 21010	
Calcs for Pile Cap				Start page no./Revision PC 3	
Calcs by RT	Calcs date 18/03/2021	Checked by	Checked date	Approved by	Approved date

Element results

Envelope - All load cases

Element	Shear force		Moment			
	Pos (m)	Max abs (kN)	Pos (m)	Max (kNm)	Pos (m)	Min (kNm)
1	0.594	-619.5	0	0	0.594	-184 (min)
2	0	632.6 (max abs)	0.606	7.8	0	-184 (min)
3	0	631.6	0.606	15.3	0	-175.9
4	0	629.6	0.604	21.1	0	-169
5	0	627.1	0.601	24.2 (max)	0	-164.4
6	1.2	-627.1	0.599	24.2 (max)	1.2	-164.4
7	1.2	-629.6	0.596	21.1	1.2	-169
8	1.2	-631.6	0.594	15.3	1.2	-175.9
9	1.2	-632.6	0.594	7.8	1.2	-184 (min)
10	0	619.5	0.594	0	0	-184 (min)

Project North Littlehampton				Job no. 21010	
Calcs for Pile Cap Torsion Check				Start page no./Revision T 1	
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RC BEAM TORSION DESIGN

In accordance with EN1992-1-1:2004 incorporating Corrigenda January 2008 and the UK national annex

Tedds calculation version 1.0.00

Concrete details - Table 3.1. Strength and deformation characteristics for concrete

Concrete strength class	C32/40
Characteristic compressive cylinder strength	$f_{ck} = 32 \text{ N/mm}^2$
Partial factor for concrete - Table 2.1N	$\gamma_C = 1.50$
Compression chord stress coefficient - cl.6.2.3(3)	$\alpha_{cw} = 1.00$
Compressive strength coefficient - cl.3.1.6(1)	$\alpha_{cc} = 0.85$
Design compressive concrete strength - exp.3.15	$f_{cd} = \alpha_{cc} * f_{ck} / \gamma_C = 18.1 \text{ N/mm}^2$
Compressive strength coefficient - cl.3.1.6(1)	$\alpha_{ccw} = 1.00$
Design compressive concrete strength - exp.3.15	$f_{c wd} = \alpha_{ccw} * f_{ck} / \gamma_C = 21.3 \text{ N/mm}^2$
Tensile strength coefficient - cl.3.1.6(2)	$\alpha_{ct} = 1.00$
Mean value of axial strength of conc. - cl.3.1.6(2)	$f_{ctm} = 0.3 \text{ N/mm}^2 * (f_{ck} / 1 \text{ N/mm}^2)^{2/3} = 3.02 \text{ N/mm}^2$
Characteristic axial strength of conc. (5% fractile)	$f_{ctk,0.05} = 0.7 * f_{ctm} = 2.12 \text{ N/mm}^2$
Design axial strength of concrete	$f_{ct,d} = \alpha_{ct} * f_{ctk,0.05} / \gamma_C = 1.41 \text{ N/mm}^2$

Reinforcement details

Characteristic yield strength of reinforcement	$f_{yk} = 500 \text{ N/mm}^2$
Partial factor for reinforcing steel - Table 2.1N	$\gamma_S = 1.15$
Design yield strength of reinforcement	$f_{yd} = f_{yk} / \gamma_S = 435 \text{ N/mm}^2$

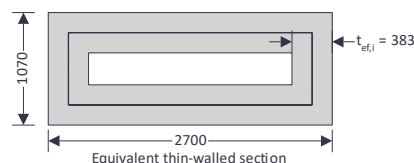
Section 1 - Pile Cap

Beam dimensions

Section width	$b = 2700 \text{ mm}$
Section depth	$h = 1070 \text{ mm}$

Design forces

Maximum design torsional moment	$T_{Ed,max} = 161.4 \text{ kNm}$
Maximum design shear force	$V_{Ed,max} = 638.0 \text{ kN}$
Area of design longitudinal reinforcement	$A_{sl} = 6872 \text{ mm}^2$
Effective depth to outer layer	$d = 970 \text{ mm}$



Torsional resistance - Section 6.3

Effective thickness of walls - cl.6.3.2(1)	$t_{ef,i} = (b * h) / (2 * (b + h)) = 383 \text{ mm}$
Area enclosed by centre lines of walls - cl.6.3.2(1)	$A_k = (b - t_{ef,i}) * (h - t_{ef,i}) = 1591309 \text{ mm}^2$
Perimeter - cl.6.3.2(3)	$U_k = 2 * ((b - t_{ef,i}) + (h - t_{ef,i})) = 6007 \text{ mm}$
Strength reduction factor	$v_1 = 0.6 * (1 - f_{ck} / 250 \text{ N/mm}^2) = 0.523$
Design shear stress	$v_{t,Ed} = V_{Ed,max} / (b * d) = 0.244 \text{ N/mm}^2$
Torsional shear stress in wall - exp.6.26	$\tau_{t,Ed} = T_{Ed,max} / (2 * A_k * t_{ef,i}) = 0.132 \text{ N/mm}^2$
Concrete strut angle	$\theta_t = \min(45\text{deg}, \max(0.5 * \text{Asin}(\min(2 * (v_{t,Ed} / 0.9 + \tau_{t,Ed}) / (\alpha_{cw} * f_{c wd} * v_1), 1)), 21.8\text{deg})) = 21.8 \text{ deg}$
Max design value of torsional resist. mnt - exp 6.30	$T_{Rd,max} = 2 * v_1 * \alpha_{cw} * f_{cd} * A_k * t_{ef,i} * \sin(\theta_t) * \cos(\theta_t) = 3989.2 \text{ kNm}$

