TensarTech® TW1 Earth Retaining Wall System: Model Specification

This document is intended to form a basis for Tender documents where the TensarTech® TW1 reinforced soil system is required.

1. General

This work shall consist of constructing retaining walls using a proprietary concrete modular block faced, reinforced soil wall 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. The contractor shall provide a complete set of drawings issued for construction and complete specifications of the proposed wall system for the approval of the Engineer 60 days prior to ordering materials to construct said walls, 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 system must demonstrate previous International experience for reinforced soil walls with a minimum height of 20.0m and a minimum in service life of 20 years.
The wall system as a whole shall have a current British Board of Agrèment (BBA) HAPAS certificate, demonstrating suitability for use in highways walls and abutments 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 Modular Block Retaining Wall Units

A	**BS EN 12878 : 2005**	Pigments for the colouring of building materials based on cement and/or lime
B	**BS 6073-2 : 2008**	Precast concrete masonry units. Specification for precast concrete masonry units

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 geotextiles 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

4. MATERIALS

The wall system will comprise interlocking concrete block facing units, uniaxially orientated high density polyethylene geogrids and connectors designed to ensure a high efficiency mechanical connection between wall face and geogrid. The independent approval certificate will have assessed this connection efficiency.

4.01 Modular Block Facing Units

A. The blocks shall be machine manufactured from Portland cement concrete specifically designed for use in a reinforced soil retaining wall system.

B. Colour of the facing units shall be as specified by the engineer/client.

C. The blocks shall have a straight split/textured face finish.

D. Block height should be between 150mm and 200mm.

E. Block units shall contain no voids and be solid through the full depth of the unit.

F. Blocks when installed shall have gap not greater than 2mm between adjacent units

G. Block units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the structure. Cracking or excessive chipping may be grounds for rejection. Units showing cracks longer than 13mm shall not be used within the wall. Units showing chips visible at a distance of 10 metres from the wall shall not be used within the wall.

H. Concrete used to manufacture block units shall have a minimum 28 days compressive strength of 30Nmm^{-2} and a maximum moisture absorption rate, by weight, of 6% as determined in accordance with BS 7263-1:1994.

I. Minimum density is 2100 kg/m^3 when tested in accordance with the method of BS 6073-2 : 1981, Appendix C

J. Modular block facing unit dimensions shall not differ more than ± 2mm from the dimensions specified in the current BBA certificate.

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 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 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.

H. 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.

I. The 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 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.'

J. 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.

K. 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 Face to geogrid connection

A. The connection between the modular block facing unit and the geogrid shall be a mechanical continuous connection manufactured using an approved High Density Polyethylene. The allowable connection strength at the face (T_{conn}) to be used in the design shall have been tested and independently assessed for each grade of geogrid reinforcement used in the design and published in the relevant BBA Roads and Bridges certificate. Pin or frictional connections shall not be allowed.

4.04 Drainage Aggregate

A. Drainage aggregate shall be angular, clean stone or granular fill meeting the following gradation as determined in accordance with BS EN 13285 : 2010

B.

Sieve Size (mm)	Percent Passing
40	100
20	80 – 99
10	50 - 90
4	30 – 75
2	15 – 60
0.500	0 – 35
0.125	0 - 4
0.063	0 - 3

4.05 Reinforced (Infill) Soil

The reinforced soil material proposed should comply with the specification for 6I/6J material as detailed in Tables 6/1 and 6/2 of the 'MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS VOLUME 1 SPECIFICATION FOR HIGHWAY WORKS – Series 600 for Earthworks'
This material should be well graded crushed and granular not sub-rounded, and should also comply with the following:

A. Minimum angle of friction ($ø_p'$) of 30 degrees

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 project grading plans. 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 the location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of wall 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 Engineer prior to placement of levelling pad materials.

5.03 Levelling Pad Construction

A. Levelling pad shall be placed as shown on the construction drawings with a minimum thickness of 150mm. Material for levelling pad shall consist of mass concrete with a minimum 28 days compressive strength of 30Nmm-2 The levelling pad should extend laterally at least a distance of 150mm min from the toe and heel of the lower most course of blocks.

5.04 Modular Block Facing and Geogrid Installation

A. The retaining walls shall be installed at the proper elevation and orientation as shown on the wall profiles and details on the construction plans or as directed by the Engineer. The wall system shall be installed in general accordance with the manufacturer's recommendations. The specifications and drawings shall govern in any conflict between the two requirements.

B. The first course is critical for accurate and acceptable construction.

C. Base blocks with a flat underside are used for the initial course. A single course of Base block should be bedded on mortar to the correct line & level. Where Base blocks are not locally available Standard blocks can be used for the initial course by laying a thicker mortar bed to accommodate for the downstand.

D. Allow the mortar bed to cure before laying additional courses.

E. Place and compact approved fill in accordance with the latest version of Manual of Contract Documents for Highway works (MCHW), Volume 1 specifications for Highway Works (MCHW1) Series 600 for Earthworks, Highways document November 2009, or as specified in the contract documents, up to the top of the course. All construction plant, with a mass exceeding 1000 kg should be kept at least 2m from the face of the wall. Use a vibrating plate compactor or vibrating roller with a mass per meter width less than 1300kg and a total mass less than 1000kg within 2m of the face. Install a minimum 150mm width of drainage material (MCHW Type A or as specified in the contract documents) immediately behind the face. Reference should be made to construction drawings where applicable and/or local fill specification for the country of construction.

F. Cut the geogrid from the roll to the required design length. At one end ensure that a row of ribs is trimmed to a length of 50mm (across the full width of the roll). Do not cut them back to the transverse bar.

G. Remove all debris from the top of the units using a brush.

H. Place the prepared end of the geogrid over the rebate in the block & locate the moulded connectors around the transverse bar. Ensure that each aperture of the geogrid is covered by a connector. The connectors should be split where necessary.

I. Position the assembly neatly into the rebate with the trimmed ribs towards the face.

J. Repeat this procedure for the whole course ensuring that adjacent lengths of geogrid are abutted at the wall face not lapped.

K. Once again, ensuring all debris is brushed away, place the next course of blocks (Standard block are now used right up to the coping course). They should be placed stretcher bond & arranged so that the downstand is pushed up against the front of the rebate in the lower unit.

L. Pull the free end of the geogrid so that the moulded geogrid connectors are up against the rear of the rebate.

M. Place a minimum of three further courses of blocks ensuring they are pushed fully forward and are square with the previous course. Every course of blocks should be checked for horizontal and vertical alignment and the line and level of the wall overall checked every 3rd course. Any adjustment necessary may be made using ribs cut from the geogrid or approved shims, placed in between blocks.

N. Insert the tensioning beam through the apertures at the free end of the geogrid & apply a load sufficient to remove any slack.

O. Whilst maintaining tension, place a layer of fill on the geogrid which is sufficient to retain it in position when the load is released. Release the tension & remove the beam.

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

Q. Plant used to place fill should be kept at least 2m away from the face.

R. If Link blocks are specified for an architectural masonry face to be attached, the approved stainless steel ties provided should be inserted into the slots of the Link blocks, during the laying process. A rate of three ties to every square metre of face in a staggered pattern should be used.

S. Place and compact fill in 150mm lifts, keeping blocks a minimum of three courses above the fill until the top of the structure is reached. Compaction should always commence nearest the face, working away toward the free end of the geogrid. