TensarTech® TR2 Earth Retaining System: Model Specification

This document is intended to form a basis for Tender documents where the TensarTech® TR2 reinforced soil system is required.

1. GENERAL

This work shall consist of constructing reinforced soil structures, 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 United Kingdom experience for reinforced soil structures 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 100 year design life.

2. DESIGN

The design, materials specification and construction methods adopted shall be in accordance with DETR, HA Technical Standard BD70 Strengthened Reinforced Soils and other Fills for Retaining Walls and Bridge Abutments (DMRB 2.1.5) and Manual of Contract Documents for Highway Works (MCHW), Volume 1 Specification for Highway Works (MCHW1) November 2009 Edition or BS8006 : 2010 Code of Practice for Strengthened/Reinforced soils and other fills, whichever is appropriate. The design must be performed by the supplier of the wall system, who shall submit proof of professional indemnity insurance coverage. 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 walls in compliance with the appropriate Design Standard
C. Soils test information of the proposed reinforced soil fill
D. Method statement for construction
E. Confirmation of the Professional Indemnity cover provided by the Wall 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 wall system.

3.01 Steel Mesh Facing Units

A. **BS4483:1998** - Steel fabric for the reinforcement of concrete
B. **BS EN ISO 1461-2009** - Hot dip galvanized coatings on fabricated iron and steel articles

3.02 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 geotextile related products. Determination of tensile creep and creep rupture behaviour

3.03 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 wall system will comprise structural steel mesh facing units, needle punched geotextile face liner uniaxially orientated high density polyethylene geogrids and a high efficiency positive connection between face and geogrid.

4.01 Steel Mesh Facing

A. Steel mesh should be welded high tensile steel mesh, Grade 460 structural fabric, manufactured in accordance with BS4483:1998

B. Longitudinal bar diameter will be a minimum of 10mm at 100mm spacing and the transverse bar diameter will be a minimum of 8mm at a 200mm spacing

C. Minimum weight shall be 8.14kg/m^2

D. Where specified the steel mesh facing will be galvanised in accordance with BS EN ISO 1461 : 2009 with a minimum mean coating of 85 µm.

4.02 Geogrid Reinforcement

A. The 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 P_C (Ultimate Limit State), for a design life of either 60 or 120 years, shall be in accordance with the following tables 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 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

		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

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 geogrid shall have an independent test certificate proving resistance and durability in a pH range of 2.0 to 12.5. Specifically, 'The a sample of the geogrid classification 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.

4.03.1 Face to geogrid connection

A. The connection between the steel mesh facing units and the geogrid shall be a continuous mechanical connection. The geogrid is connected to the face by looping around a 12mm dia. steel bar on the outside of the face and by connecting back onto itself using a high strength bodkin connection.

4.04 Geotextile Face Liner

A. The face liner shall be a black needle punched geotextile manufactured from 100% virgin polypropylene in compliance with the following specification:

B. The geotextile shall be manufactured in accordance with a Quality Management System which complies with the requirements of BS EN ISO 9001:2000.

Polymer	100% virgin black polypropylene
Thickness (mm) under 2kPa according to BS4501:1987	3.50
Unit weight (gm^{-2})	400
Maximum Tensile Strength (kN/m) according to BS EN ISO 10319:1996	
MD	16
TD	32
Elongation at Maximum Tensile Strength(%) according to BS EN ISO 10319:1996	
MD	110
TD	75
Puncture Resistance (CBR) according to BS EN ISO 12236	
Maximum Force (kN) (5)	3.5
Maximum Displacement (mm) (6)	67
Metal Detector test for broken needles	YES
Roll size (m)	2.1 x 50
Roll weight (kg)	44

4.05 Reinforced (Infill) Soil

4.05.1 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 Wall 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.

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 Engineer.

B. Contractor shall verify 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 Owner's 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 compacted approved 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 Clients Engineer prior to placement of Steel Mesh panels and reinforced fill.

5.03 System Installation

A. The steel components may be galvanised although this is not usually necessary and is dependent on the requirements of the design.

B. Steel components may be stored outside without fear of damage from the weather.

C. Geogrids are delivered in either 75m or 50m long x 1.3m wide rolls and may be stored outside without fear of damage from the weather.

D. Prepare a level foundation as required by the contract.

E. The high tensile steel mesh face consists of 10mm bars at 100mm spacing and 8mm bars at 200mm spacing. The mesh should be cut into 2.4m x 2.4m square panels or similar.

F. Position the steel mesh face in accordance with the drawing, with the 10mm bars vertical. Use the "L" shaped bars at 1.2m horizontal spacing to keep the first lift of mesh at the correct angle by tying to the steel mesh face with a suitable tying wire. It may also be necessary to prop or tie back the face temporarily to maintain alignment.

G. The face liner geotextile, which is normally a non-woven needle-punched fabric, should be placed and fixed inside the steel mesh face. This face liner needs to be lapped back horizontally top and bottom between the layers of geogrid by a minimum 100 mm to prevent loss of fines from the fill material.

H. Place and compact fill in accordance with the Contract specification up to the level of the lowest geogrid layer. Fill should be placed by plant such as an excavator bucket or a dozer with an opening bucket, which causes the fill to cascade onto the grids. A minimum of 150mm thick cover of fill must be maintained between the tracks of any plant and the geogrid to avoid damage.

I. Compact fill in layers. Only nominal compaction is required for the 150mm directly behind the face but elsewhere compaction should be in accordance with the latest DOT Specification for Highway Works . Use a vibrating plate compactor or vibrating roller with a mass per metre width less than 1300kg and a total mass less than 1000kg within 2m of the face.

J. Return the geotextile over the fill with a minimum of 100mm horizontal lap.

K. Cut and position the first layer of geogrid and connect to the face using the horizontal anchor bar and the HDPE bodkin. Adjacent lengths of geogrid are butt jointed at the face.

L. It is important that if the centre of any anchor bar is less than 50mm above the centre of the horizontal bar of the steel mesh face, then the level of that geogrid and it's anchor bar shall be lowered so that it is located immediately below that horizontal bar of the steel mesh face. This will accommodate settlement of the fill and geogrid relative to the face.

M. Tension from the free end of grid using a tensioning beam inserted through the apertures until all the slack is removed from the face connection.

N. Whilst maintaining tension, place a layer of fill on the grid, which will be sufficient to restrain it when the load is removed. Release the tension and remove beam.

O. Position the next geotextile liner with a minimum horizontal lap of 100mm.

P. Place and compact fill in layers up to the next layer of geogrid. All geogrids should be installed to the levels, lengths and orientation as shown on the contract drawings.

Q. Repeat steps K-P up to the design height of the structure extending steel mesh as necessary by tying in additional panels with a vertical lap of 400mm and a horizontal lap of 90mm.

R. Protect the exposed top of the vertical mesh bars with the plastic caps provided.

S. The Contractor must fully assess the safety risk associated with working at height and where appropriate install any necessary temporary edge protection.

T. As well as following procedures for health and safety, it is essential when handling wire products that protective glasses and gloves are worn.

6. SUBMISSION OF ALTERNATIVES

6.01 Any alternative to the specified system for Reinforced Soil Structure 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 Soil Structure 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.

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