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Max design shear force - exp.6.9

$$V_{Rdt,max} = \alpha_{cw} * b * 0.9 * d * v_1 * f_{cwd} / (\cot(\theta_t) + \tan(\theta_t)) = \mathbf{9071.6 \text{ kN}}$$

Interaction formulae - exp.6.29

$$T_{Ed,max} / T_{Rd,max} + V_{Ed,max} / V_{Rdt,max} = \mathbf{0.111}$$

PASS - concrete section is adequate

Torsional and shear resistance of the concrete alone

Max torsional resist mnt no shear reinf. - cl.6.3.2(5) $T_{Rd,c} = 2 * A_k * f_{ct,d} * t_{ef,i} = \mathbf{1720.8 \text{ kNm}}$

Shear resistance constant - cl.6.2.2

$$C_{Rd,c} = 0.18 / \gamma_C = \mathbf{0.120}$$

Reinforcement ratio - cl.6.2.2

$$\rho_l = \min(A_{sl} / (d * b), 0.02) = \mathbf{0.003}$$

Effective depth factor - cl.6.2.2

$$k_v = \min(1 + \sqrt{(200\text{mm} / d)}, 2) = \mathbf{1.454}$$

Minimum shear stress

$$v_{min} = 0.035 \text{ N/mm}^2 * k_v^{3/2} * (f_{ck} / 1\text{N/mm}^2)^{0.5} = \mathbf{0.3 \text{ N/mm}^2}$$

Design value for shear resistance - exp.6.2.a

$$V_{Rd,c} = \max(C_{Rd,c} * k_v * 1\text{N/mm}^2 * (100 * \rho_l * f_{ck} / 1\text{N/mm}^2)^{1/3} * b * d, v_{min} * b * d) = \mathbf{928.8 \text{ kN}}$$

Interaction formulae - exp.6.31

$$T_{Ed,max} / T_{Rd,c} + V_{Ed,max} / V_{Rd,c} = \mathbf{0.781}$$

No additional reinforcement required

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RC CORBEL DESIGN

In accordance with EN1992-1-1:2004 incorporating Corrigenda January 2008 and the UK national annex

Tedds calculation version 1.0.04

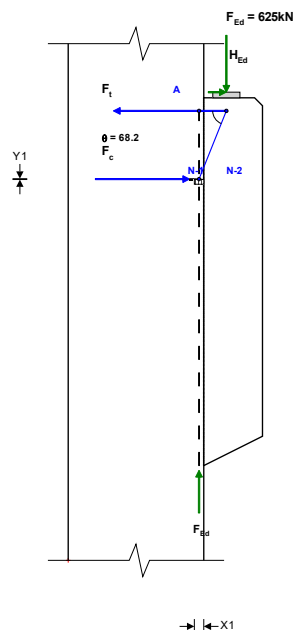
Corbel geometry

Width of the corbel	$a = 260$ mm
Breadth of the corbel	$b = 1000$ mm
Depth of the corbel at front face of column	$h_c = 1630$ mm
Depth at front face of corbel	$h_{corbel} = 1500$ mm
Chamfered corner	$d_{chamfer} = 35$ mm

Load plate geometry (Bearing)

Width of the bearing	$a_{bearing} = 120$ mm
Breadth of the bearing	$b_{bearing} = 1000$ mm
Height of the bearing	$h_{bearing} = 25$ mm

STRUT AND TIE MODEL



Concrete details

Characteristic compressive cylinder strength	$f_{ck} = 30$ N/mm ²
Partial factor for concrete – Table 2.1N	$\gamma_c = 1.5$
Compressive strength coefficient – cl.3.1.6(1)	$\alpha_{cc} = 0.85$
Design compressive concrete strength - exp.3.15	$f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_c = 17.00$ N/mm ²
Node in compression factor k_1 – cl.6.5.4(4)a)	$k_1 = 1.00$
Node in compr./tension factor k_2 – cl.6.5.4(4)b)	$k_2 = 0.85$
Node in compr./tension factor k_3 – cl.6.5.4(4)c)	$k_3 = 0.75$
Strength reduction factor – cl.6.5.2(2)	$\psi' = [1 - f_{ck} / 250 \text{ N/mm}^2] = 0.88$

Reinforcement details

Characteristic yield strength of reinforcement	$f_{yk} = 500$ N/mm ²
Partial factor for reinforcing steel – Table 2.1N	$\gamma_s = 1.15$
Design yield strength of reinforcement	$f_{yd} = f_{yk} / \gamma_s = 435$ N/mm ²

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Loads

Vertical force $F_{Ed} = 625.0$ kN
Horizontal force $H_{Ed} = 125.0$ kN
Distance from the face of the column to F_{Ed} $a_c = 100$ mm

Reinforcement

Number of bars for main tension $N = 5$
Diameter of bars for main tension $D_{main} = 16$ mm
Area of main tension provided $A_{s,main} = N \times \pi \times (D_{main}^2) / 4 = 1005$ mm²
Nominal cover to reinforcement $c_{nom} = 50$ mm
Depth to main reinforcement $d = h_c - c_{nom} - D_{main} / 2 = 1572$ mm
Distance to main reinforcement $_{d1} = c_{nom} + D_{main} / 2 = 58$ mm

Node N-1

Strength reduction factor –cl.6.5.2(2) $\nu' = 0.880$
Nodes in compression stress cl.6.5.4.(4)a) $\sigma_{1Rd} = k_1 \times \nu' \times f_{cd} = 14.96$ N/mm²
Vertical strut width $X_1 = F_{Ed} / (\sigma_{1Rd} \times b) = 41.8$ mm
N-1 is located from the outer side of the column $X_1 / 2 = 20.9$ mm
Taking moments about A $M_a = "F_c * (d - Y_1 / 2) = F_{Ed} * (a_c + X_1 / 2) + H_{Ed} * (h_{bearing} + d_1)"$
Substitution of " $F_c = Y_1 \times \sigma_{1Rd} \times b$ "
Resolving Y_1 $Y_1 = - (-C_2 + (C_2^2 - 4 \times C_1 \times C_3)^{1/2}) / (2 \times C_1) = 3.7$ mm
N-1 is located from the bottom of the corbel $Y_1 / 2 = 1.8$ mm

