Assessment and Technical Investigations

The following gives a summary of the assessment and technical investigations carried out on Redi-Rock Retaining Wall and Free Standing Wall Systems.

Design Considerations

4 Use

4.1 Redi-Rock Retaining Wall and Free Standing Wall Systems are satisfactory for use in constructing retaining and free standing walls founded on granular or concrete foundations, designed by a suitably qualified engineer.

4.2 Correctly designed free standing and retaining walls can be used up to 2.3 m (5 courses) and 5 m high respectively. Walls more than this height are outside the scope of this Certificate.

4.3 Depending on soil parameters, a concrete foundation may be required.

4.4 The BBA has not assessed the systems for supporting parapet loading caused by vehicle collision at the top of the wall. When applicable, this aspect of a design would require separate consideration and approval by Highways England.

4.5 Prior to commencement of the work, the designer must satisfy Highways England technical approval requirements.

4.6 Where appropriate to specific projects, the designer should provide the main contractor with:

- working drawings
- calculations
- specification for fill material
- acceptable moisture content of fill material at time of placement
- sequence of placing fill material
- tolerance on the position of finished line of the wall.

5 Practicability of installation

The systems are designed to be installed by a competent general builder, or a contractor, experienced with these types of systems.

6 Design

6.1 Retaining wall systems constructed using Redi-Rock blocks must be designed to resist the loads determined in accordance to BS EN 1997-1 : 2004.

6.2 To evaluate the overall design strength of the wall system, it is necessary to consider the design strength of the connection between the dome and the corresponding recess of the concrete blocks. Shear tests were carried out on the concrete dome, and the characteristic ultimate shear resistance per dome is 70 kN. A material factor of 1.5 in accordance to BS EN 1992-1-1 : 2004 should be applied to the characteristic ultimate shear resistance to give the ultimate resistance of 46.6 kN.

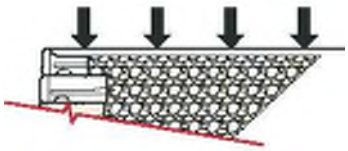
6.3 Redi-Rock International provides a design service which adopts the following methodology to check the suitability of a Redi-Rock wall structure:

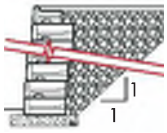
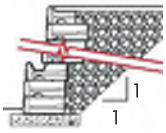
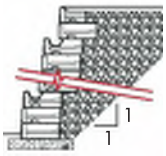
- site survey
- determine characteristic weight of material values for wall, retained and founding soil
- calculate characteristic values of actions for unfavourable and favourable conditions
- calculate design values of above actions
- design against overturning of overall wall structure
- design against sliding of overall wall
- design against bearing failure
- check the overturning and sliding between foundation and the base block
- check subsequent blocks for overturning and shear resistance.

6.4 Example criteria required to achieve a 5 m retaining wall are shown in Table 3.

Table 3 Example criteria for a 5 m retaining wall[1][2]

Load condition
- no back slope
- 12 kPa live load surcharge



Scheme drawings	Wall height (m)	Minimum cover to foundation (mm)	Foundation thickness (mm)
 0 planters	3.66	300	300
 1 planter	4.57	300	300
 2 planters	5.03	450	300

(1) Soil properties: crushed stone with (ø) = 40° over native soil with (ø) = 34°.

(2) Non-reinforced walls with 1040 mm wide blocks and crushed stone backfill and granular foundation.

Note: Information extracted from Redi-Rock design charts.

6.5 Granular material with an assumed (ø) = 30° is used in the foundation to achieve 2.3 m (5 courses) for free standing wall constructions.

6.6 Adequate consideration must be given to the provision of drainage to the wall in accordance with Highways England requirements.

6.7 With correct design and workmanship and by following the recommendations of this Certificate, normally accepted tolerances of line and level for the construction of retaining walls, as defined in BS 8006-1 : 2010, Table 23, can be achieved.

7 Mechanical properties

Tests have shown that blocks used in Redi-Rock Retaining Wall and Free Standing Wall Systems have a sufficient strength and interlocking mechanism to be used as part of a retaining or free standing wall structure.

8 Maintenance

8.1 Blocks may become soiled in time, the rate depending on the finish chosen, degree of exposure, level of atmospheric pollution and the design and detailing of the wall. The appearance may be restored by use of a powerwash.

8.2 Walls must be checked periodically to ensure that there are no signs of cracks or fatigue.

9 Durability

9.1 In the opinion of the BBA, when used and installed in accordance with this Certificate, the wall systems can achieve a design life greater than 120 years. This is based on the assumption that the exposure environment for the concrete is classified as XF2 in accordance with BS 8500-1 : 2015.

9.2 Where concrete wall units are to be embedded in potentially aggressive soils, the guidance given in BRE Special Digest 1 : 2005 should be followed.

10 General

10.1 The execution of Redi-Rock Retaining Wall Systems must be carried out in accordance with the Certificate holder's Installation Guide.

10.2 It is important that the first course of concrete block units is laid accurately to the correct line and level to avoid compounding errors in alignment as the wall is built.

10.3 To lay the gravity-retaining wall, the foundation should be made with compacted crushed stone or graded granular fill, to provide a safe bearing pressure of 250 $kN \cdot m^{-2}$.

11 Procedure

Retaining wall structure

11.1 Detailed information on installation of Redi-Rock Retaining Wall Systems can be found in the Certificate holder's Installation Guide.

11.2 The blocks are laid on a levelling pad composed of either well-graded, good compactible material or a suitable concrete foundation (not less than RC40 in accordance with BS 8500-2 : 2015) laid to the correct level for the first course, with the aesthetic surface facing out and the front edges tight together. The first course of the wall units are laid and checked for level and alignment. The blocks should be in full contact with the foundation pad.

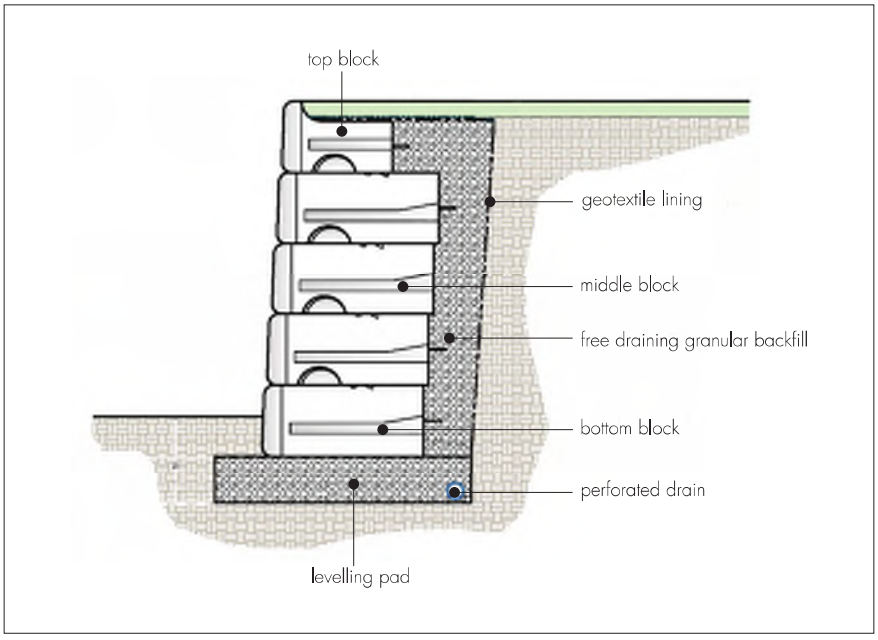
11.3 The next course of wall units is installed in an offset position from the seams of blocks below. The blocks are placed fully forward so the dome and corresponding recess are engaged.

11.4 A perforated drainpipe is laid behind the base course of blocks, surrounded by a minimum of 150 mm of pipe gravel.

11.5 Suitable backfill of a maximum diameter of 75 mm, followed by selected granular drainage fill with a maximum diameter of 20 mm in a minimum depth of 300 mm are placed behind the blocks up to the top level of the wall. Both the backfill and the granular fill are compacted to a 95% standard proctor density within 2% of its optimum moisture content.

