

The Specialist Element Designer:		Our Client:		Final Client:	
					
PROJECT:		HARTS FARM WAY, BROCKHAMPTON WEST, HAVANT – RSS BUND			
OUR CLIENT:		BURROWS GRAHAM			
PRINCIPAL ENGINEER:		BURROWS GRAHAM			
SPECIALIST DESIGNER:		TAILOR ENGINEERING GROUP LTD			
PROJECT NUMBER:		UK-2309			
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FOREWORD

Burrows Graham requested that Tailor Engineering Group Ltd. (TEG) carry out specialist element design for reinforced soil slopes (RSS) to a bund as an element of the permanent works at Harts Farm Way Havant, Hampshire.

This report does not cover, and it not intended to cover, geotechnical aspects of the development beyond those mentioned above and within this document. For geotechnical recommendations beyond the aforementioned scope, the reader is referred to the Principal Designer and to the full GDR of the scheme.

Specific notes for this revision:

This design report presents a specific geotechnical component such as the reinforced soil slopes. Any solution outside this scope is not covered by this design and TEG should be informed so that a new design can be advised if required.

The Geotechnical Risk Register for the project is presented in Section 9.0. This attempts to close out risks wherever possible, but highlights residual risks, where considered appropriate.

All temporary works associated with the project are outside the scope of this report and associated specifications and drawings.

Further version can be provided and modified to incorporate comments following Client's review.

1.0 INTRODUCTION

The design of the reinforced soil slope has been undertaken by TEG as defined within this design report. The slopes in this scheme, will be combined with reinforcement geosynthetics and erosion control systems to create reinforced soil slopes (RSS) as part of a bund structure.

In this project:

- Burrows Graham (BG) is our Client and Principal Designer
- Principal Contractor is to be confirmed
- RSS Installer is to be confirmed
- Clowes Development (UK) Ltd is the developer (and BG's Client)
- Client's Geotechnical Advisor is to be confirmed
- Tailor Engineering Group Ltd (TEG) is the specialist element designer for the RSS.

The above parties should all read and check this design document before proceeding.

Please advise TEG before proceeding with construction if there are any errors in the scope.

The RSS are forming a screening bund. The RSS are indicated on TEG drawings attached to this document in the Appendix B.

The most onerous cross-sections have been considered in the design as per Appendix A (rev. 0 from 08/02/2023).

For intermediate slope heights the geosynthetic lengths from the higher section should be used.

2.0 SCOPE OF WORKS

1. This report is limited to the design of the geosynthetic reinforcement and it is assumed that the reinforced soil slopes are placed over a suitable formation layer with sufficient strength and stiffness to prevent failure and excess settlement of the RSS.
2. The limits of this element design are the reinforced soil zone extending from the front face of the green faced slope back to the rear of the geosynthetic reinforcement tails, and up to the underside of the surface vertically above the rear of the uppermost reinforcement tail. Deep seated rotational failures are excluded from the scope of TEG design.
3. The RSS will be constructed from Class 2 material to be compacted to 95% of maximum dry density (maximum dry density to be confirmed via compaction testing throughout the works). Compaction is to be in accordance with MCHW Specification for Highway Works, Series 600.
4. Further design and calculations might be required on specific sections and interfaces included but not limited to approach to culverts / other structures, tie-in zones to existing structures, strategic



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services, fences or light posts etc. These specific sections and interfaces are not part of this design report. These details must be considered during the design process. Burrows Graham should advise and provide TEG with further details. If required, dedicated calculation appendixes and detailed drawings would be created in due course to cover these interactions / interfaces.

For the sections mentioned in this design document:

- The RSS are modelled with a slope angle of 26 degrees from horizontal (1 vertical : 2 horizontal) and a flat crest slope; individual geosynthetic lifts are set as 400 mm high.
- Settlement of the structures due to consolidation of the foundation soil may also occur but is outside the scope of this design. Determination of both the short- and long-term settlements of the RSS are not part of this design.
- This design is for the permanent works only and is issued on the basis that a safe system of works is provided for construction.
- All slopes geometry, setting out and required offsets to be confirmed by others prior to construction. The party undertaking this work must identify the locations of all services prior to construction and ensure that none will be affected by the geosynthetics and its installation.

This design report is based on the information provided to TEG as follows:

- Enabling works excavation and filling specification for Clowes Development & Exton estates, Harts Farm Way, Havant prepared by Burrows Graham Ltd. Ref 21048-BGL-XX-XX-SP-S-D20, Version 1, dated 09/12/2022.
- Geo-Environmental Assessment, Former Brockhampton West Landfill, North of Harts Farm Way, Havant, Presented to Clowes Developments (UK) Ltd, Issued: July 2021, Delta-Simons Project No. 19-2099.04
- Preliminary Settlement Discussion, Brockhampton West, Havant, Presented to Exton Estates, Issued: 11th June 2021, Delta-Simons Project No. 19-2099.06.
- Factual Geo-Environmental Investigation Report, Former Brockhampton West Landfill, North of Harts Farm Way, Havant, Presented to Clowes Developments (UK) Ltd, Issued: November 2021, Delta-Simons Project No. 19-2099.08
- Havant Bund Assessment January 2022 prepared for Burrows Graham Ltd by Ground and Project Consultants Ltd, Final Report, Report No. 70634-1, Dated 06/01/2022.
- Brockhampton West report for Havant borough Council, Job No: A102760, WYG Environment Planning Transport Limited, dated August 2017.
- TEG keep a record of all email correspondence and phone calls (March 2022).