Angle of inclination

$$\theta = \text{atan}((d - Y_1 / 2) / (a_c + X_1 / 2)) = 85.6^\circ$$

NOTE- The angle of inclination θ is limited to a maximum value equal to $\theta = 68.2^\circ$

Lever arm

Lever arm at the outer side of the column $z = 2.5 \times (a_c + X_1 / 2) = 302$ mm

Bearing stress check at node N-2

Strength reduction factor –cl.6.5.2(2) $\nu' = 0.880$
Safe bearing stress –cl.6.5.4(4) b) $\sigma_{2Rd} = k_2 \times \nu' \times f_{cd} = 12.72$ N/mm²
Actual bearing stress $\sigma_{Ed} = F_{Ed} / (a_{bearing} \times b_{bearing}) = 5.21$ N/mm²

PASS- Design force at bearing is less than the maximum design bearing resistance

Compression strut stress check at node N-2

Horizontal concrete compression force at N-1 $F_c = 0.4 * (F_{Ed} + H_{Ed} \times (h_{bearing} + _{d1}) / (a_c + X_1 / 2)) = 284.3$ kN
Strut force $F_{str} = F_c \times \cos(68.2) + F_{Ed} \times \sin(68.2) = 685.9$ kN
From Fig.6.27 $u = 2 \times (c_{nom} + D_{main} / 2) = 116$ mm
Width of the concrete strut – Fig.6.27 $a_2 = a_{bearing} \times \sin(68.2) + u \times \cos(68.2) = 154.5$ mm
Minimum allowable distance – Fig. 6.27 $dist_{allowable} = 2 \times (c_{nom} + D_{main} / 2) + c_{nom} + D_{main} / 2 = 174.0$ mm
Actual distance $dist_{act} = a - a_c - a_{bearing} / 2 = 100.0$ mm

FAIL- Distance from edge of the bearing to front face of the corbel is less than required (Fig. 6.27)

Concrete strut stress $\sigma_{str} = F_{str} / (a_2 \times b) = 4.44$ N/mm²
Safe strut stress –cl.6.5.4(4) b) $\sigma_{2Rd} = 12.72$ N/mm²

PASS- Stress in the concrete strut is less than the maximum stress resistance

Compression strut crushing check

Height of the corbel at the location of F_{Ed} $h_a = 1580.0$ mm
Effective depth of reinf. at location of F_{Ed} $d_a = h_a - c_{nom} - D_{main} / 2 = 1522$ mm

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Concrete compressive stress due to axial loading $\sigma_{cp} = -H_{Ed} / (b \times h_a) = -0.08 \text{ N/mm}^2$
 Compression chord coefficient - cl.6.2.3(3) $\alpha_{cw} = 1.000$
 Strength reduction factor in shear $\nu_1 = 0.6 \times [1 - f_{ck} / 250 \text{ N/mm}^2] = 0.528$
 Maximum design shear resistance – cl.6.2.3(2) $V_{Rd,max} = \alpha_{cw} \times b \times z \times \nu_1 \times f_{cd} / (2.9) = 935.4 \text{ kN}$

PASS- Design force in the compression strut is less than the maximum allowable

Tie force

Resolving horizontally $F_t = F_c + H_{Ed} = 409.3 \text{ kN}$

Main tension steel check

Minimum area of tension reinforcement $A_{s,main,min} = F_t / f_{yd} = 941 \text{ mm}^2$

Area of main tension provided $A_{s,main} = N \times \pi \times (D_{main}^2) / 4 = 1005 \text{ mm}^2$

PASS-Area of main tension reinforcement provided is greater than area of reinforcement required

Horizontal links check

Min. area of total horizontal links – P.D.-6687 $A_{s,link,t,min} = A_{s,main} = 1005 \text{ mm}^2$

Number of horizontal links $N_{Link} = 2$

Diameter of bars for horizontal links $D_{Link} = 16 \text{ mm}$

Number of legs per link $N_{Legs} = 5$

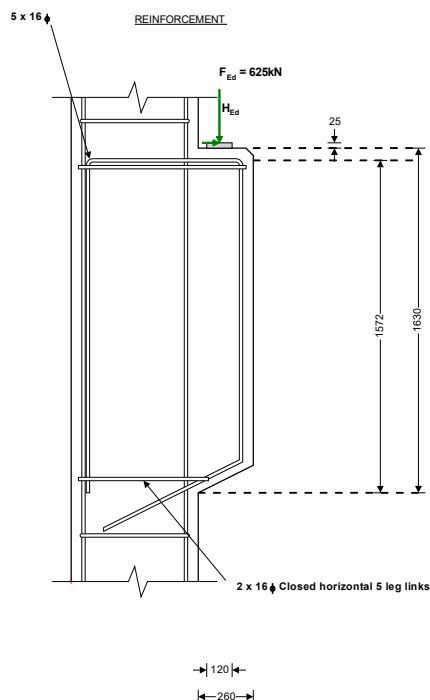
Total area of horizontal links provided $A_{s,link,t} = N_{Legs} \times N_{Link} \times \pi \times (D_{Link}^2) / 4 = 2011 \text{ mm}^2$

PASS- Total area of horizontal link reinforcement provided is greater than the minimum area required Design value for horizontal link bars – P.D.-6687 $K_{j1} = 0.50$

Area of one horizontal link provided $A_{s,link} = N_{Legs} \times \pi \times (D_{Link}^2) / 4 = 1005 \text{ mm}^2$

Min. area for one horizontal link– P.D.-6687 $A_{s,link,min} = K_{j1} \times A_{s,main} = 503 \text{ mm}^2$

PASS-Provided area of one horizontal link bar is greater than the minimum area required



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Engineering Consultants

Project: North Littlehampton

Job No 21010

Calc Sheet No
SK-001A

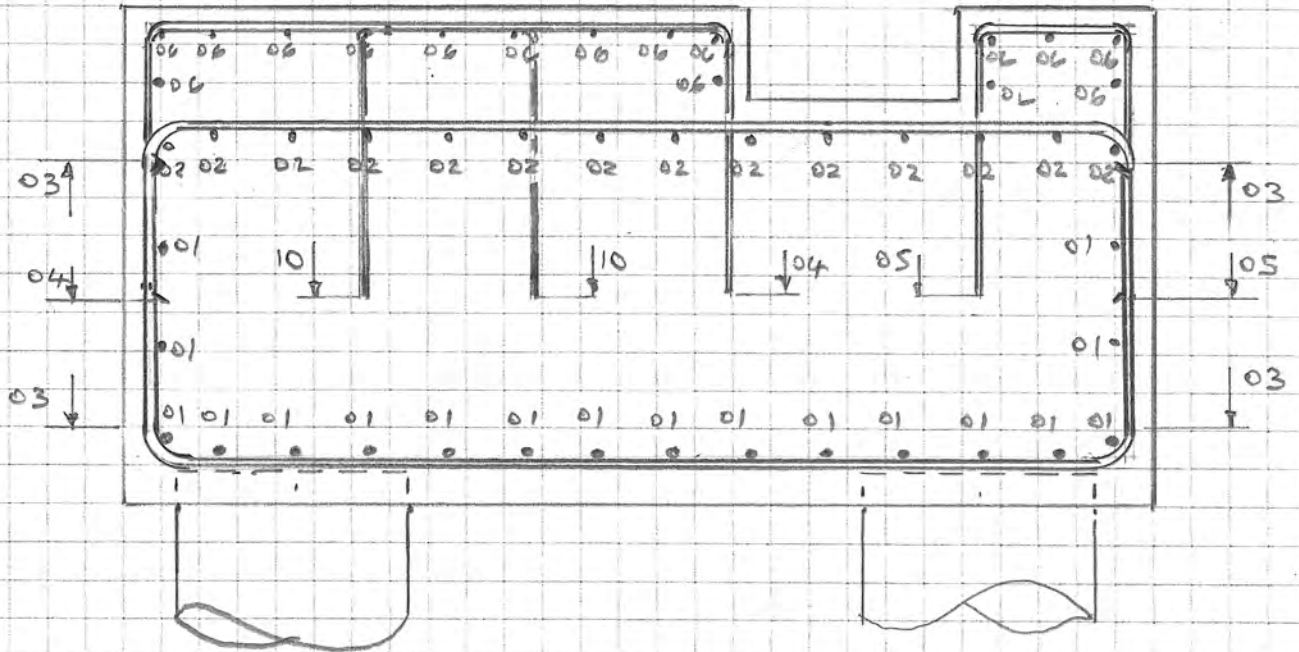
Part of Structure: Pile Cap.

Date 17/03/2021

Calc By RT

Section

Rev A-MK10 Added.



- 01 - H25 - 200 (250% on sides).
- 02 - H25 - 200
- 03 - H25 - 200 (L BARS)
- 04 - H16 - 200 (L BARS)
- 05 - H16 - 200 (U BARS)
- 06 - H16 - 200

Concrete C32/40

Cover 50 mm Sides and Top
75 mm Bottom

Tension Lap 25 mm 1275 mm Sides + Bottom
1700 mm Top
16 mm 1100 mm.

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Tedds calculation version 1.0.07

Reinforcement schedule

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Member	Bar mark	Type and size	No. of mbrs	No. of bars in each	Total no.	Length of each bar + mm	Shape code	A* mm	B* mm	C* mm	D* mm	E/R* mm	Rev letter
Pile Cap	01	H25	2	108	216	6000	00	6000					
	02	H25	2	98	196	6000	00	6000					
	03	H25	2	350	700	4175	21	850	2590	850			
	04	H16	2	175	350	2875	21	700	1520	700			
	05	H16	2	175	350	1750	21	700	410	700			
	06	H16	2	96	192	6000	00	6000					
	07	H25	2	14	28	4250	21	1750	885	1750			
	08	H25	2	14	28	8750	21	4000	885	4000			
	09	H25	2	14	28	2400	00	2400					
	10	H16	2	175	350	1825	21	700	470	700			
	11	H16	2	16	32	2575	11	700	1900				
	12	H16	2	16	32	4075	11	700	3400				
	13	H16	2	16	32	2200	00	2200					
	14	H16	2	4	8	4650	21	1100	2510	1100			
	15	H25	2	18	36	3700	00	3700					

This schedule conforms to BS 8666:2005

* Specified in multiples of 5 mm.

+ Specified in multiples of 25 mm.

