CALCULATIONS

Geobond
PILING & FOUNDATION SOLUTIONS

Head Office: 0870 801 0080
www.geobond.co.uk

Job No: 9715

Date: 1st August 2022

Job Name: 59 Elm Avenue
Ruislip
Middlesex HA4 8PE

Calc Title: Contiguous Pile Wall Design and bearing piles

59 Elm Avenue, Ruislip
Middlesex HA4 8PE

Design for Contiguous Pile Wall & Bearing Piles

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See Piling Contractor

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DESIGN STATUS & ISSUE RECORD

Revision	Status	Description	Design	
			Engineer	Date
	Contract	Design for Contiguous pile wall & Bearing Piles	TP	01/08/22

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DESIGN FOR Ø 350 CONTIGUOUS PILE WALL

1.0 INTRODUCTION

GEOBOND UK Limited has been appointed by Matthew Stylianides of GGM Contractors Ltd to carry out the design and installation of the contiguous pile wall & Foundation piles at the above property in Ruislip, Middlesex, London.

At present we've assumed working from the levels similar to the top of the capping beams/ existing ground level, although the method of working is to be agreed.

It is proposed to support the embankment to the side of the property adjacent to Oak Grove with a contiguous pile retaining wall.

The Contiguous pile wall will comprise of Ø 350 piles at a spacing of 500mm c/c for a length of 14m.

For the bearing/ foundation piles we have allowed for 350mm diameter piles to 15m.

The design calculations are presented under the following headings:

- INPUT DATA
- OUTLINE OF DESIGN
- GROUND CONDITIONS
- CONTIGUOUS PILE WALL DESIGN
  - Geotechnical Design
  - Structural Design

- BEARING PILE DESIGN
- REFERENCES
- APPENDICES
  Fig 1 – Design Line
  Fig 2 – Pile loads
  Fig 3 – Design Sheet
  Fig 4 – Pile Schedule
  Fig 5 – Pile Layout
  CADS PWS Print outs

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2.0 INPUT DATA

The following documents have been received from the client:

(i) Fernhurst Design drawing no. 2022-021_SE01 Rev P1

(ii) STM Environmental & Geotechnical Report Ref: GT-2022-000020 dated May 2022

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3.0 OUTLINE OF DESIGN

- Design is based on ICE SPERW (2007), Eurocode and BS8110.
- Contiguous pile wall shall comprise of ∅350 piles @ 500mm c/c.
- Bearing/ Foundation piles are 350mm diameter to 15m.
- Wall retained height is 1.5m
- Contiguous pile wall is designed to provide both temporary and permanent earth retention.
- Piling platform level for the contiguous pile wall has been taken to be the level of the pavement/ adjacent existing ground level and for the bearing/ foundation piles existing ground level.
- Capping beam to be installed prior to any excavation works for the contiguous piled wall.
- Pile reinforcement bars to project into capping/ pile caps by a minimum of 40D (Where d is the bar diameter).
- In temporary conditions, London clay assumed to exhibit undrained behaviour and in the long term drained behaviour (with effective stress parameters).
- Concrete grade C28/32 DC-2
- 50mm cover to pile reinforcement.

Typical wall sections considered in design are described overleaf;

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CONTIGUOUS PILE WALL (∅ 350mm diameter at 500mm spacing):

Proposed Sequence of Construction:

1. Install contiguous pile wall.
2. Construct RC capping beam.
3. Wait 7 days minimum for concrete in capping beam to cure.
4. Proceed with excavation to general garden formation level (max depth 1.5m).

4.0 GROUND CONDITIONS

Soils information has been provided by STM Environmental Report Ref: GT-2022-000020 dated May 2022 & BGS. Based this information, site stratigraphy may be generalised as shown in table 1 below:

LEVEL (m BGL)	DESCRIPTION	Representative N_{spt} Value
0 – 1m	Made Ground	-
Below 1m	Firm Clay	10 at 2m to 50 at 17m

Table 1 - Generalised Site Stratigraphy

Soil parameters used in design are presented in table 2 overleaf. In table 2;

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SOIL LAYER	**N_{spt}**	**γ (kN/m^3)**	**ϕ' (°)**	**C' (kPa)**	**C_u (kPa)**	**E_u**	**E' (kPa)**
Made Ground	-	18	25	0	-	-	25000
Firm Clay	10 to 50 at 17m	20 (10 sub)	27	0	50 at 2m to 250 at 17m		30000

- Static groundwater level lies at 5m bgl in short term and in the long term 1m bgl is used.

Table 2 – Input soil parameters

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5.0 CONTIGUOUS PILE WALL DESIGN

(i) Geotechnical Design

The geotechnical design involved three stages, which are summarised below;

(i) *Ultimate Limit State (ULS) Analysis* – This involves the use of factored soil parameters to estimate the required embedment of the wall, for overall stability to be maintained. This analysis has been carried out with the 'CADS PWS2' geostructural modelling programme. Analysis also provides information on ultimate bending moments, shear forces and if applicable, ultimate loads on the struts.