11.6 The general construction procedure is repeated until the required level for the top unit is reached. Construction tolerance at the wall face is 2 degrees vertically and 25 mm in 3 m horizontally. A typical cross-section of a retaining wall is shown in Figure 5.

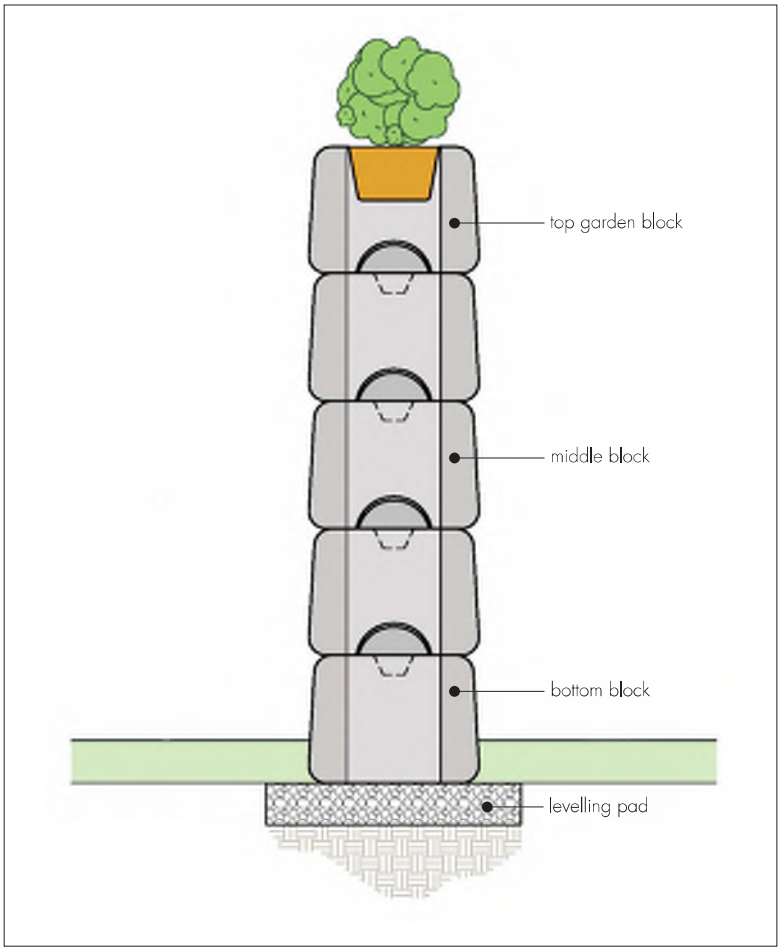
Figure 5 Typical construction



Free standing wall structure

11.7 Blocks designed to be used in a free standing wall system are stacked on top of each other on a compacted base founded a minimum of 150 mm below the finished ground level (see Figure 6).

Figure 6 Typical construction



11.8 Depending on intended shape, straight or curved blocks, or a combination of both, are used.

11.9 Free standing blocks can be installed on a gravity-retaining wall to meet clients demand and special project specification.

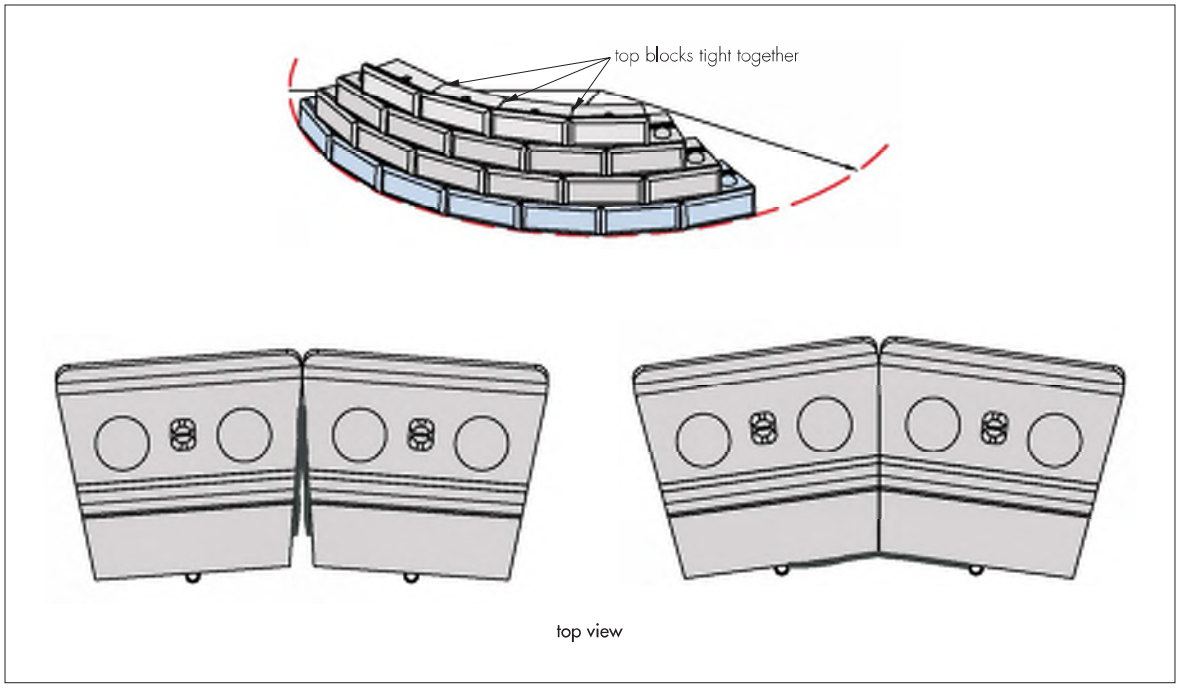
11.10 Coping stone is grouted to free standing wall systems with a minimum of two beads of construction adhesive. Mortar cement may also be used if desired.

Curved wall

11.11 For retaining wall structures, blocks can be laid at varying radii as the edges are tapered[1] (see Figure 7). Owing to the set-back of the retaining wall blocks, the radius of curve will decrease as the height of the wall increases.