Status: P Preliminary

T Tender

C Construction;



Dales Calcs Ltd
16 Ure Bank Terrace
Ripon
North Yorkshire HG4 1JG

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Tedds calculation version 1.0.07

Calculate weight of steel reinforcement

Steel bar weights in tonnes by type and size

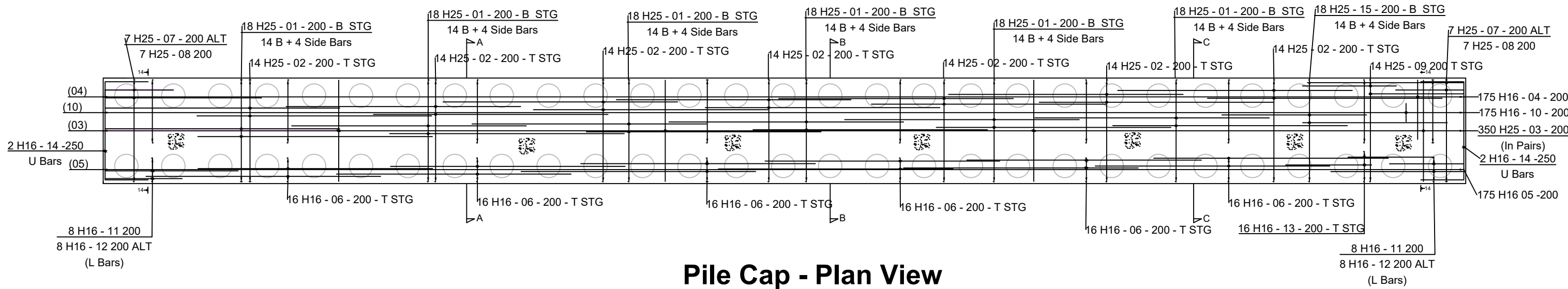
Type	6 mm	8 mm	10 mm	12 mm	16 mm	20 mm	25 mm	32 mm	40 mm	50 mm	Total;
H	0.000	0.000	0.000	0.000	5.887	0.000	22.962	0.000	0.000	0.000	28.849
Total	0.000	0.000	0.000	0.000	5.887	0.000	22.962	0.000	0.000	0.000	28.849

Total weight of steel is 28.849 tonnes

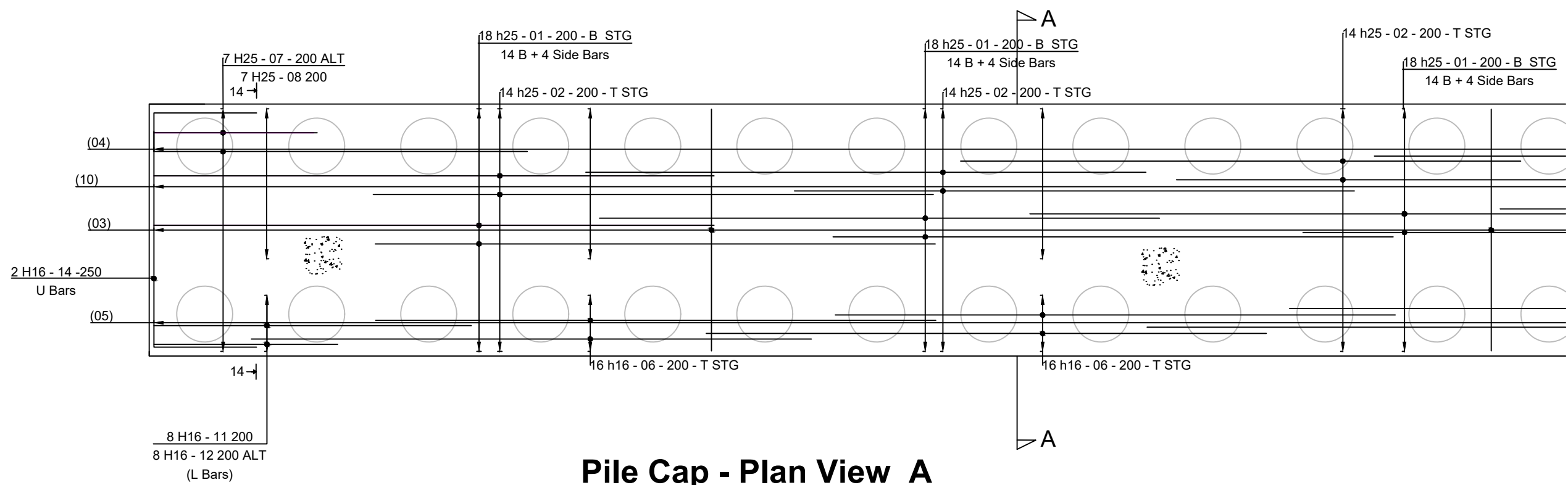
Job No.	2231	Designer	Rachel Salter	Date	05/08/2021
Job Name	North Littlehampton	Checker	Jim Martin	Date	05/08/2021
Section	Bearing Pile Design Calculations	Revision	A	Page	11 of 11

