TensarTech® NaturalGreen™ Earth Retaining Structures: Model Specification

This document is intended to form a basis for Tender documents where the TensarTech® NaturalGreen™ reinforced soil system is required.

1. GENERAL

This work shall consist of constructing reinforced soil steep slopes (often referred to as strengthened embankments) typically using a proprietary system, constructed in accordance with the suppliers drawings and specifications and in conformity with the alignment, grades and dimensions shown on the contract documents or as established by the Engineer. Where necessary the Contractor shall provide complete set of drawings issued for construction, design calculations and complete specifications of the proposed system for the approval of the Engineer 90 days prior construction. Any particular requirements of approved detailed specifications for the approved proprietary system shall override any conflicting or incompatible requirement contained within this section.

The proposed solution must demonstrate previous use for reinforced soil steep slopes with a minimum height of 20.0m and a minimum in service life of 20 years.

The soil reinforcement must have a current British Board of Agrèment (BBA) HAPAS certificate, demonstrating suitability for use in highways structures with a minimum 60-year design life.

2. DESIGN

The design shall address the climatic and soil conditions existing in UK and the specifically the site in question and provide a minimum design life of 60 years. The specifications as presented to the Engineer shall state any requirements for or limitations on the backfill used in the structure to ensure the design life. The tender submission shall be accompanied by:

A. A copy of the current BBA certificate
B. Sample design calculations for the proposed slopes in compliance with HA68/94 or BS8006 as appropriate
C. Soils test information of the proposed reinforced soil fill
D. Method statement for construction
E. Confirmation of the Professional Indemnity and Product Liability insurance cover provided by the Slope System Supplier

3. STANDARDS

The following standards and codes in their latest edition shall be particularly applied to work covered by this specification where applicable; together with any further standards or codes as described within the approved Specification for the approved reinforced soil slope system.

3.01 Geogrid Reinforcement

A	**ISO 2602: 1980**	Statistical Interpretation of Test Results
B	**BS EN ISO 9001: 2000**	Quality Systems – Model for Quality Assurance in Production, design and development Installation & Servicing
C	**BS 2782: Part 4**	Methods of Testing Plastics. Part 4: Chemical Properties
D	**GRI GG2 - 87**	Geogrid Junction Strength
E	**BS EN ISO 10321: 1996**	Geotextiles – Tensile Test for Joints-Seams by Wide-Width Method
F	**BS EN ISO 10319: 1996**	Wide-Width Tensile Test
G	**BS EN ISO 13431: 1999**	Geotextiles and geotextiles related products. Determination of tensile creep and creep rupture behaviour

3.02 Soils

A	**BS1377: 1990**	Moisture Density Relationship for Soils, Standard Method
B	**BS1377: 1990**	Gradation of Soils
C	**BS1377: 1990**	Atterberg Limits of Soil
D	**BS1377: 1990**	Shear Box Test
E	**BS3882: 1994**	Specification for topsoil

4. MATERIALS

The slope system will comprise primary horizontal layers of uniaxially orientated high density polyethylene (HDPE) geogrids and secondary polypropylene geogrids with a rolled erosion control product for erosion protection to the slope face helping establish and reinforce the root system of the vegetation in the long-term.

4.01 Geogrid Reinforcement

4.01.1 Primary Geogrid reinforcement

A. The primary reinforcing element shall be a geogrid manufactured in accordance with a Quality Management System which complies with the requirements of BS EN ISO 9001:2000. If required by the Engineer, the Contractor shall provide evidence that the manufacturer's Quality Assurance System has been certified to conform with BS EN ISO 9001:2000 by an external authenticating authority approved by the Department of Trade and Industry.

B. The reinforcing element shall be a geogrid manufactured from high density polyethylene sheet, oriented in one direction so that the resulting ribs shall have a high degree of molecular orientation, which is continued through the integral transverse bar.

C. The long term creep rupture strength $_{PC}$ (Ultimate Limit State), for a design life of 60 or 120 years, shall be in accordance with the following table at a mean temperature for design country (10°C, 20°C or 30°C). This shall be determined by application of standard extrapolation techniques to creep data obtained in accordance with BS EN ISO 13431:1999 and shall be a lower bound value. Values shall be based on a minimum 100,000 hour of continuous creep testing.