In addition, the following documents were used in the preparation of this design:

- BS 8006-1:2010+A1:2016. Code of practice for strengthened/reinforced soils and other fills.
- MCHW Specification for Highway Works, Series 600.
- BS EN 14475:2006. Execution of special geotechnical works. Reinforced fill.
- BS EN 1997-1:2004+A1:2013. Eurocode 7: Geotechnical design. – Part 1: General rules.
- BS EN 16907:2018 Earthworks.
- Tensar Basetex geotextile soil reinforcement technical specifications and relevant product partial factors.

Any solution outside this scope is not covered by this design and TEG should be informed so that a new design can be advised if required.

3.0 DESIGN PARAMETERS

The Principal Designer, Client's Geotechnical Advisor and Principal Contractor must ensure that all parameters used comply with those found on site. Any variance in these must be reported to TEG immediately so that the implications can be assessed. TEG have not conducted a site investigation nor tested the proposed fill. It is assumed that the values assumed for the fills are a true interpretation of the extent and properties of the soils and fills on the project.

TEG has not received a formal Ground Investigation Report (GIR) but a series of reports with the findings of physical ground investigation work and associated laboratory test, listed in Section 2.

A GIR should be included as part of the Geotechnical Design Report (GDR) as stated in section 3.4.1 of BS EN1997-1 (Eurocode 7). This should be forwarded to TEG so the design can be reviewed if available.



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The RSS bund will be constructed directly on top of a historic landfill site. Ground conditions considered in this design consist of the capping and landfill. During construction of the bund the capping geometry should not be altered. TEG has assumed for analysis purposes the following design parameter.

3.1 RSS FORMATION / FOUNDATION

The capping and landfill material at the bund formation / foundation level has been assumed to have the properties given in Table 1.

Table 1 – Geotechnical parameter assumed for the existing ground condition in drained condition

DESCRIPTION	UNIT WEIGHT (kN/m ³)	ASSUMED EFFECTIVE ANGLE OF INTERNAL FRICTION (°)	Pore pressure parameter, r_u	UNDRAINED SHEAR STRENGTH (kPa)
Capping	19	27	0.1	30
Landfill	8	30	0.1	25

3.2 REINFORCED SOIL SLOPE BACKFILL

The reinforced soil slope will be constructed using Class 2 (stoney-cohesive) fill in accordance with the MCHW Specification for Highway Works, Series 600.

The material proposed for use in the reinforced zone must be tested prior to placement to ensure that it complies with all the requirements of the above specification. Reference should be made to the Earthworks Specification for the project for testing requirements and testing frequencies.

Fills are to be compacted to 95% of maximum dry density (maximum dry density to be confirmed via compaction testing throughout the works). Compaction is to be in accordance with MCHW Series 600. The properties of the fills are summarised in Table 2:

Table 2 – Geotechnical parameter in the design of the RSS

DESCRIPTION	UNIT WEIGHT (kN/m ³)	ANGLE OF SHEARING RESISTANCE (°)	Pore pressure parameter, r_u	UNDRAINED SHEAR STRENGTH (kPa)
Reinforced soil fill within geosynthetics on RSS shallow slopes; Class 2 (series 600, MCHW)	19	25 (minimum)	0.1	80

The pH of the Class 2 fill will be in the range $4 < \text{pH} < 9$; the maximum moisture content must be kept below 20% (also to be confirmed by testing throughout works).

The fill shall be screened to remove cobbles and boulders before compaction. If the fill material becomes wet and/or adequate compaction cannot be achieved earthworks has to stop.

Classification testing of the proposed up-fill material must be undertaken by the RSS Installer to ensure the proposed fill material complies with Class 2 fill and that a minimum angle of internal friction of 25 degrees is achieved.

In addition to classification testing to ensure any site won material meets the requirements of Class 2, post placement testing, such as MCV and nuclear density testing must be carried out to ensure the fill is sufficiently compacted in accordance with the MCHW Specification for Highway Works, Volume 1.

QA/QC should follow the principles set out in BS EN 16907:2018 Earthworks and under responsibility of the RSS Installer or Principal Contractor.

3.3 UPFILL BEHIND THE REINFORCED SOIL STRUCTURES

Levels are to be raised behind the RSS, to create the proposed bund structure. We have therefore assumed that the fill material required to raise levels behind the reinforced soil zone of the slope will be Class 2 fill which complies with the requirements set on Table 2 above. The fill properties will be confirmed by the RSS Installer prior to construction.

3.4 SURCHARGE LOADS

It was assumed a traffic load of 10 kPa acting over the reinforced soil slope crest.

In this design, no allowance is included for temporary or permanent loadings or surcharge coming from fences / noise barriers and / or run-on slab and / or other structures.



3.5 GROUND WATER

It is assumed the reinforced slopes will be maintained in a fully drained condition. Please advise in which locations / sections of the project it is expected to have higher ground water level, so it can be included within the design of the RSS at specific location / section. A pore pressure ratio of 0.1 was assumed in the RSS and bund fill, capping and landfill.

No consideration of flood risk is undertaken in this report. Specialist flood risk advice should be sought with regard to drainage and flooding. Site drainage and erosion control measures are outside the scope of TEG design. Hydraulic limit states and the performance of the reinforced soil slope as a hydraulic or flood attenuation solution is beyond the scope of this design.