Appendix K

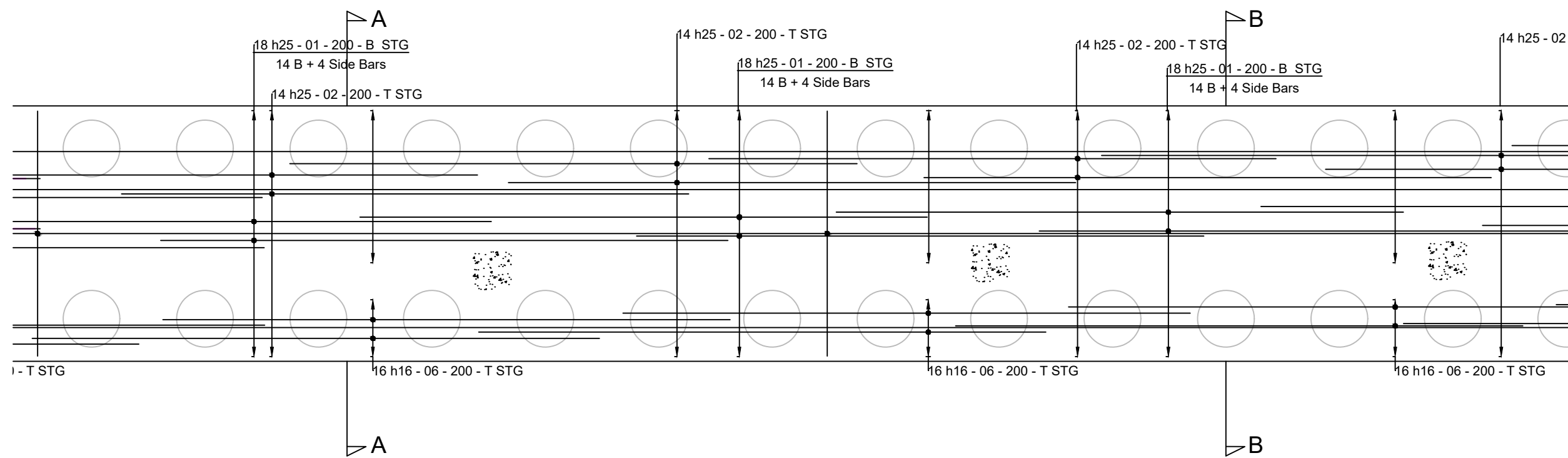
Pile Cap Reinforcement Drawings - 2231-002