		Geogrid Type - design life of 60 years					
	Units	RE510	RE520	RE540	RE560	RE570	RE580
$P_{C\ 10°C}$	kN/m	21.10	27.85	34.02	46.78	62.44	72.41
$P_{C\ 20°C}$	kN/m	19.37	25.56	31.23	42.95	57.33	66.48
$P_{C\ 30°C}$	kN/m	17.56	23.18	28.32	38.94	51.98	60.27

		Geogrid Type - design life of 120 years					
	Units	RE510	RE520	RE540	RE560	RE570	RE580
$P_{C\ 10°C}$	kN/m	20.71	27.34	33.40	45.93	61.31	71.09
$P_{C\ 20°C}$	kN/m	19.01	25.10	30.66	42.16	56.28	65.27
$P_{C\ 30°C}$	kN/m	17.24	22.76	27.80	38.23	51.03	59.17

D. The geogrid shall have an appropriate partial factor for site installation and construction damage, determined by the particle size distribution of the reinforced fill and in accordance with the values used in the design. This factor shall be based on full-scale tests carried out in accordance with BS8006 Annex D and witnessed by an independent Approval Authority. If required by the Engineer, the Contractor shall provide supporting documented evidence of testing for this and any other partial factors assumed in the design. Partial factors for site installation and construction damage based on limited laboratory based testing are not acceptable.

E. The strength of the junctions between the longitudinal ribs and transverse bars, as determined by the Geosynthetics Research Institute, Drexel University, USA, Test Method GG2-87, shall be not less than 95% of the Quality Control Strength.

F. Any site joints in the reinforcement roll length shall be capable of carrying 100% of the geogrid long term creep rupture strength. If required by the Engineer, the Contractor shall provide evidence of this.

G. The geogrid shall be inert to all chemicals naturally found in soils and shall have no solvents at ambient temperature. It shall not be susceptible to hydrolysis, shall be resistant to aqueous solutions of salts, acids and alkalis, shall be non-biodegradable and shall have a minimum of 2% finely divided carbon black, as determined by BS 2782 Part 4, Method 452B 1993, to inhibit attack by ultraviolet light.

H. The primary geogrid shall have an independent test certificate proving resistance and durability in a pH range of 2.0 to 12.5. Specifically, 'The sample of the primary geogrid chosen shall have a test certificate from a recognised independent test authority, showing that when tested to ENV ISO 12960, March 1998, they can withstand immersion in a saturated solution of calcium hydroxide with a pH of 12.5, at 60 deg C for 3 days with no loss of tensile strength'.

I. The geogrid shall be CE Marked by an independent, authorised Certification Body to demonstrate that the product has been tested in accordance with the relevant European Standard relating to its specific use in construction, in accordance with the EU Construction Products Directive.

J. The product labelling must show the CE Mark, together with the Certification Body Number and the FPC (factory production control) number. 'Accompanying Documentation' indicating the relevant testing 'declared values', should be available on request.

4.01.2 Erosion Control Product

To establish a grass cover to the finished structure by dry seeding, the face should be covered with one of the following as determined by the engineer:

A. rolled erosion control product comprising of biodegradable coconut fibres incorporated into a permanent three-dimensional polypropylene mesh.

B. Non-biodegradable rolled erosion control product comprising of four layers of polyethylene mesh which are heat bonded together to form a three-dimensional mat.

C. Where a depth of topsoil greater than 150mm is required, a cellular confinement erosion control product should be used.

4.02 Erosion control to slope face

A. Horticultural topsoil should be applied to the face of the slope to a thickness determined for the contract, but typically not greater than 100mm. The rolled erosion control product should be fixed to the slope face, in accordance with specification clause 5.03.

4.03 Reinforced (Infill) Soil

The reinforced soil material proposed should conform to the following:

A. Minimum angle of friction ($ø_{cv}$') of 30 degrees unless agreed with the Engineer.

B. The Contractor should provide the Slope System supplier and the Engineer/Client with Effective Stress Parameters soil test information including soil density to allow completion and checking of the final design.

4.04 Horticultural Topsoil Layer

A. The horticultural soil layer shall be a medium loam with a workable 'crumb-like' consistency placed and lightly compacted immediately onto the trimmed fully compacted reinforced soil for the purpose of supporting vegetation and in accordance with BS3882:2007 'Specification for Topsoil'.

B. It shall have moisture content in the range 20 to 25% when placed.

4.05 Vegetation

4.05.01 Primary vegetation

A. Grass cover will be established by applying the specified seed mix at the specified rate(typically 60g/m^2)

B. One suggested specification of seed mix is as follows or as proposed by the engineer.

75%	Creeping Red Fescue
25%	Smooth Stalked Meadow Grass

4.05.02 Secondary vegetation (where detailed on the construction drawings)

A. Ground cover vegetation will be established by planting healthy plants from an approved supplier at the base and on the face of the structure.

B. Plants on the face should be planted on a 2m square grid pattern. This is may be carried out either during or post construction but with the approval and agreement of the engineer.

C. All plants should be well established in 75mm pots prior to planting and should be seen to have a good quality rootball.

D. All plants should be correctly irrigated when necessary during the first 3 months after completion of the structure.

E. One suggested specification for ground cover planting is: Vinca Major Variegate or as specified elsewhere by the Engineer.