(ii) *Serviceability Limit State (SLS) Analysis* – This involves the use of unfactored soil parameters to estimate the lateral displacement of the wall, as well as service bending moments, shear forces and if applicable, service loads on the struts. The analysis has been carried out with the 'CADS PWS2' geostructural modelling programme.

(iii) *Wall Capacity under Vertical Axial Loading* – This is based on the traditional bearing capacity approach for axially loaded piles. However, the wall is assumed to act as a continuous deep strip footing below basement formation level, surrounded by a block of soil, with the assumption of a block type failure mechanism in the ultimate state. In addition, the bearing capacity factor N_c in the London clay is reduced with a reduction factor f, to account for the existence gaps between piles in the wall.

The reduction factor f is expressed as;

$$f = \frac{\pi D}{4S} \qquad \text{----------------- (1)}$$

Where D = pile diameter and S = pile centre to centre spacing. This approach produces an estimate of the axial capacity of the wall per metre run. Multiplying this value by the centre to centre spacing of the piles yields the vertical capacity of an individual pile. See Adekunte (2014) for more detailed information on this methodology.

(ii) Structural Design

The 'CADS PWS2' geostructural modelling programme has also been used to design the reinforcement bars in the piles. See attached output files.

350mm diameter piles at 500mm c/c spacing to a length of 8m.

Retained height 1.5m

Bending Reinforcement
The ULS analysis produces the worst case bending moment for this section;
'CADS PWS' structural design output – for a Ø350 grade C28/35 concrete section with **4 – B16s** and 50mm cover to reinforcement.

Shear Reinforcement
The SLS analysis produces the worse case shear force for this section;
'CADS PWS' structural design output – **provide B10 links or helicals @ 150mm c/c**

The results of the wall analysis and design are presented in the CADS PWS Print out attached.

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WALL SECTION	Maximum Excavation Depth (m)	Required Pile Length for Wall Stability and supporting Vertical Load (m)	Maximum Pile Deflection (mm)	Service Prop / Slab Loads (kN/m run)	Required Steel Reinforcement
Standard	1.5m	8m	10	n/a	4 B16s with B10 helical @ 150mm pitch

- 'CADS PWS2' computer output files for wall lateral stability analysis are also attached to the appendices.

Table 3 – Summary of Results

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6.0 BEARING PILE DESIGN

(i) Geotechnical Design

The geotechnical design involved two stages, which are summarised below;

- *Pile capacity under vertical axial loading.*

Pile Capacity under Vertical Axial Loading

Design is generally based on the traditional bearing capacity approach.

In cohesive layers, ultimate shaft friction capacity is given by the equation:

$Q_s = \alpha * C_u * A_s$ ------------------------- (1)

And ultimate end bearing capacity is given by the equation:

$Q_b = N_c * C_u$ ------------------------- (2)

Where

α = adhesion factor. This is taken to be circa. 0.5 in London clay for CFA piles

C_u = undrained shear strength

A_s = pile shaft surface area

N_c = bearing capacity factor accounting for cohesion. This is taken to be 9 in London Clay.

In cohesionless layers, ultimate shaft friction capacity Q_s is given by the equation:

$$Q_s = k_s \cdot \overline{\sigma'_{vo}} \cdot tan(\delta) \cdot A_s \quad \text{------------------------- (3)}$$

And ultimate end bearing capacity is given by the equation:

$$Q_b = N_q \cdot \sigma'_{v1} \cdot A_b \quad \text{------------------------- (4)}$$

where

$k_s =$ Coefficient of lateral earth pressure.

$\overline{\sigma'_{vo}} =$ Average effective overburden pressure along shaft. (kPa)

$\delta =$ Angle of friction between pile and soil. For concrete piles, δ = 0.75 * ϕ' (Broms, 1966).

$\sigma'_{v1} =$ Effective overburden pressure at toe level. (kPa)

$N_q =$ Bearing capacity factor (after Berezanstev et al., 1961).

(ii) Structural Design

1. Compression Reinforcement:
∅350 Section

Capacity of concrete section under axial compressive loading is given by:

$$Compressive\ SWL \leq \frac{0.4 \times f_{cu} \times A_c}{\gamma_f} \qquad \text{------------- (5)}$$

$\gamma_f =$ 1.5
$f_{cu} =$ 28N/mm^2
$A_c =$ 96223 mm^2

$$SWL \leq \frac{0.4 \times 28 \times 96223}{1.5}$$

$SWL \leq$ 718 KN (o.k.).

Maximum pile load is 500kN which is less than 718kN, therefore Grade C28/35 concrete o.k. Compression reinforcement is not required.

2. Tension (Heave) Reinforcement:
∅350 Section

Heave force is 2 x 3.142 x 0.175 x 50 x 0.5 x 2 = 55kN
Capacity of shaft at 8m is 350kN – see Fig 2 Design Sheet
As 55kN < 350kN therefore okay (Factor of safety 350/55 = 6.3 therefore okay)

Capacity of B20 steel bar is (3.142 x 10^2 x 500/1000) divide by 1.5 = 104kN
As 55kN<104kN therefore okay

Provide B20 central tension (heave) bar to 8m

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7.0 REFERENCES

British Standards Institution (1986), "BS 8004 - Code of Practice for Foundations".

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