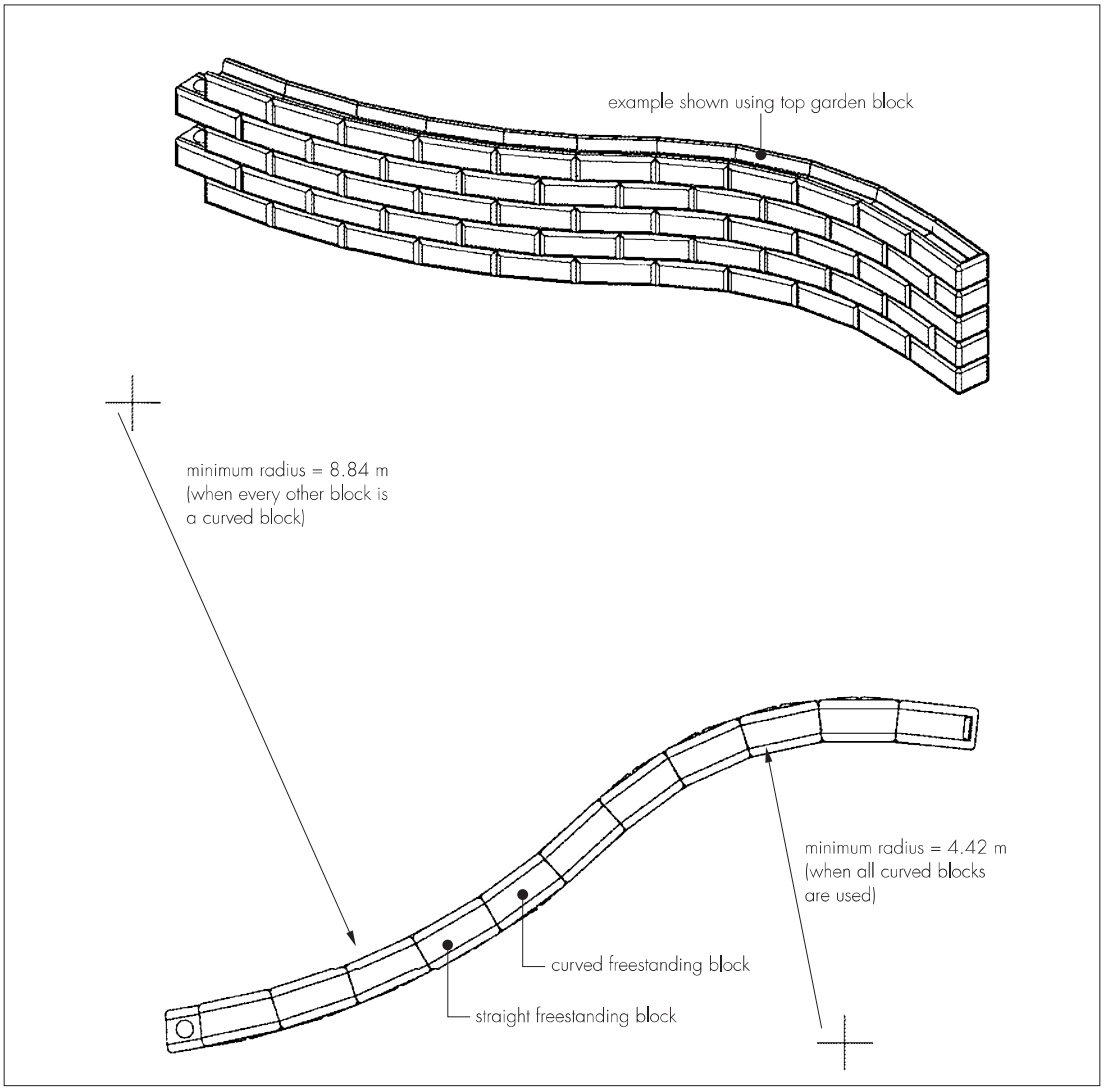
(1) For details of permissible radii achievable for both internal and external curves, and for more information relating to the construction of curved walls, the advice of the Certificate holder should be sought.

Figure 7 Curved retaining wall detail



11.12 For free standing wall structures, the appropriate blocks are selected and laid accordingly. A combination of straight and curved blocks can be used, with a minimum outside radius of 8.8 m when curved and straight blocks are laid alternately. A minimum outside radius of 4.4 m can be achieved when using only curved blocks (see Figure 8).

Figure 8 Curved free standing wall detail



12 Investigations

12.1 The manufacturing process for the concrete modular block was evaluated, including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

12.2 An assessment was made of test data relating to:

- strength of concrete block
- durability
- performance of the retaining wall system under simulation of longitudinal settlement
- interface shear capacity between the blocks.

12.3 An assessment was made of the method of installation to assess the practicability of installation and ease of construction.

12.4 Design methods including partial material factors were assessed in relation to the requirements of BS EN 1997-1 : 2004.

12.5 Dimensional checks were carried out on block units.

Bibliography

BS 8006-1 : 2010 + A1 : 2016 *Code of practice for strengthened/reinforced soils and other fills*

BS 8500-1 : 2015 + A1 : 2016 *Concrete — Complementary British Standard to BS EN 206 — Method of specifying and guidance for the specifier*
BS 8500-2 : 2015 + A1 : 2016 *Concrete — Complementary British Standard to BS EN 206 — Specification for constituent materials and concrete*

BS EN 1992-1-1 : 2004 *Eurocode 2 : Design of concrete structures — General rules and rules for buildings*

BS EN 1997-1 : 2004 *Eurocode 7 : Geotechnical design — General rules*

BS EN ISO 9001 : 2015 *Quality management systems — Requirements*

BRE Special Digest 1 : 2005 *Concrete in aggressive ground : Part 1 : Assessing the aggressive chemical environment*

TD 19/06 Design Manual for Roads and Bridges : *Volume 2, Highway Structures : Design (Substructures and Special Structures) Materials : Section 2, Special Structures : Part 8, Requirement for Road Restraint Systems*

13 Conditions

13.1 This Certificate:

- relates only to the product/system that is named and described on the front page
- is issued only to the company, firm, organisation or person named on the front page — no other company, firm, organisation or person may hold or claim that this Certificate has been issued to them
- is valid only within the UK
- has to be read, considered and used as a whole document — it may be misleading and will be incomplete to be selective
- is copyright of the BBA
- is subject to English Law.

13.2 Publications, documents, specifications, legislation, regulations, standards and the like referenced in this Certificate are those that were current and/or deemed relevant by the BBA at the date of issue or reissue of this Certificate.

13.3 This Certificate will remain valid for an unlimited period provided that the product/system and its manufacture and/or fabrication, including all related and relevant parts and processes thereof:

- are maintained at or above the levels which have been assessed and found to be satisfactory by the BBA
- continue to be checked as and when deemed appropriate by the BBA under arrangements that it will determine
- are reviewed by the BBA as and when it considers appropriate.

13.4 The BBA has used due skill, care and diligence in preparing this Certificate, but no warranty is provided.

13.5 In issuing this Certificate, the BBA is not responsible and is excluded from any liability to any company, firm, organisation or person, for any matters arising directly or indirectly from:

- the presence or absence of any patent, intellectual property or similar rights subsisting in the product/system or any other product/system
- the right of the Certificate holder to manufacture, supply, install, maintain or market the product/system
- actual installations of the product/system, including their nature, design, methods, performance, workmanship and maintenance
- any works and constructions in which the product/system is installed, including their nature, design, methods, performance, workmanship and maintenance
- any loss or damage, including personal injury, howsoever caused by the product/system, including its manufacture, supply, installation, use, maintenance and removal
- any claims by the manufacturer relating to CE marking.

13.6 Any information relating to the manufacture, supply, installation, use, maintenance and removal of this product/system which is contained or referred to in this Certificate is the minimum required to be met when the product/system is manufactured, supplied, installed, used, maintained and removed. It does not purport in any way to restate the requirements of the Health and Safety at Work etc. Act 1974, or of any other statutory, common law or other duty which may exist at the date of issue or reissue of this Certificate; nor is conformity with such information to be taken as satisfying the requirements of the 1974 Act or of any statutory, common law or other duty of care.

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Countryside Partnerships

Redi-Rock Retaining Wall Design

Project Number: 0121-265

Author: Stephen Webster | CEng MICE

May 2023

Revision B

Contents

Introduction & Project Info

This report details the design of a Redi-Rock type retaining wall for a project at Blue Hills Estate Farm, Birkenshaw for client Countryside Partnerships. This report includes the results and a summary of the technical calculations, an overview of the proposed design and any limitations and assumptions made.

Construction Sequence

The retained soils will be cut back to a temporary stable slope as determined by the Contractor. The foundations will be poured, Redi-Rock units will be installed onto the foundations.

Proposed Retaining Wall System

The retaining wall system proposed is a proprietory system called Redi-Rock. These concrete blocks have been designed to lock together to form a retaining wall face with 41mm steps at each block, forming a 5 degree slope. The mass of the interlocking concrete blocks is sufficient to resist the sliding and overturning forces of the retained material.

Design Parameters

The following information provided by the client (Sam Buswell – Countryside Partnerships) has been used to determine the correct design parameters;

- Site Layout Drawings
- Site Investigation Report

The design parameters and levels used for the soils have been taken from information provided by the client. The following assumptions have been made;

- The Site Investigation Report shows one borehole in the vicinity of the proposed wall, WS09. This borehole shows that the proposed base of the new wall will likely be founded in firm-stiff clay of intermediate to high plasticity. This material has been assumed to extend a reasonable depth below the level of the proposed foundations.
- Note the higher section of the wall is assumed to be founded in the stiffer clay material as indicated in the SI report. Since this is based on one borehole only care must be taken during construction that this is accurate. If this found to be inaccurate during construction, an alteration to the design will be necessary.
- All soil design parameters have been taken as reasonably conservative values based on typical firm and stiff clay soils.
- Bearing capacity at the base of the higher sections of wall has been taken as >150kN/m^2 based on the SPT values of >20 at this depth. If this is found to be inaccurate during construction, an alteration to the design will be necessary

- A perforated drain should be installed to the rear of the wall to allow any trapped water to escape without allowing any hydrostatic pressures to develop.
- Surcharges of 5.0kN/m^2 have been allowed for on the top of the retaining wall. This is deemed to be conservative for the location as the area on top of the wall will not be accessible by vehicles and will be garden/soft landscaping.
- It is assumed that the slope is generally stable. No assessment has been made of the global stability of the slope and wall system.
- Note that cranes, heavy plant and equipment must not be placed immediately behind the wall either during or after construction of the wall.