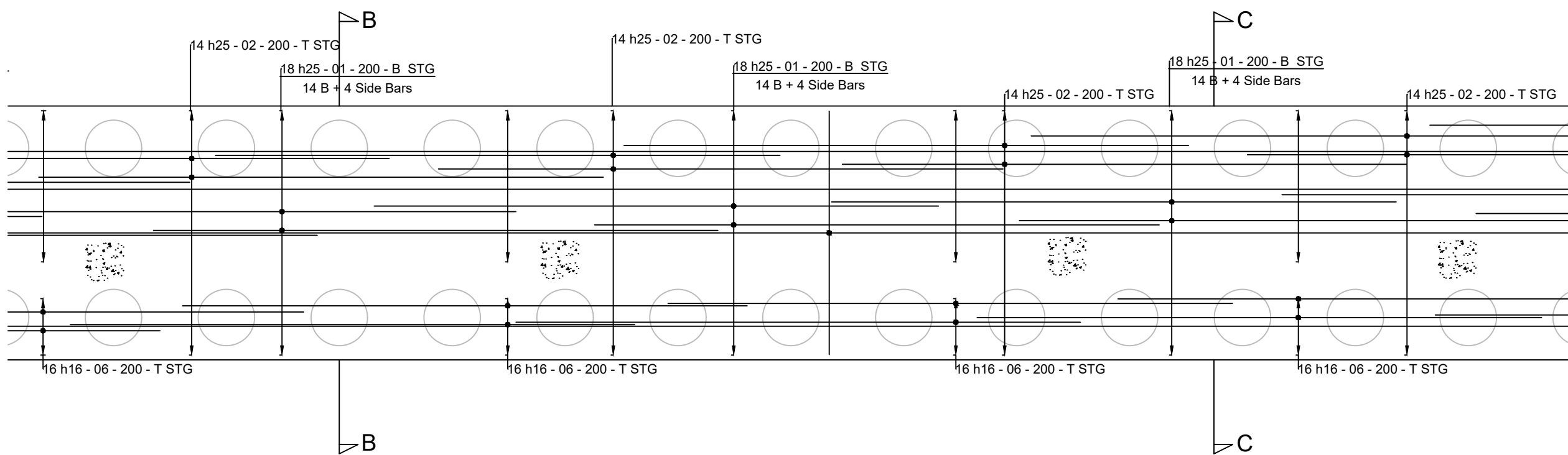
Pile Cap - Plan View
Scale 1:100



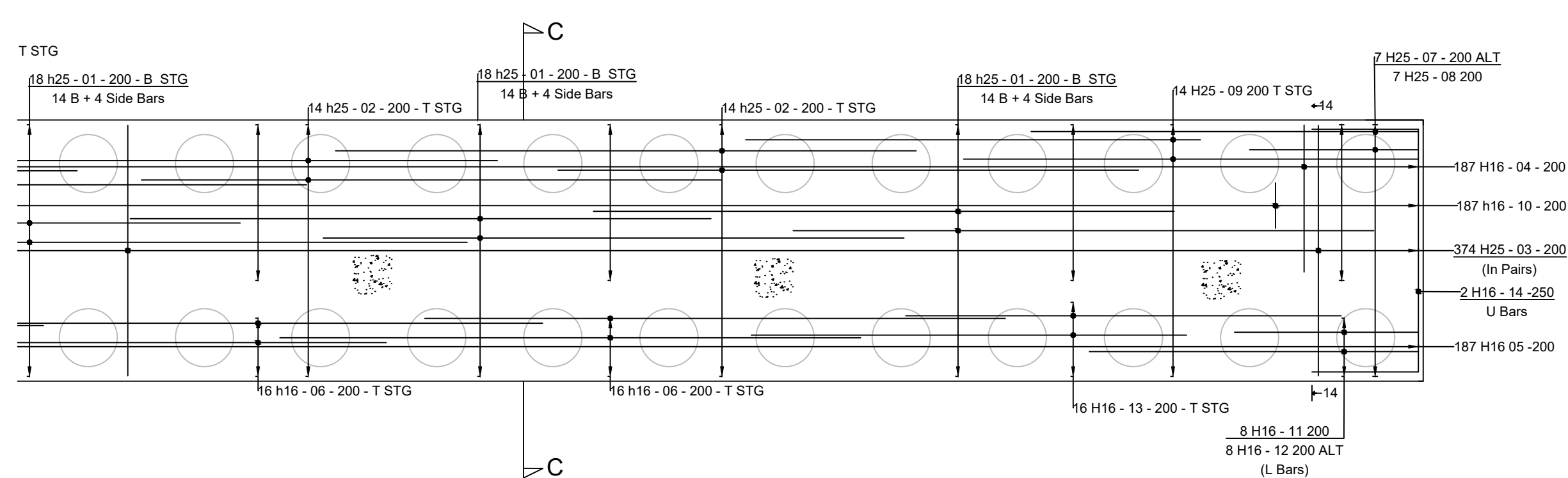
Pile Cap - Plan View A
Scale 1:50



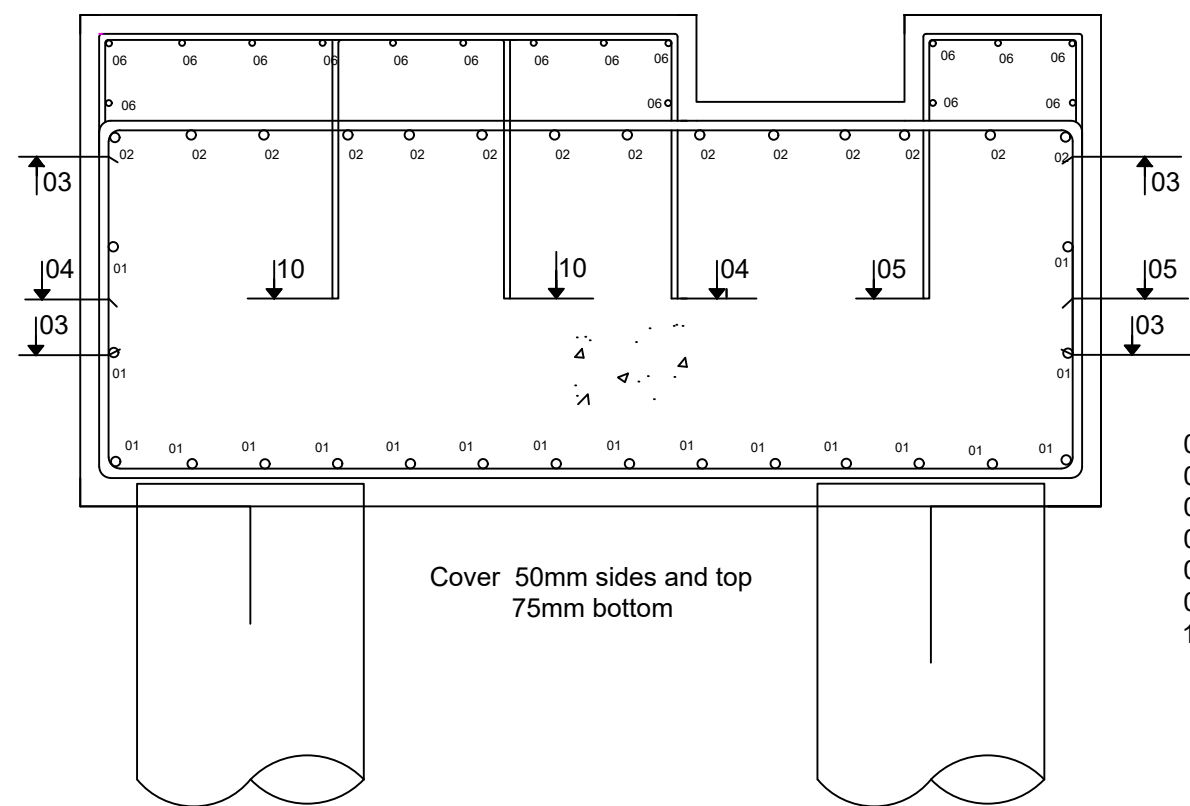
Pile Cap - Plan View A - B
Scale 1:50



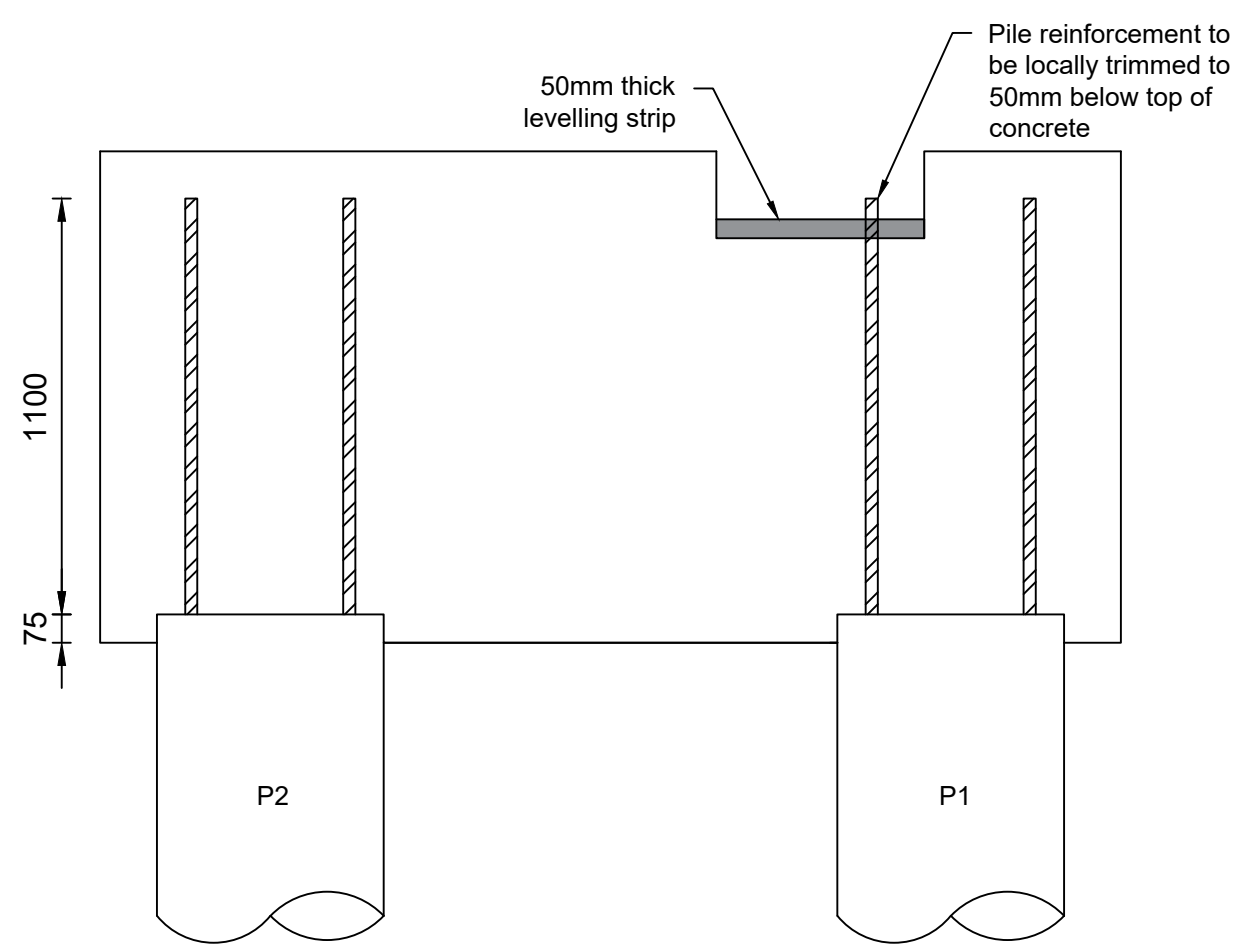
Pile Cap - Plan View B - C
Scale 1:50



Pile Cap - Plan View C
Scale 1:50



Pile Cap - Reinforcement
Scale 1:20



Typical Pile Reinforcement Section
Scale 1:20

Reinforcement schedule											
Page 1 of 1											
Member	Bar mark	Type and size	No. of bars	No. of bars in each	Total no.	Length of each bar* mm	Shape code	A* mm	B* mm	C* mm	Rev letter
Pile Cap	01	H25	2	108	216	6000	00	6000			
	02	H25	2	98	196	6000	00	6000			
	03	H25	2	350	700	4175	21	850	2590	850	
	04	H16	2	175	350	2875	21	700	1520	700	
	05	H16	2	175	350	1750	21	700	410	700	
	06	H16	2	98	192	6000	00	6000			
	07	H25	2	14	28	4250	21	1750	885	1750	
	08	H25	2	14	28	8750	21	4000	885	4000	
	09	H25	2	14	28	2400	00	2400			
	10	H16	2	175	350	1825	21	700	470	700	
	11	H16	2	16	32	2575	11	700	1900		
	12	H16	2	16	32	4075	11	700	3400		
	13	H16	2	16	32	2200	00	2200			
	14	H16	2	4	8	4650	21	1100	2510	1100	
	15	H25	2	18	36	3700	00	3700			
This schedule conforms to BS 8006:2006											
* Specified in multiples of 5 mm.											
Status: P Preliminary T Tender C Construction;											

Pile Cap Bar Bending Schedule

CDM 2015 :

The following presents a designers record of the significant hazards which are considered for the scope of this design. Routine hazards which should be managed by the main contractor are not listed.

Scope of design
The design of the reinforced pile cap of the bebo bridge
Significant hazard assessment

No.	Description
1	Design strength capping beam must be in place before bulk excavation commences
2	
3	
4	

Suggested construction sequence