3.6 REINFORCEMENT GEOSYNTHETIC

The reinforced soil slopes will be constructed using BaseTex geotextile soil reinforcement or similar approved product. The properties and partial material factors for BaseTex geotextile soil reinforcement are listed in Table 3:

Table 3 – BaseTex geotextile soil reinforcement properties and partial factors

PARAMETER	Basetex 200/50
Ultimate Tensile Strength (longitudinal direction)	200 kN/m
Long Tensile Design Strength (longitudinal direction)	97 kN/m
PARTIAL MATERIAL FACTORS	
fd, installation damage coarse gravel	1.40
fe, environmental conditions design temperature 20°C, 4 < pH < 9	1.05
Creep, design temperature 20°C (%)	1.40
fm, factor for extrapolation of data	1.00
fn, factor for ramification of failure	1.00
Cds, coeff. of direct slip along reinforcement (Class 2 fill)	0.50*
ci, coeff. of interaction soil/geosynthetic reinforcement (Class 2 fill)	0.50*

*values to be checked with relevant laboratory test according to ISO 12957-1:2018; "Determination of friction characteristics Part 1: Direct shear test".

3.7 GENERAL

In this design, no allowance is included for loads coming from building foundation and / or run-on slab and / or other structures.

4.0 ANALYSIS

All geotechnical analysis undertaken has been completed following BS EN1997-1:2004 Eurocode 7 (Design Approach 1) & BS 8006-1:2010 (Combination A).

- *System:* Steep reinforced soil slope.
- *Structure Category:* Strengthened Earthworks
- *Method of Analysis:* BS EN1997-1:2004 & BS 8006-1:2010
- *Design Life:* 60 years
- *Reinforcement included in the analysis:* BaseTex geotextile or similar approved

Tables 4 – 7 summarise the output of the analysis for each location examined. Detailed analysis files for each case are presented in Appendix A.

The length and strength of each BaseTex geotextile soil reinforcement in each section are defined in Appendix A and B.

Table 4. Summary of analysis, Section S2

Section		S2			
		Left hand side		Right hand side	
Maximum retained height of slope		4.52m		2.6m	
Number of reinforcement layers		11		6	
Reinforcement spacing in the vertical direction		0.4m			
		Left hand side		Right hand side	
		Short-term	Long-term	Short-term	Long-term
Global stability, Design Approach 1	Combination 1	2.69	2.85	3.94	4.74
	Combination 2	1.92	2.29	2.93	3.71
Short-term analysis					
		Left hand side		Right hand side	
Internal stability	Top	6.92		8.51	
	Bottom	2.20		>10	



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	Left hand side			Right hand side		
	Sliding	Overturning	Bearing	Sliding	Overturning	Bearing
Top	>10	>10	1.17			
Middle	>10	>10	1.08	>10	>10	1.28
Bottom	>10	>10	1.42	>10	>10	1.47
Long-term analysis						
		Left hand side		Right hand side		
Internal stability	Top	1.10		1.16		
	Bottom	1.16		1.21		
	Left hand side			Right hand side		
	Sliding	Overturning	Bearing	Sliding	Overturning	Bearing
Top	>10	>10	2.37			
Middle	>10	>10	1.51	>10	>10	1.66
Bottom	>10	>10	5.31	>10	>10	2.88

Table 5. Summary of analysis, Section S5

Section			S5			
			Left hand side		Right hand side	
Maximum retained height of slope			7.82m		7.51m	
Number of reinforcement layers			19		18	
Reinforcement spacing in the vertical direction			0.4m			
			Left hand side		Right hand side	
			Short-term	Long-term	Short-term	Long-term
Global stability, Design Approach 1	Combination 1		1.74	3.72	>10	>10
	Combination 2		1.24	2.98	>10	>10
Short-term analysis						
		Left hand side			Right hand side	
Internal stability	Top	6.95			6.73	
	Bottom	1.39			1.37	
		Left hand side			Right hand side	
	Sliding	Overturning	Bearing	Sliding	Overturning	Bearing
Top	>10	>10	4.99			
Middle	>10	>10	2.37	>10	>10	1.27
Bottom	>10	>10	1.43	>10	>10	1.17
Long-term analysis						
		Left hand side			Right hand side	
Internal stability	Top	1.10			1.18	
	Bottom	1.05			1.02	
		Left hand side			Right hand side	
	Sliding	Overturning	Bearing	Sliding	Overturning	Bearing
Top	>10	>10	2.81			
Middle	>10	>10	1.66	>10	>10	1.27
Bottom	>10	>10	1.14	>10	>10	3.09

Table 6. Summary of analysis, Section S6

Section			S6			
			Left hand side		Right hand side	
Maximum retained height of slope			5.35m		5.13m	
Number of reinforcement layers			13		12	
Reinforcement spacing in the vertical direction			0.4m			
			Left hand side		Right hand side	
			Short-term	Long-term	Short-term	Long-term
Global stability, Design Approach 1	Combination 1		1.92	3.21	>10	>10
	Combination 2		1.38	2.57	>10	>10
Short-term analysis						
			Left hand side		Right hand side	
Internal stability	Top		5.81		5.92	
	Bottom		1.75		2.03	
		Left hand side			Right hand side	
	Sliding	Overturning	Bearing	Sliding	Overturning	Bearing
Middle	>10	>10	2.16	>10	>10	2.29
Bottom	>10	>10	1.35	>10	>10	1.39
Long-term analysis						
			Left hand side		Right hand side	
Internal stability	Top		1.03		1.38	
	Bottom		1.15		1.10	
		Left hand side			Right hand side	
	Sliding	Overturning	Bearing	Sliding	Overturning	Bearing
Middle	>10	>10	2.75	>10	>10	2.88
Bottom	>10	>10	3.09	>10	>10	3.81