If any of the above details are found to be incorrect, the construction of the wall must cease and the design re-evaluated.

Redi-Rock Wall Design

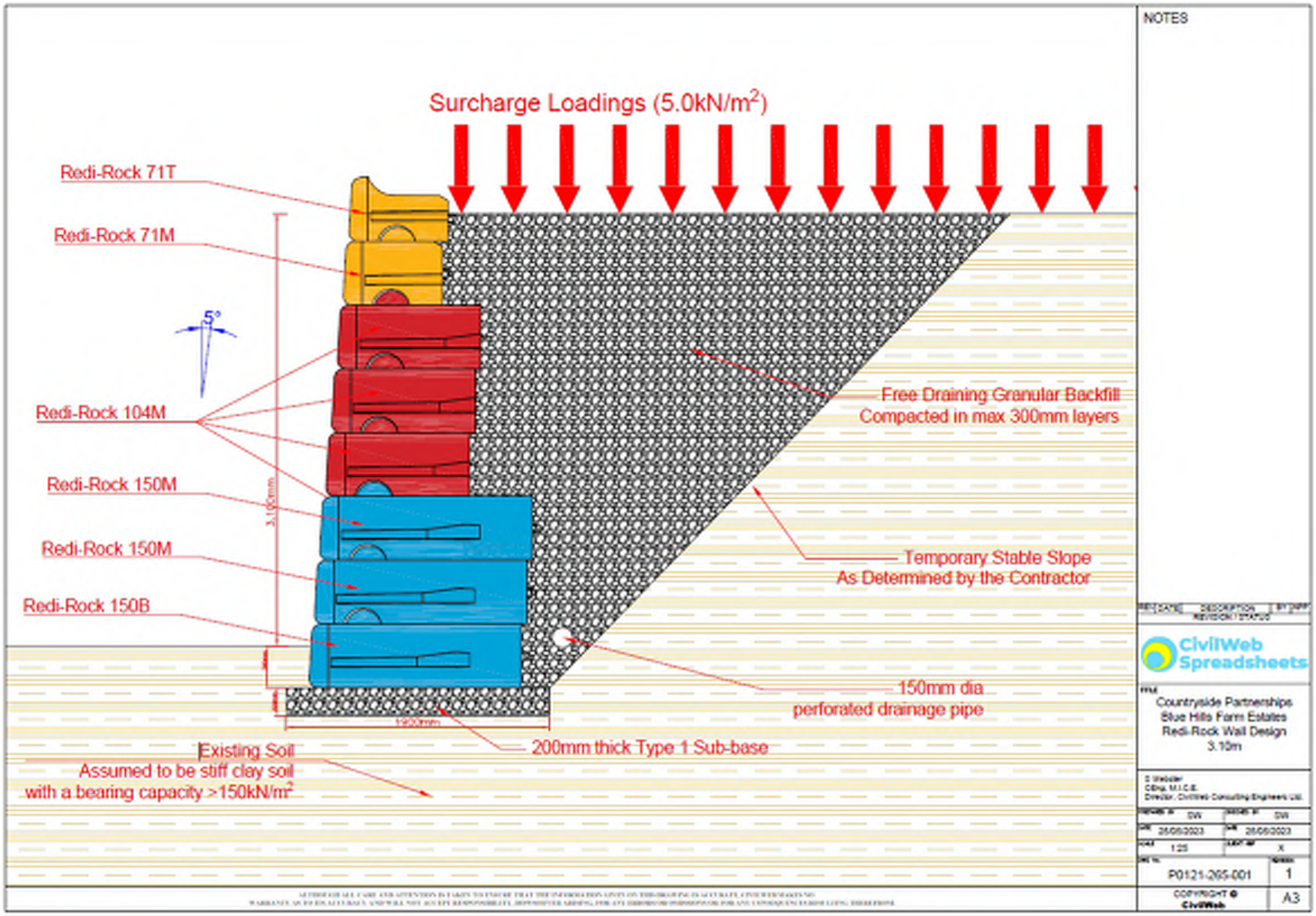
The design of the retaining wall was completed using GEO5 Redi-Rock Wall Design software. All calculations are completed in accordance with BS EN 1997, BS EN 1993, BS EN 1996 and other relevant UK and European standards.

The results of this analysis are presented in the table below;

Retained Height (m)	Required Foundation
up to 3.10	1900mm wide x 200mm deep (Sub-Base)

Full details of the design calculations are presented in Annex A.

Appendix A – Redi-Rock Retaining Wall Detail



Analysis of Redi Rock wall

Input data

Task : Redi-Rock Wall Design
Part : Blue Hills Estate Farm
Description : 3.10m Height
Customer : Countryside Partnerships
Author : SW
Date : 24/10/2023
Project number : 0121-265

Settings

United Kingdom - EN 1997

Wall analysis

Verification methodology :	according to EN 1997
Active earth pressure calculation :	Coulomb
Passive earth pressure calculation :	Caquot-Kerisel
Earthquake analysis :	Mononobe-Okabe
Shape of earth wedge :	Calculate as skew
Allowable eccentricity :	0.333
Internal stability :	Standard - straight slip surface
Reduction coeff. of contact first block - base :	1.00
Design approach :	1 - reduction of actions and soil parameters

Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)					
Permanent design situation					
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]
Partial factor on Poisson's ratio :	γ_v =	1.00	[–]	1.00	[–]

Partial factors for variable actions			
Permanent design situation			
Factor for combination value :	ψ_0 =	0.70	[–]
Factor for frequent value :	ψ_1 =	0.50	[–]
Factor for quasi-permanent value :	ψ_2 =	0.30	[–]

Blocks

No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m³]
1	Block 28	457.2	711.2	18.85
2	Block 41	457.2	1028.7	18.85
3	Block 60	457.2	1524.0	20.42
4	Top block 24 straight	457.2	609.6	16.97

No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m³]
5	Planter 41	457.2	1028.7	18.85
6	Planter 60	457.2	1524.0	17.59
7	Top block 28	457.2	711.2	18.85
8	Top block 41	457.2	1028.7	18.85
9	Top block 24 straight garden	457.2	609.6	12.57
10	Block R-5236 HC	914.4	1320.8	17.28
11	Block R-7236 HC	914.4	1828.8	17.28
12	Block R-9636 HC	914.4	2438.4	17.28
13	Block R-41 HC	457.2	1028.7	17.28

No.	Description	Min. shear strength F_{min} [kN/m]	Max. shear strength F_{max} [kN/m]	Friction f [°]
1	Block 28	88.45	164.56	44.00
2	Block 41	88.45	164.56	44.00
3	Block 60	88.45	164.56	44.00
4	Top block 24 straight	88.45	164.56	44.00
5	Planter 41	88.45	164.56	44.00
6	Planter 60	88.45	164.56	44.00
7	Top block 28	88.45	164.56	44.00
8	Top block 41	88.45	164.56	44.00
9	Top block 24 straight garden	88.45	164.56	44.00
10	Block R-5236 HC	66.40	175.13	44.00
11	Block R-7236 HC	66.40	175.13	44.00
12	Block R-9636 HC	66.40	175.13	44.00
13	Block R-41 HC	78.19	188.35	37.00

Setbacks

No.	Setback s [mm]
1	0.254
2	9.525
3	41.275
4	238.125
5	422.275

Geometry

No. group	Description	Count	Setback s [mm]
1	Block 60	3	41.3
2	Block 41	3	41.3
3	Block 28	1	41.3
4	Top block 28	1	-