- Form piling platform
- Install piles
- Trim piles
- Form capping beam

NOTES :

General

All dimensions mm UNO

All elevations mOD UNO

Do not scale, use figured dimensions only

Piling

Piles to be installed in accordance with ICE Specification for piling and embedded retaining walls - 3rd edition (2017) and the requirements of this drawing.

Concrete

Concrete and workmanship (including protection and curing after placement) to be in accordance with EN 206, BS8110 and BS8500.

Concrete for pile cap is C32/40.

Concrete for piles to be a designed mix supplied in accordance with EN 206-1 : 2000. Mix designs to be submitted for acceptance prior to commencement of work. Concrete is of normal weight with nominal maximum aggregate size 20mm, chloride content class Cl 0,20.

In accordance with BRE SD1 (2005) design concrete class is DC-1.

Reinforcing Steel

Ribbed reinforcing bars shall be grade B500B hot rolled and cold worked steel bars conforming to BS10080 and BS4449 and/or shall be cut and bent in accordance with BS8666. The bars shall be obtained from a firm holding a valid CARES (or fully equivalent scheme) certificate of approval. Bars shall be fixed in accordance with BS8110 Part 7. No bar shall contain a flash weld.

Minimum tension lap lengths to steel reinforcement :

Bars

25mm - 1275 mm Sides and Bottom
1700mm Top
16mm - 1100mm Top

Pile General Arrangement

Refer to drawing 2231-001 for piling general arrangement and schedule.

1	2	3	4	5	6
A	Pile Cap Length Revised	RS	JM	05/06/21	
REV	AMENDMENTS	DRAWN	CHECK	DATE	



Client:

Van Elle

Project :

North Littlehampton

Title :

Reinforced Concrete Pile Cap Details

Drawing Status :

FOR COMMENT

DRAWN	EP	DATE	SCALE	DRAWING NUMBER
CHECKED	JM	19/03/21	AS SHOWN	2231 - 002
DATE	MARCH 2021	ORIGINAL SHEET SIZE	A1	REVISION : A