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Table 7. Summary of analysis, Section S7

Section			S7			
			Left hand side		Right hand side	
Maximum retained height of slope			7.58m		6.2m	
Number of reinforcement layers			18		15	
Reinforcement spacing in the vertical direction			0.4m			
			Left hand side		Right hand side	
			Short-term	Long-term	Short-term	Long-term
Global stability, Design Approach 1	Combination 1		1.40	3.21	10.01	>10
	Combination 2		1.00	2.57	4.61	>10
Short-term analysis						
			Left hand side		Right hand side	
Internal stability	Top		4.10		5.71	
	Bottom		1.36		1.60	
			Left hand side		Right hand side	
	Sliding	Overturning	Bearing	Sliding	Overturning	Bearing
Middle	>10	>10	1.50	>10	>10	1.72
Bottom	>10	>10	1.05	>10	>10	1.07
Long-term analysis						
			Left hand side		Right hand side	
Internal stability	Top		1.15		1.16	
	Bottom		1.05		1.04	
			Left hand side		Right hand side	
	Sliding	Overturning	Bearing	Sliding	Overturning	Bearing
Middle	7.08	>10	1.72	>10	>10	1.45
Bottom	>10	>10	2.00	8.66	>10	3.44

5.0 SUMMARY

The design analysis demonstrates that BaseTex 200/50 geotextile soil reinforcement RSS, if constructed in accordance with this document, TEG's drawings and the installed in accordance with the requirements of BS 8006-1:2010 and BS EN 14475:2006, is appropriate and fit for the intended purpose.

This design proposal and associated drawing have been produced using the methodology detailed above. However, it should be noted that the design proposal has been generated from information provided to TEG, which has not been independently verified and may contain assumptions and inaccuracies regarding geotechnical, hydraulic and other parameters.

The RSS Installer must ensure that all parameters assumed comply with those found on site. Any variance in these must be reported to TEG immediately so that the implications can be assessed. If any discrepancy is noted between the site conditions and the design assumptions (regarding slope geometry, water levels, soil conditions, proposed loadings etc.), the RSS Installer is to inform the Principal Contractor who will and must contact TEG immediately to facilitate a review of the design.

TEG did not undertake to supervise the construction of the reinforced soil slope structure, and therefore cannot comment on the standard of workmanship. The main issues to consider are rate of construction of the slopes, adequate compaction of the foundation soils and site won fill, and adequate drainage.

TEG accordingly does not accept responsibility for the accuracy or completeness of information or assumptions from which the design proposal has been produced.

The material suppliers can provide typical health & safety hazards to consider when approaching this work. Designer's hazards include falling from height, lifting geosynthetic rolls and metallic formwork units, plant operations, sharp wires moving under tension and cutting causing eye or skin damage.



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6.0 FURTHER NOTES

The following supervision requirements should be adhered to by the parties as defined in Section 1.0. If any issues arise on site which differ from what has been assumed in this design, TEG should be contacted urgently so the possible ramifications can be appraised.

The RSS construction should be carried out in accordance with the manufacturer's installation guidelines. The various sections of RSS to be constructed should be checked for the required retained height to ensure that they are within the scope of this design.

6.1 GROUND CONDITIONS

The Principal Contractor, RSS Installer and/or Principal Designer must ensure that all parameters used comply with those found on site. Any variance in these must be reported to TEG immediately so that the implications can be assessed.

The Principal Designer must ensure that RSS formation or foundation level provides sufficient bearing capacity to support the RSS over its full extent.

6.1.1 Soft soil and organic material

Organic material is an unsuitable material for founding any RSS. Should any organic material be found at formation level it should be excavated out down to competent stratum (prior to the construction of the RSS) and be replaced with compacted Class 6F5 or 6F2 granular fill compacted in layers in accordance with Series 600 of SHW.

6.1.2 Bearing capacity

The Principal Designer and/or the Client's Geotechnical Advisor must confirm the localised suitability of the material at formation level of the RSS. It must be ensured that RSS foundation material has an allowable bearing capacity as specified in this design report (refer also to Appendix A for bearing loads on each RSS). The Principal Contractor / Principal Designer must instruct to undertake a series of plate bearing tests at formation level to confirm the allowable bearing capacity prior to construction.

Field tests like plate bearing test, standard penetration test, pressuremeter test and / or field vane shear test are generally used to determine bearing capacity of soil. The Client's Geotechnical Advisor must select the most appropriate based on the existing ground condition and should prescribe test to be carried out at formation level to confirm the allowable bearing capacity prior to construction.

Formation level should also be proof-rolled and carefully inspected prior to construction to check for any soft spots. RSS can fail due to lower than required undrained shear strength in the foundation soil.