Base

Geometry

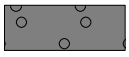
Upper setback a_1 = 0.20 m
Lower setback a_2 = 0.20 m
Height h = 0.20 m

Width b = 1.90 m

Material

Soil creating foundation - Granular Fill

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]	γ_{su} [kN/m³]	δ [°]
1	Granular Fill		38.50	0.00	21.00	11.00	10.00
2	Clay with high or very high plasticity (CH, CV, CE), firm consistency		15.00	5.00	20.50	10.50	10.00
3	Clay with high or very high plasticity (CH, CV, CE), very stiff consistency, Sr > 0.8		15.00	18.00	20.50	10.50	10.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

Granular Fill

Unit weight : γ = 21.00 kN/m³
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.50 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 10.00 °
Saturated unit weight : γ_{sat} = 21.00 kN/m³

Clay with high or very high plasticity (CH, CV, CE), firm consistency

Unit weight : γ = 20.50 kN/m³
Stress-state : effective
Angle of internal friction : φ_{ef} = 15.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Angle of friction struc.-soil : δ = 10.00 °
Saturated unit weight : γ_{sat} = 20.50 kN/m³

Clay with high or very high plasticity (CH, CV, CE), very stiff consistency, Sr > 0.8

Unit weight : γ = 20.50 kN/m³
Stress-state : effective
Angle of internal friction : φ_{ef} = 15.00 °
Cohesion of soil : c_{ef} = 18.00 kPa
Angle of friction struc.-soil : δ = 10.00 °
Saturated unit weight : γ_{sat} = 20.50 kN/m³

Backfill

Assigned soil : Granular Fill
Slope = 45.00 °

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	3.10	0.00 .. 3.10	Clay with high or very high plasticity (CH, CV, CE), firm consistency	
2	-	3.10 .. ∞	Clay with high or very high plasticity (CH, CV, CE), very stiff consistency, Sr > 0.8	

Terrain profile

Terrain behind the structure is flat.
Depth of terrain below the top of wall h = 0.36 m.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [kN/m²]	Mag.2 [kN/m²]	Ord.x x [m]	Length l [m]	Depth z [m]
1	Yes		variable	5.00				on terrain

No.	Name
1	Surcharge

Resistance on front face of the structure

Resistance on front face of the structure: at rest
Soil on front face of the structure - Clay with high or very high plasticity (CH, CV, CE), very stiff consistency, Sr > 0.8
Soil thickness in front of structure h = 0.50 m

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : permanent
Reduction of soil/soil friction angle : do not reduce

Verification No. 1

Pressure at rest on front face of the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	K_r	Comment
1	0.30	0.00	15.00	18.00	20.50	0.741	
2	0.00	89.61(80.00)	15.00	18.00	20.50	0.741	MODIFIED
3	0.20	0.00	15.00	18.00	20.50	0.741	

Pressure at rest distribution on front face of the structure

Layer No.	Start [m] End [m]	σ_z [kPa]	σ_w [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.30	6.15	0.00	4.56	4.56	0.00
2	0.30	6.15	0.00	6.11	0.79	6.06
	0.30	6.18	0.00	6.14	0.80	6.08
3	0.30	6.18	0.00	4.58	4.58	0.00
	0.50	10.25	0.00	7.60	7.60	0.00

Active pressure behind the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	δ_d [°]	K_a	Comment
1	0.07	0.00	38.50	0.00	21.00	10.00	0.218	
2	0.03	25.75	38.50	0.00	21.00	38.50	0.535	
3	0.46	25.75	38.50	0.00	21.00	38.50	0.535	
4	0.53	-3.44	38.50	0.00	21.00	10.00	0.197	
5	0.84	25.75	38.50	0.00	21.00	38.50	0.535	
6	1.05	-3.44	38.50	0.00	21.00	10.00	0.197	
7	0.13	25.75	38.50	0.00	21.00	38.50	0.535	
8	0.20	25.75	38.50	0.00	21.00	38.50	0.535	

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	δ_d [°]	K_a	Comment
9	0.20	0.00	15.00	18.00	20.50	10.00	0.533	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_W [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.07	1.41	0.00	0.31	0.30	0.05
2	0.07	1.41	0.00	0.76	0.33	0.68
	0.10	2.04	0.00	1.09	0.47	0.98
3	0.10	2.04	0.00	1.09	0.47	0.98
	0.55	11.64	0.00	6.23	2.71	5.61
4	0.55	11.64	0.00	2.29	2.27	0.26
	1.09	22.87	0.00	4.50	4.47	0.51
5	1.09	22.87	0.00	12.25	5.32	11.03
	1.93	40.45	0.00	21.66	9.41	19.51
6	1.93	40.45	0.00	7.96	7.90	0.91
	2.97	62.44	0.00	12.28	12.20	1.40
7	2.97	62.44	0.00	33.43	14.52	30.11
	3.10	65.10	0.00	34.86	15.14	31.40
8	3.10	65.10	0.00	34.86	15.14	31.40
	3.30	69.25	0.00	37.08	16.11	33.40
9	3.30	69.25	0.00	12.46	12.28	2.16
	3.50	73.35	0.00	14.65	14.43	2.54

Pressure distribution from surcharge - Surcharge

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	1.07	0.19
2	0.07	1.07	0.19
3	0.07	1.16	2.41
4	0.10	1.16	2.41
5	0.55	1.16	2.41
6	0.55	0.98	0.11
7	1.09	0.98	0.11
8	1.09	1.16	2.41
9	1.93	1.16	2.41
10	1.93	0.98	0.11
11	2.97	0.98	0.11
12	2.97	1.16	2.41
13	3.10	1.16	2.41
14	3.30	1.16	2.41
15	3.30	2.62	0.46
16	3.50	2.62	0.46

Forces acting on construction - combination 1

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.54	88.18	0.94	1.000	1.000	1.350
FF resistance	-1.89	-0.17	0.01	-0.10	1.000	1.000	1.350
Weight - earth wedge	0.00	-0.31	0.60	1.79	1.000	1.000	1.350
Weight - earth wedge	0.00	-1.85	3.99	1.52	1.000	1.000	1.350
Weight - earth wedge	0.00	-3.10	1.40	1.27	1.000	1.000	1.350
Active pressure	26.88	-1.18	26.50	1.70	1.350	1.350	1.350
Surcharge	4.06	-1.64	4.26	1.57	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 162.38 kNm/m
Overturning moment M_{ovr} = 52.63 kNm/m

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 65.51 kN/m
Active horizontal force H_{act} = 40.49 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Pressure at rest on front face of the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	K_r	Comment
1	0.30	0.00	12.10	14.40	20.50	0.790	
2	0.00	89.61(80.00)	12.10	14.40	20.50	0.790	MODIFIED
3	0.20	0.00	12.10	14.40	20.50	0.790	

Pressure at rest distribution on front face of the structure

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_W [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.30	6.15	0.00	4.86	4.86	0.00
2	0.30	6.15	0.00	6.12	0.84	6.06
	0.30	6.18	0.00	6.14	0.85	6.08
3	0.30	6.18	0.00	4.88	4.88	0.00
	0.50	10.25	0.00	8.10	8.10	0.00

Active pressure behind the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	δ_d [°]	K_a	Comment
1	0.07	0.00	32.47	0.00	21.00	8.43	0.282	
2	0.03	25.75	32.47	0.00	21.00	32.47	0.570	
3	0.46	25.75	32.47	0.00	21.00	32.47	0.570	
4	0.53	-3.44	32.47	0.00	21.00	8.43	0.260	
5	0.84	25.75	32.47	0.00	21.00	32.47	0.570	
6	1.05	-3.44	32.47	0.00	21.00	8.43	0.260	
7	0.13	25.75	32.47	0.00	21.00	32.47	0.570	