5. Construction

5.01 Excavation

A. Contractor shall excavate to the lines and grades shown on the Contract Drawings. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted approved infill material, or as directed by the client's Engineer.

B. Contractor shall verify the location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of any excavation. Excavation support, if required, is the responsibility of the Contractor.

5.02 Foundation Preparation

A. Following the excavation, the foundation soil shall be examined by the Engineer to assure actual foundation soil strength meets or exceeds the design bearing strength. Soils not meeting the required strength shall be removed and replaced with infill soils, as directed by the Engineer.

B. Foundation soil shall be proof rolled and compacted to 95% standard Proctor density and inspected by the Engineer prior to commencement of construction of the reinforced soil slopes.

5.03 Construction of Steep Slope

A. Cut and position the base layer of primary uniaxial geogrid reinforcement at the formation level shown on the contract drawings. The principle strength direction of the uniaxial geogrids is along the roll length and as such should be laid perpendicular to the longitudinal alignment of the slope structure. Adjacent lengths of geogrid are butt jointed at the slope face.

B. The geogrid reinforcement need not be folded up the face on NaturalGreen slopes which have a maximum face angle of 45° to the horizontal.

C. All of the geogrids should be installed to the levels, lengths and orientations as shown on the construction drawings.

D. Selected suitable fill material should be in full compliance with the needs of the design and have the approval of the engineer. Place and compact the fill in layers to the Contract's specification incorporating primary reinforcement and secondary reinforcement as shown on the construction drawings.

E. The secondary reinforcement geogrid must be laid in the correct direction. As such the material must be rolled out parallel to the face. The 4m wide material may be cut whilst still on the roll, into the widths which correspond with the construction drawing; normally 2m, but this must be checked. The newly cut narrower roll may now be laid out easily and parallel with the slope face.

F. Fill should be placed by plant such as an excavator with an opening bucket, which causes the fill to cascade onto the geogrids. A 150mm thick cover of fill must be maintained between the tracks of any plant and the geogrid to avoid damage.

G. The embankment may be overfilled, compacted and face trimmed in a conventional manner to the design angle.

H. Use of a toothless excavator bucket is recommended for face trimming to prevent snagging on the edge of the buried geogrids. Although care should be taken not to over cut, the machine performing the face trim will not cause structural damage whilst performing this task.

I. On completion of the structural filling operation the slope surface should be covered with a layer of suitable topsoil in accordance with BS3882 and the landscaping requirements. The thickness of the topsoil layer is typically 100mm thick or as indicated on the construction drawing. Over compaction of the topsoil should be avoided.

J. Where a grass cover is detailed, scatter the chosen seed mix on to the slope at the specified rate per square metre.

K. The rolled erosion control product should then be carefully installed.

L. The rolled erosion control product is rolled down the slope face lapping adjacent rolls by a minimum of 100mm. The barbed polymer pegs supplied should be used to fix the mat at 1.0m centres along the laps by driving them into the soil using an appropriate hammer, preferably rubber to prevent damage. Rolled erosion control product must follow exact slope profile and remain in contact with the underlying topsoil layer. Additional pinning and/or pinning of the centre of roll may be required.

M. Roll ends shall be buried at the shoulder and toe respectively in shallow trenches approximately 450mm wide by 250mm deep.

N. Where the rolled erosion control used is a non-biodegradable product the finished slope surface should be filled with a friable topsoil brushed into the mat and sown with selected grass seed mix.

O. If demanded by the Client, the slope may be planted with a suitable ground cover plant species as per the Client's requirements. The rolled erosion control product should be carefully cut and the chosen plants pushed into the topsoil below.

P. Care should be taken at this stage when using biodegradable rolled erosion control products to avoid exposing it to naked flame or spark, as it may be flammable until it has had the opportunity to absorb moisture.

Q. The Contractor must fully assess the safety risk associated with working on the slope and at height and where appropriate install any necessary temporary edge protection and provide operatives with the appropriate safety equipment.

6. Submission of Alternatives

6.01 Any alternative to the specified system for Reinforced Steep Slopes proposed by the Tenderer shall be submitted with the tender and shall include:

- the names of the supplier and designer
- a full set of calculations
- outline drawings
- product samples and specifications
- test certificates for the reinforcing elements

The outline drawings must be sufficient to indicate the details of the construction of the Reinforced Steep Slopes including:

- typical plans
- elevations and section drawings
- foundations
- facing details (including vegetation if appropriate)
- anchoring reinforcing elements at the face
- reinforcing element joints and overlaps
- The width and length of the soil reinforcing elements should be clearly shown along with details of their orientation in the works.

This document is drafted on an entirely generic basis and its use in any tender documentation in any way must be reviewed by the user and made specific to their project

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