6.2 CONSTRUCTION MATERIALS

The material proposed for use in the reinforced zone (i.e. Class 2) must be tested prior to placement to ensure that it complies with all the requirements set into this document. Any material outside the requirements must not be used in the reinforced soil zone.

6.3 CONSTRUCTION CONSIDERATIONS

The RSS construction should be carried out in accordance with:

- BS 8006-1:2010+A1:2016. Code of practice for strengthened/reinforced soils and other fills.
- BS EN 14475:2006. Execution of special geotechnical works. Reinforced fill.
- And manufacturer's installation guidelines.

6.3.1 RSS construction

The fill in the reinforced block should be placed in layers and compacted in accordance with the MCHW. The fill should comply with Class 2 material and should be compacted in accordance with relevant specifications as specified before on Section 3.0.

BaseTex 200/50 geotextile soil reinforcement (or similar approved) would be placed in 400 mm high layers in which full width reinforcement, such as BaseTex 200/50, is extended forward from the reinforced fill to the face of each intervening layer of fill.

No form-work it is required to create the geotextile soil reinforcement layer structure and the geosynthetic must be extended 500 mm towards the face, so it can be trimmed down during the slope grading procedure, without reducing the length required from design. An erosion mat must be placed to avoid top-soil washing out.



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The stability of the face area of shallow slopes is generally influenced by the infiltration of water into the surface soils and the potential generation of a shallow slip parallel to the slope surface.

Simple overlaps should be used to make effective joints between the geotextile soil reinforcement placed horizontally in layers. The minimum overlap should be 200 mm wide and maintained during the operation. Further information on the installation can be supplied by the geotextile soil reinforcement manufacturers.

6.3.2 Rules to follow

Quality control testing of the fill materials should follow the principles set out in EN 16907:2018 and is the responsibility of the RSS Installer.

Seeded topsoil or hydroseeding should be placed in the face to achieve rapid vegetation. It should be ensured that the front face does not dry out in the first few months by watering as necessary. Seeding or hydroseeding specification by Specialist.

Should, three months after completing construction, no significant vegetation be visible we recommend that the face of the slope is hydroseeded.

Recommended rate of construction: when using geotextile soil reinforcement with site won fills the construction rate is very important. This design follows a staged construction process to allow pre-consolidation and pore pressure dissipation. Time is required between construction phases, defined as the construction of one or more lifts each day, to allow excess pore water pressures to dissipate.

For shallow slopes: up to no. 1 lifts a day (400 mm) can be constructed at any section.

The reinforced soil slope should not be constructed at a rate faster than recommended above. Constructing the structure at faster than recommended could lead to excessive settlement and movement of the structure and possible localised failure cause by excess pore pressures in the site won low permeability fill. Where excess movement or localised failure is observed construction activity must cease immediately and TEG notified.

The maximum rate of construction given refers to construction of the reinforced soil structure only and are not applicable to the dissipation of excess pore water pressures that may develop in the Class 2 fills elsewhere in the embankment.

6.4 PERMANENT AND TEMPORARY WORKS

The RSS design produced by TEG is issued on the basis that a safe system of works is provided for construction. Principal Contractor must produce a method statement and risk assessment for the works to be approved by the Principal Designer.

TEG is not responsible for temporary stability or design of any other temporary works.

The geometry of the capping over the landfill should not altered during construction of the bund.

6.5 HEAVY PLANTS

Heavy construction plant should not traffic behind the RSS during construction as this can cause possible bulging of the RSS. If construction plant is to operate at the crest of the RSS, a suitable haul road design must be undertaken (by others) and the RSS design amended by TEG.

6.6 EXCAVATION

There is allowance for unforeseen future excavation in front of the slope of 10% of its height, in accordance with BS EN 1997-1:2004 Eurocode 7. The Principal Contractor must contact TEG to ensure that if any possible excavation are required, those are not affecting the stability of the designed RSS.

6.7 DRAINAGE

Any excavated slopes should be checked for any flows or seepage that requires drainage measures. Any flows, seepage or standing water should be directed to a suitable outfall as soon as they are encountered. Provision must be made to drain water from the soil during dissipation of excess pore pressures generated during construction and over the life time of the structure.

Given the proposed slope is positioned on the boundary of the site, there is a significant risk that runoff following rainfall events, will be directed towards the reinforced soil zone. If this occurs, pore water pressures in the retained soil would increase, adversely affecting the RSS stability. A build-up of water inside the slope can wash out fine material and cause excess bulging and swelling. This is especially the case where cuts are made in the existing ground.



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Inadequate drainage can result in pore water pressure in the fill, reduced shear strength resulting in possible stability issues and the possibility of settlement and deformation in the fill.

The Principal Contractor must ensure that prior to construction temporary cut-off drains are installed across the slope to direct any run-off away from the reinforced soil zone. Following construction, permanent maintained drainage must be provided alongside the plot to prevent site run-off from flowing towards the RSS bund.

Failure of RSS could occur if surface water is being allowed to drain towards the reinforced slope structure. This water could penetrate the Class 2 fill to such an extent that it flows through the reinforced backfill emerging through the front face, washing out material and distorting area of the face.

RSS are renowned to be very robust structures and failures are relatively rare. When they do occur the majority of the causes are found to be water management and drainage problems, also potentially under-compaction of the structural backfill.

6.8 FENCE

No fences are being installed on top of the soil reinforcement structure.

6.9 PLANTING AND TREES

Low height plants (e.g. small shrubs) might be allowed at the slope crest and within the reinforced soil zone. However, longer roots species and trees should be avoided as the stability of the RSS as well as the un-reinforced embankment may be affected in the long term.

6.10 SITE GEOMETRY

All slope geometry, setting out and required offsets to be confirmed by Principal Contractor prior to construction. Principal Contractor must also confirm the locations of all services prior to construction and ensure that none will be affected by the reinforced soil slope and its installation.

The various sections of reinforced soil slope constructed should be checked for the required retained height to ensure that they are within the scope of this design.

The batter of the slope should be checked with every 1 m of construction to ensure it is within the allowed tolerances as set on BS EN 14475:2006.

6.11 AS BUILT DRAWINGS

Following construction, the Principal Contractor should provide as-built drawings and construction report for all aspect of the works. This should form the base of the final completion validation & verification report, post construction. Showing the following details as a minimum:

- Location of RSS structure with its line and level of the formation and/or levelling pad;
- Location and details of any existing services which may require maintenance;
- Locations of installed geosynthetic reinforcement e.g., geosynthetic layer depths, lengths & tail ends.
- GPS location and depth / level for all tests carried out on site.

As built drawings, construction report and validation & verification report are outside TEG scope.

6.12 MAINTENANCE REQUIREMENTS

Maintenance requirements for the reinforced soil slopes are as follows:

- The RSS should be routinely inspected for signs of any faults, vandalism or movement. The batter of the slope should be checked to ensure it remains within the allowed tolerances in accordance with BS EN 14475:2006.
- The ground above and below the embankments should also be inspected for signs of any movement.
- The RSS slope drainage must be routinely inspected and maintained annually and after particularly heavy rainfall events. This is essential to prevent the pore water pressures increasing behind the slope.
- It should be ensured that the front face does not dry out by watering as necessary. The front erosion mat is flammable. The erosion mat function is to retain fines on the front face until vegetation becomes established. Once vegetation is established the erosion mat becomes redundant.

These requirements should be included in the maintenance regime for the site/development.

TEG advise that this element of works should be treated as a 'Geotechnical Asset' and therefore managed in accordance with the "Risk-Based Approach to Geotechnical Asset Management" in the following way:



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- An annual inspection by the assigned designer to identify geotechnical defects. The first inspection should be undertaken no more than six months after completion of the construction contract in order to allow remedial work before payment of retention.
- Record the verticality, face steps and any movement of the slopes in a way which may be repeated in the future.
- Photograph areas of interest and maintain a photograph record.
- A report to the Client on issues noted during inspection that require monitoring or remedial.

7.0 CDM REGULATIONS

TEG is not the Principal Designer nor the GA (Geotechnical Advisor) in this scheme, but has considered the risks associated with this element of the works that affect or are affected by the design.

“Designers” are responsible for fulfilling their obligations as defined in the Construction (Design & Management) Regulations 2015.

TEG, as specialist element designer, understand that under the Regulations its duties are generally to;

- Ensure that the client for the project is aware of the duties and responsibilities that they have.
- So far as is reasonably practicable, taking due account of other relevant design considerations, avoid foreseeable risks to the health and safety of any persons carrying out, liable to be affected by such or maintaining the permanent fixtures and fittings of construction work.

In discharging this duty, the designer shall:

- Eliminate hazards that may give rise to risks
- Reduce risks from any remaining hazards and in doing so give collective measures priority over individual measures.

The designer shall also:

- Take all reasonable steps to provide with the design sufficient information about aspects of the design of the structure or its construction or maintenance as will adequately assist clients, other designers and contractors to comply with their duties under the Regulations.

In respect of this particular project, TEG hereby draws to the attention of the Principal Designer (Burrow Grahams) and the Principal Contractor that they have specific duties under CDM 2015.

However, since the Principal Designer has designated the chosen location and dimensions of the structure on this site, the Principal Designer has, in this respect, acted as a ‘designer’ under CDM 2015. The Principal Designer is therefore responsible for fulfilling all the obligations that this entails.

The scope of TEG, as element ‘designer’, to minimise design risks is therefore limited by those elements of the design pre-determined by the Principal Designer. The following significant design risks remain and must therefore be addressed by the Principal Designer and Principal Contractor.



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8.0 CONSTRUCTION HAZARDS

8.1 CONSTRUCTION OF GREEN FACED RSS

Table 8 – Notice of hazard identification (generic designer risk assessment)

CATEGORY C/D/M	ACTIVITY/ELEMENT	POSSIBLE HAZARD	RISK ASSESSMENT Low/Medium/High	ACTION PROPOSED	ACTION BY
C	Working at heights >2m	Falling	H	Wear Harness OR provide access scaffold	RSS Installer
C/M	Working at heights	Falling	M	Wear Harness OR provide access scaffold	RSS Installer
C	Cutting mesh, lacing, etc.	Personal Injury	M	Use of suitable PPE (safety goggles, gloves, etc.)	RSS Installer
C	Placing backfill	Personal Injury	M	Use mini excavator to place stone fill where practicable	RSS Installer
C	Excavation of embankment prior to installation of slope	Embankment Slip – Personal Injury	H	Excavation of embankment to a safe angle of repose for the short term.	RSS Installer
M	Steep retaining structures > 2m in height	Falling/Personal Injury	H	Provision of permanent fence / barrier at crest of RSS	Principal Contractor