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	δ_d [°]	K_a	Comment
8	0.20	25.75	32.47	0.00	21.00	32.47	0.570	
9	0.20	0.00	12.10	14.40	20.50	8.07	0.599	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [m] End [m]	σ_z [kPa]	σ_w [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.07	1.41	0.00	0.40	0.39	0.06
2	0.07	1.41	0.00	0.80	0.42	0.68
	0.10	2.04	0.00	1.16	0.61	0.99
3	0.10	2.04	0.00	1.16	0.61	0.99
	0.55	11.64	0.00	6.64	3.49	5.64
4	0.55	11.64	0.00	3.03	3.01	0.26
	1.09	22.87	0.00	5.94	5.92	0.52
5	1.09	22.87	0.00	13.03	6.86	11.08
	1.93	40.45	0.00	23.05	12.14	19.59
6	1.93	40.45	0.00	10.51	10.47	0.91
	2.97	62.44	0.00	16.23	16.16	1.41
7	2.97	62.44	0.00	35.58	18.74	30.25
	3.10	65.10	0.00	37.10	19.54	31.54
8	3.10	65.10	0.00	37.10	19.54	31.54
	3.30	69.25	0.00	39.47	20.79	33.55
9	3.30	69.25	0.00	20.51	20.31	2.88
	3.50	73.35	0.00	22.96	22.74	3.22

Pressure distribution from surcharge - Surcharge

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	1.40	0.21
2	0.07	1.40	0.21
3	0.07	1.50	2.42
4	0.10	1.50	2.42
5	0.55	1.50	2.42
6	0.55	1.29	0.11
7	1.09	1.29	0.11
8	1.09	1.50	2.42
9	1.93	1.50	2.42
10	1.93	1.29	0.11
11	2.97	1.29	0.11
12	2.97	1.50	2.42
13	3.10	1.50	2.42
14	3.30	1.50	2.42
15	3.30	2.96	0.42
16	3.50	2.96	0.42

Forces acting on construction - combination 2

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.54	88.18	0.94	1.000	1.000	1.000
FF resistance	-2.02	-0.17	0.01	-0.10	1.000	1.000	1.000
Weight - earth wedge	0.00	-0.31	0.60	1.79	1.000	1.000	1.000
Weight - earth wedge	0.00	-1.85	3.99	1.52	1.000	1.000	1.000
Weight - earth wedge	0.00	-3.10	1.40	1.27	1.000	1.000	1.000
Active pressure	35.97	-1.16	26.76	1.70	1.000	1.000	1.000
Surcharge	5.21	-1.66	4.27	1.57	1.300	1.300	1.300

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 145.80 kNm/m
Overturning moment M_{ovr} = 52.62 kNm/m

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 48.33 kN/m
Active horizontal force H_{act} = 40.72 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Pressure at rest on front face of the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	K_r	Comment
1	0.30	0.00	15.00	18.00	20.50	0.741	

Pressure at rest distribution on front face of the structure

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_W [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.30	6.15	0.00	4.56	4.56	0.00

Active pressure behind the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	δ_d [°]	K_a	Comment
1	0.07	0.00	38.50	0.00	21.00	10.00	0.218	
2	0.03	25.75	38.50	0.00	21.00	38.50	0.535	
3	0.46	25.75	38.50	0.00	21.00	38.50	0.535	
4	0.53	-3.44	38.50	0.00	21.00	10.00	0.197	
5	0.84	25.75	38.50	0.00	21.00	38.50	0.535	
6	1.17	-3.44	38.50	0.00	21.00	10.00	0.197	
7	0.20	-3.44	38.50	0.00	21.00	10.00	0.197	
8	0.00	-3.44	15.00	18.00	20.50	10.00	0.512	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [m] End [m]	σ_z [kPa]	σ_w [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.07	1.41	0.00	0.31	0.30	0.05
2	0.07	1.41	0.00	0.76	0.33	0.68
	0.10	2.04	0.00	1.09	0.47	0.98
3	0.10	2.04	0.00	1.09	0.47	0.98
	0.55	11.64	0.00	6.23	2.71	5.61
4	0.55	11.64	0.00	2.29	2.27	0.26
	1.09	22.87	0.00	4.50	4.47	0.51
5	1.09	22.87	0.00	12.25	5.32	11.03
	1.93	40.45	0.00	21.66	9.41	19.51
6	1.93	40.45	0.00	7.96	7.90	0.91
	3.10	65.10	0.00	12.80	12.72	1.46
7	3.10	65.10	0.00	12.80	12.72	1.46
	3.30	69.21	0.00	13.61	13.52	1.55
8	3.30	69.21	0.00	10.03	9.96	1.14
	3.30	69.25	0.00	10.05	9.98	1.15

Pressure distribution from surcharge - Surcharge

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	1.07	0.19
2	0.07	1.07	0.19
3	0.07	1.16	2.41
4	0.10	1.16	2.41
5	0.55	1.16	2.41
6	0.55	0.98	0.11
7	1.09	0.98	0.11
8	1.09	1.16	2.41
9	1.93	1.16	2.41
10	1.93	0.98	0.11
11	3.10	0.98	0.11
12	3.30	0.98	0.11
13	3.30	2.54	0.29
14	3.30	2.54	0.29

Forces acting on construction - combination 1

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.48	80.20	0.74	1.000	1.000	1.350
FF resistance	-0.68	-0.10	0.00	0.00	1.000	1.000	1.350
Weight - earth wedge	0.00	-1.65	3.99	1.32	1.000	1.000	1.350
Weight - earth wedge	0.00	-2.90	1.40	1.07	1.000	1.000	1.350
Active pressure	23.41	-1.14	16.21	1.41	1.350	1.350	1.350
Surcharge	3.48	-1.69	3.42	1.31	1.500	1.500	1.500

Verification of most stressed block No. 1

Check for overturning stability

Resisting moment M_{res} = 103.45 kNm/m
Overturning moment M_{ovr} = 44.67 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 89.57 kN/m
Active horizontal force H_{act} = 36.14 kN/m

Joint for verification is SATISFACTORY

Pressure at rest on front face of the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	K_r	Comment
1	0.30	0.00	12.10	14.40	20.50	0.790	

Pressure at rest distribution on front face of the structure

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_W [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.30	6.15	0.00	4.86	4.86	0.00

Active pressure behind the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	δ_d [°]	K_a	Comment
1	0.07	0.00	32.47	0.00	21.00	8.43	0.282	
2	0.03	25.75	32.47	0.00	21.00	32.47	0.570	
3	0.46	25.75	32.47	0.00	21.00	32.47	0.570	
4	0.53	-3.44	32.47	0.00	21.00	8.43	0.260	
5	0.84	25.75	32.47	0.00	21.00	32.47	0.570	
6	1.17	-3.44	32.47	0.00	21.00	8.43	0.260	
7	0.20	-3.44	32.47	0.00	21.00	8.43	0.260	
8	0.00	-3.44	12.10	14.40	20.50	8.07	0.580	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_W [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.07	1.41	0.00	0.40	0.39	0.06
2	0.07	1.41	0.00	0.80	0.42	0.68
	0.10	2.04	0.00	1.16	0.61	0.99
3	0.10	2.04	0.00	1.16	0.61	0.99
	0.55	11.64	0.00	6.64	3.49	5.64
4	0.55	11.64	0.00	3.03	3.01	0.26
	1.09	22.87	0.00	5.94	5.92	0.52
5	1.09	22.87	0.00	13.03	6.86	11.08
	1.93	40.45	0.00	23.05	12.14	19.59
6	1.93	40.45	0.00	10.51	10.47	0.91
	3.10	65.10	0.00	16.92	16.85	1.47
7	3.10	65.10	0.00	16.92	16.85	1.47
	3.30	69.21	0.00	17.99	17.92	1.56

Layer No.	Start [m] End [m]	σ_z [kPa]	σ_w [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
8	3.30	69.21	0.00	18.27	18.21	1.47
	3.30	69.25	0.00	18.29	18.23	1.47

Pressure distribution from surcharge - Surcharge

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	1.40	0.21
2	0.07	1.40	0.21
3	0.07	1.50	2.42
4	0.10	1.50	2.42
5	0.55	1.50	2.42
6	0.55	1.29	0.11
7	1.09	1.29	0.11
8	1.09	1.50	2.42
9	1.93	1.50	2.42
10	1.93	1.29	0.11
11	3.10	1.29	0.11
12	3.30	1.29	0.11
13	3.30	2.89	0.23
14	3.30	2.89	0.23

Forces acting on construction - combination 2

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.48	80.20	0.74	1.000	1.000	1.000
FF resistance	-0.73	-0.10	0.00	0.00	1.000	1.000	1.000
Weight - earth wedge	0.00	-1.65	3.99	1.32	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.90	1.40	1.07	1.000	1.000	1.000
Active pressure	30.79	-1.13	16.29	1.41	1.000	1.000	1.000
Surcharge	4.55	-1.68	3.44	1.31	1.300	1.300	1.300

Verification of most stressed block No. 1

Check for overturning stability

Resisting moment M_{res} = 94.70 kNm/m
Overturning moment M_{ovr} = 44.69 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 84.59 kN/m
Active horizontal force H_{act} = 35.97 kN/m

Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [–]	Stress [kPa]
1	18.90	169.31	39.82	0.059	100.98
2	19.79	136.35	40.49	0.076	84.70

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [–]	Stress [kPa]
3	26.98	126.49	40.72	0.112	85.86
4	26.98	126.49	40.72	0.112	85.86

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	13.56	124.94	29.05

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force $e = 0.076$
Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom $\sigma = 120.53$ kPa
Bearing capacity of foundation soil $R_d = 150.00$ kPa

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Annexes

SOCOTEC UK Limited
29 Rufford Court
Woolston, Warrington
Cheshire
WA1 4RF, United Kingdom
Telephone: 01925 286220
Laboratory Testing At: Carcroft Laboratory

Equivalent CBR Value derived from Plate Bearing Test

TEST REPORT

UKAS TESTING 0001

Client Details

Client: VISTRY PARTNERSHIPS(London Contracting OU4002):
Address: Broadway Chambers,
2 Broadway

E15 4QS
Project: Blue Hills Farm

Code: P231964

Report Details

Report No: PLT:NOR23-01661-S002
Date of Issue: 18/09/2023
Issue No: 1
Recipients:

Signature

For and on behalf of SOCOTEC UK Limited
Certified that testing was carried out in accordance with the test methods identified herein. This test report may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Matthew Cooper - Senior Technician
For and on behalf of SOCOTEC UK Limited

Testing Details

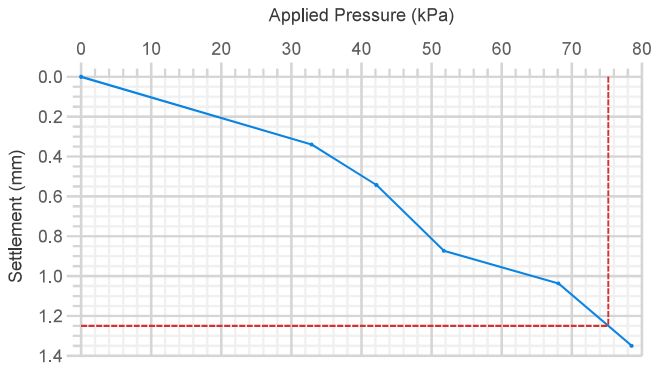
Date Tested:	15/09/2023	**Weather:**	Dry, Overcast
Field Test Methods:	DIHM 301/IAN73/06 Rev 1 (2009)		
General Location:	Blue Hills Farm		
Location:	Retaining Wall 1 re - test		
Supplier:		**Source:**	
Material:	Brown Clay		
Layer Thickness (mm):	Data Not Supplied	**Depth of Test (mm):**	Data Not Supplied
Kentledge:	15 Tonne Excavator	**Plate Diameter (mm):**	450

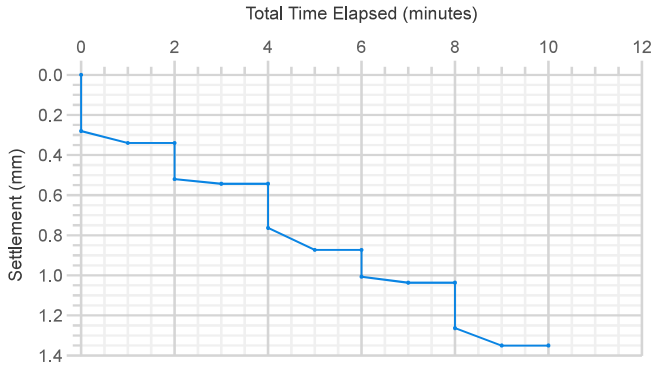
Results

Pressure at 1.25mm Deformation (kPa): 75.2
Modulus of Subgrade Reaction (MN/m²/m): 37.5
Equivalent CBR by Plate Loading (%): 5.1

Load Increments

Applied Load (kN)	Applied Pressure (kPa)	Average Plate Settlement (mm)
5.23	32.9	0.34
6.70	42.1	0.54
8.23	51.7	0.87
10.83	68.1	1.04
12.49	78.5	1.35





Comments

Depth of test is relative to existing ground level at the time of testing.
The results relate to the item(s) tested only. Opinions and interpretations expressed herein are outside of the scope of our UKAS accreditation.

SOCOTEC UK Limited
29 Rufford Court
Woolston, Warrington
Cheshire
WA1 4RF, United Kingdom
Telephone: 01925 286220
Laboratory Testing At: Carcroft Laboratory

Equivalent CBR Value derived from Plate Bearing Test

TEST REPORT

UKAS TESTING 0001

Client Details

Client: VISTRY PARTNERSHIPS(London Contracting OU4002):

Address: Broadway Chambers,
2 Broadway

E15 4QS

Project: Blue Hills Farm

Code: P231964

Report Details

Report No: PLT:NOR23-01661-S003

Date of Issue: 18/09/2023

Issue No: 1

Recipients:

Signature

For and on behalf of SOCOTEC UK Limited
Certified that testing was carried out in accordance with the test methods identified herein. This test report may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Matthew Cooper - Senior Technician
For and on behalf of SOCOTEC UK Limited

Testing Details

Date Tested:	15/09/2023	**Weather:**	Dry, Overcast
Field Test Methods:	DIHM 301/IAN73/06 Rev 1 (2009)		
General Location:	Blue Hills Farm		
Location:	Retaining Wall 2		
Supplier:		**Source:**	
Material:	Brown Clay		
Layer Thickness (mm):	Data Not Supplied	**Depth of Test (mm):**	Data Not Supplied
Kentledge:	15 Tonne Excavator	**Plate Diameter (mm):**	450

Results

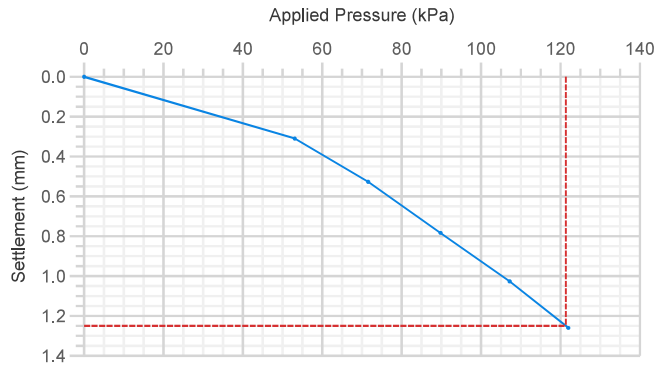
Pressure at 1.25mm Deformation (kPa): 121

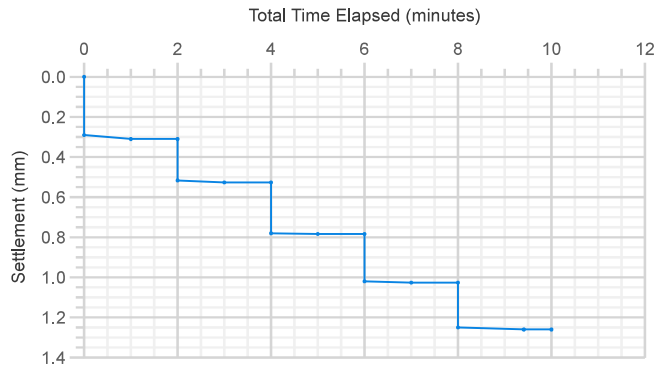
Modulus of Subgrade Reaction (MN/m²/m): 60.5