Category: C = Construction, M = Maintenance/Use, D = Demolition

Table 9 – Notice of hazard identification (specific designer risk assessment)

CATEGORY C/D/M	ACTIVITY/ELEMENT	POSSIBLE HAZARD	RISK ASSESSMENT Low/Medium/High	ACTION PROPOSED	ACTION BY
C	Excavation into existing material to foundation level	Bank slip / Personal injury	H	Excavation of ground to a safe angle of repose for the short term and/ or foundation excavation & construction of lower courses carried out in short lengths. Use of granular backfill.	RSS Installer
C	Excavation into existing material to foundation level	Striking existing services/ Personal injury	M	Principal Designer to provide details of all existing services in the vicinity of the slope to Principal Contractor / RSS Installer. Use of Cable Avoidance Tools (CAT scanners).	RSS Installer
C	Excavation into existing material to foundation level	Striking live cables/ electrocution	M	Principal Designer to provide details of all existing electrical services in the vicinity of the slope to Principal Contractor. Electrical services to be relocated where risk is unacceptable. Use of Cable Avoidance Tools (CAT scanners).	RSS Installer
C	General Installation of RSS	Personal Injury	M	Adhere to Supplier Installation Guidelines.	RSS Installer

Category: C = Construction, M = Maintenance/Use, D = Demolition



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9.0 SIGNIFICANT DESIGN RISK REMAINING

An essential part of the project lifecycle is the identification and management of risks, and all parties have a role in ensuring that risks are identified and avoided or reduced to tolerable levels. TEG has identified the below. All the parties involved should all read and check this Section 9.0 before proceeding.

1. RISK: FAILURE CAUSED BY ADOPTION OF INADEQUATE DESIGN PARAMETERS

No Ground Investigation Report (GIR) in accordance with Eurocode 7 has been received for the site, therefore this analysis is based on information from the received site investigation reports and soil parameters advised by the Client. Should a GIR be available, it must be forwarded for review prior to proceeding with these works.

Ground conditions are often uncertain and present risks which have to be managed proactively. The Principal Contractor, the Principal Designer and RSS Installer must ensure that all parameters assumed comply with those found on site. Any variance in these must be reported to TEG immediately so that the implications can be assessed. Particular attention should be given to areas of differing engineered fill thickness and varying geologies.

2. RISK: FAILURE CAUSED ON SHORT-TERM CONDITIONS IN THE FOUNDATION SOILS

The Principal Designer and/or the Geotechnical Advisor must ensure that all parameters assumed comply with those found on site. Any variance in these must be reported to TEG immediately so that the implications can be assessed.

3. RISK: INADEQUATE BEARING STRATUM AT FORMATION OF SLOPE

The Principal Contractor and the Principal Designer must confirm the localized suitability of the material at formation level of the reinforced slope. It must be ensured that competent material with an adequate allowable bearing is present at formation level by the Principal Designer prior to construction. The Principal Contractor and Principal Designer are responsible for ensuring that the RSS foundation has sufficient strength and stiffness to prevent failure and excess settlement of the reinforced soil slopes.

A series of plate bearing tests must be carried out at proposed formation level to confirm the allowable bearing capacity prior to construction. Failure to remove all unsuitable material at the formation level will also increase the possibility of settlement of the structure.

4. RISK: FAILURE OF THE REINFORCED SOIL STRUCTURES DUE TO INCORRECT ASSUMPTIONS ON THE STATE OF THE FOUNDATION SOILS

It is assumed in this design that the foundation soils will be in a drained state at all times, during construction and operation, of the embankment. The consequence of the foundation soil being in an undrained state could be that the factors of safety against failure would be lower and most likely reduce below the required 1.0.

5. RISK: INSTABILITY IN THE RSS AT THE FACE TRANSITIONS FROM 50 DEGREES TO SHALLOW GRADIENT

In transitioning from the RSS: care must be exercised to ensure that the reinforcement is installed at the correct elevations and is of the correct length for that elevation. Care is also required to ensure that the transition zone does not result in an over steep slopes that has not been considered in this design.

6. RISK: INSTABILITY OR SETTLEMENT DUE TO CONSTRUCTION SEQUENCE

In developing the construction sequence / methodology consideration must be given to the impacts this could have on the stability of the RSS. The entire embankment cross section (RSS & un-reinforced) is constructed from fills (Class 2) which can be sensitive to moisture. Careful control of moisture content is required to achieve adequate compaction / dry density in the fill. With these fills there is a possibility that excess pore pressures may develop which could lead to a reduction in strength and consolidation settlements in the body of the constructed earthworks.

It is recommended that the entire width of the embankment (RSS & un-reinforced) is be constructed at the same time to a uniform height. This would ensure that compaction of the fill is consistent and uniform over the full width of the embankment. If this is not possible and benching is used to join older and newly placed fill adequate compaction and quality control testing must be undertaken at the bench location and in the newly placed fill. Furthermore, adequate time must be allowed for dissipation of excess pore water pressures in all the embankment fills.



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7. RISK: SETTLEMENT DUE TO INSUFFICIENT FOUNDATION IMPROVEMENT

Any ground improvement should be designed to provide adequate strength and stiffness improvement to the in-situ soil to prevent settlement of the reinforced soil structure.