Equivalent CBR by Plate Loading (%): 12

Load Increments

Applied Load (kN)	Applied Pressure (kPa)	Average Plate Settlement (mm)
8.44	53.1	0.31
11.38	71.6	0.53
14.28	89.8	0.78
17.05	107	1.03
19.40	122	1.26





Comments

Depth of test is relative to existing ground level at the time of testing.
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Groundshire Limited, Littleburn House, Littleburn Industrial Estate, Langley Moor, DURHAM, DH7 8HJ
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E-mail: enquiries@groundshire.com
www.groundshire.com

SPECIFICATION V4

TREATMENT OF SHALLOW MINE WORKINGS AND MINE SHAFTS BY DRILLING AND GROUTING

SITE: Blue Hills Farm, Birkenshaw, BD11 4DU

REF: 13813

DATE: 24/05/2024

Site Specific Information

Source of Information:	Arc Environmental CMRA Ref: 24-054.01L Grid Reference: 420011, 427700
Summary of SI Boreholes:	RBH3 RH c1.6m, coal c1.6m to c1.9m, broken ground c10.6m to c12.0m RBH4 RH c4.5m, broken ground c9.0m to c11.0m RBH5 RH c4.5m, broken ground c10.6m to c11.5m
Target Seam Name (if known):	Third Brown Metal or Middleton Little coal seam
Target Depth:	~15m
Grout Hole Drawing No:	13813-003

Treatment of Shallow Mine Workings

Drilling Rig

Drilling will be carried out by rotary hydraulic rigs using water flush.

Perimeter Drilling – General

Perimeter holes will be vertical, 75mm in diameter and taken to a depth of 0.5m below the floor of the seam or workings. Casing will be inserted through the overburden as necessary.

Holes will be drilled at 6m intervals 3m outside the footprint of the buildings and a grout curtain formed subsequently to prevent leakage of grout outside the required treatment zones and to allow for the angle of draw effect of crown hole development through the overburden. Gravity pressure will be used on the perimeter grouting.

Where necessary, the spacing of perimeter holes will be reduced to 3m.

Inclined drilling will replace vertical drilling where necessary.

Infill Drilling – General

Primary infill holes will be drilled inside the perimeter holes on a 6m horizontal square grid and where the strata are proved to have been subject to legacy mining or where excessive quantities of grout are subsequently injected, secondary holes will be put down on a domino five pattern, midway between the primaries, forming a 4.25m grid.

Where grout takes on the secondary grid holes are excessive, further boreholes will be drilled between the primary and secondary infill holes forming a localised 3m grid.

Inclined drilling will replace vertical drilling where necessary.

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Perimeter Drilling – Roads

Perimeter holes will be vertical, 75mm in diameter and taken to a depth of 0.5m below the floor of the seam or workings. Casing will be inserted through the overburden as necessary.

Holes will be drilled at 3m intervals at the outer edge of the adoptable footpath and a grout curtain formed subsequently to prevent leakage of grout outside the required treatment zones and to allow for the angle of draw effect of crown hole development through the overburden. Gravity pressure will be used on the perimeter grouting.

Infill Drilling – Roads

Infill holes will be drilled inside the perimeter holes on a 6m horizontal square grid and where the strata are proved to have been subject to legacy mining or where the grout take exceeds the theoretical volume of the hole (>0.1 tonne) then further boreholes will be drilled between the primary infill holes forming a localised 3m grid.

At this site we have determined that a full 3m grid will be drilled, regardless of the findings of the primary boreholes or of grout takes in the primary boreholes.

Inclined drilling will replace vertical drilling where necessary.

Grout Injection – General

Grout will consist of a 12:1 PFA/cement mixture at a water/solids ratio generally of 0.45 but varied where necessary to suit the prevailing geological conditions.

This blend will give a 28 day strength of more than 1.0 N/mm².

Where large cavities (>0.50m in height) are encountered by the perimeter or infill holes, dry sand or pea-gravel may be added to the grout at the mouth of the hole.

Additionally, in any borehole where the total grout take exceeds 15 tonne with no sign of the hole being completed then consideration shall be given to drilling additional boreholes and / or the addition of dry sand or pea-gravel added to the grout at the mouth of the hole.

Grout will be mixed by loading bulk PFA from the sheeted stockpile into the grout plant by a loading shovel fitted with a weighing device while cement will be added from 25kg bags.

The surrounding areas will be sprayed to minimise dust nuisance.

The grout will be injected by double-acting diaphragm pumps via a grout head screwed to the hole casings or via a packer at a maximum pressure of 15 psi for the infills.

Testing

Grout flow tests and bleed tests will be carried out as necessary.

Grout crushing strengths at 28 days will be determined weekly.

At the conclusion of grouting 6 random holes will be drilled and subjected to grout acceptance testing as a check on the efficacy of the consolidation.

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Treatment Of Mine Shafts

Drilling Rig

The drilling rig shall be one of Groundshire's C6XP rigs or other appropriate plant, using water flush. It shall be suitable of drilling to the depth for the treatment works.

Drilling

The Drilling Crew will be harnessed and secured to an anchor point outside the influence of the collapse zone (rockhead has already been established).

The rig will be set up on an appropriate safety platform and a 75mm diameter hole drilled through the shaft fill material to the base of the shaft(s) at 10.5m (Shaft A) and 13m (Shaft B) plus 5m.

If required, casing will then be installed for grout injection purposes or grouting may take place through the drill rods.

It is presently envisaged that two holes will be drilled, with the second hole acting as an injection/test hole, with a third hole drilled as required.

Grout Injection

Grout will consist of a 10:1 PFA/cement mixture at a water/solids ratio generally of 0.4 but varied where necessary to suit the nature of the shaft fill.

This blend will give a 28 day strength of more than 1.0 N/mm².

Grout will be mixed by loading bulk PFA into the grout plant by a loading shovel fitted with a weighing device, cement being added from 25kg bags.

Injection will be by a double-acting diaphragm pump via a grout head screwed on to the casing or the rods and when grout acceptance is complete at the required pressure, the casing or rods will be raised 3m and the procedure repeated until the shaft contents are grouted from the bottom to the surface.

If substantial cavities are found in the fill, pea gravel will be placed in addition to grout injection.

Testing

Grout flow tests and bleed tests will be carried out daily.

Grout crushing strengths at 28 days will be determined weekly.

It is currently envisaged that the second injection hole will act as a test hole, however, should grout take remain high, then a further hole would be drilled and grouted as a check on the efficacy of the consolidation of the shaft fill.

General Information

Gas Monitoring

During the works gas monitors with alarms will be used to check for carbon dioxide, carbon monoxide, oxygen, methane and hydrogen sulphide. Should the alarm be triggered drilling will cease and all personnel will withdraw from the affected working area.

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Working Hours

The plant will typically work from 8.00am to 4.30pm Monday to Thursday and 8.00am until 3.30pm on Friday.

Records

All holes will be referenced on a master plan and colour-coded to indicate whether pillars, cavities or broken strata are encountered.

Daily returns will be completed giving a brief log of each hole, the daily and cumulative totals of drilling, the dry weight of grout injected into each hole with daily and cumulative totals and the type and weight of materials brought to site, again on a daily and cumulative basis.

Supervision

An engineer with more than 10 years' experience will control the work with frequent visits as necessary from a geologist (MSc.,FGS.,MIMMM.). Further back-up if required will be given by a mining engineer (CEng.,MIMMM.).

Environmental Issues

Environmental issues will be managed by a Member of the Institute of Environmental Sciences (MIEnvSc.).

Health & Safety

Health and Safety matters, COSHH and risk assessments will be managed by our Safety Officer.