8. RISK: FAILURE TO PROTECT THE REINFORCED SOIL SLOPE TOE

Embedment 10% of the height of the RSS with a minimum of 300 mm.

9. RISK: FAILURE DUE TO USE OF UNSUITABLE FILL WITHIN THE REINFORCED SOIL ZONE

The RSS Installer is responsible for all the selection and testing of the proposed Class 2 material both before and during construction, to ensure compliance with the geotechnical characteristics specified in 'Series 600' of the MCHW Specification for Highway Works. Testing is to include Plasticity Index, compaction and dry density tests as defined previously in this report.

10. RISK: EXCESSIVE SETTLEMENT/MOVEMENT CAUSED BY RAPID CONSTRUCTION

The reinforced soil slope should not be constructed at a rate faster than recommended in Section 6.3 CONSTRUCTION CONSIDERATIONS.

Constructing the structure at faster than recommended rates could lead to excessive settlement and movement of the structure and possible localized failure cause by excess pore pressures in the site won low permeability fill. Where excess movement or localized failure is observed construction, activity must cease immediately and TEG notified. Some settlement will occur after construction, depending on the compaction and condition of the backfill placed.

The maximum rate of construction given in Section 6.3 refer to construction of the reinforced soil structure only and are not applicable to the dissipation of excess pore water pressures that may develop in the Class 2 and fills elsewhere in the site. An analysis of the dissipation times required for the Class 2 should be undertaken and the rate of construction adjusted to control settlement/movement in the reinforced zones in the RSS.

11. RISK: EXCESSIVE SETTLEMENT/MOVEMENT CAUSED BY POOR PLACEMENT AND COMPACTION OF EMBANKMENT FILL

Proper placement and compaction of the backfill will avoid and minimize this possible issue. RSS are flexible, and some settlement will occur during and after construction. Some settlement of the subgrade will also occur after construction, depending on the compaction of the foundation soils and backfill. The settlement should be monitored, and all finishes, fences etc should be delayed until settlement is complete. Settlement calculations are outside TEG scope of works.

12. RISK: FAILURE OF THE REINFORCED SOIL STRUCTURES DUE TO POOR QUALITY FILL CONTROL

Quality control testing of the fill materials should follow the principles set out in EN 16907:2018 and is the responsibility of the RSS Installer.

13. RISK: FAILURE OF THE RSS SLOPE DUE TO INCORRECT CONSTRUCTION GEOMETRY

All slope geometry, setting out and required offsets to be confirmed by the RSS Installer and / or Principal Contractor / Principal Designer prior to construction.

14. RISK: RSS CONSTRUCTED OUTSIDE DESIGN TOLERANCES

We recommend that the batter of the slope is checked with every 1m of construction to ensure it is within the allowed tolerances. Heavy construction plant should not be trafficking behind the RSS slope during construction as this can cause excessive bulging of the RSS face. We recommend that an experienced installer is appointed to construct the reinforced soil slopes.

15. RISK: PROCEEDING WITH CONSTRUCTION PRIOR TO ACHIEVING NECESSARY APPROVALS

TEG is not responsible for gaining approval from public authorities for any works associated with this project. The Principal Contractor and / or Principal Designer are responsible for ensuring all relevant approvals are met prior to construction commencing. TEG advise that construction does not proceed until all necessary approvals are granted.

16. RISK: INEXPERIENCED INSTALLER APPOINTED TO CONSTRUCT THE RSS

An experienced installer and/or earthworks contractor should be appointed to construct the RSS bund. The installer should have experience on work of a similar nature in terms of constructing high reinforced soil slopes and earthworks with site-won stoney-cohesive fills.



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17. RISK: CHANGE IN PROPERTIES OF RSS FILL

An angle of friction of 25 degrees was assumed for the reinforced soil slope fill in preparing this design. If the embankment fill is found to have an angle of friction less than 25 degrees, TEG must be notified immediately so the design implications can be assessed.

18. RISK: FAILURE DUE TO POOR WATER MANAGEMENT AND DRAINAGE DESIGN

Site drainage is outside the scope of this design and further comments can be found on Section 6.7 of this document.

As previously mentioned, all hydraulics calculations (e.g., checking the seepage under and around the structure; so as to check the erosion of the stream close by the slopes) and the performance of these structures as a hydraulic or flood attenuation solution is beyond the scope of this design. No consideration of flood risk is undertaken in this report. Specialist flood risk advice should be sought with regard to drainage and flooding. Site drainage and erosion control measures are outside the scope of TEG.

Any requirements for this structure to perform as a hydraulic or flood/dam prevention structure are the responsibility of the Principal Designer.

19. RISK: FAILURE DUE TO AN EXTREME STORM or FLOOD EVENT RESULTING IN INSTABILITY OF THE STRUCTURE

Ponds / flood alleviation ditches may be constructed in close proximity to the RSS at some locations in the future. At locations of ponds / flood alleviation ditches it was assumed the water table would be at finish ground level when assessing stability.

20. BURIED SEWER / SERVICES

Buried sewer/services needs to be able to accommodate the loading imposed by the RSS and its construction. At the design stage the Principal Designer must satisfy themselves that any increase in ground stresses, from construction of the building or upfilling of the ground, does not increase the stress such that the stability of the sewer is compromised.



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APPENDIX

- Appendix A: calculation report
- Appendix B: RSS drawings
- Appendix C: Tensar Basetex 200/50 specifications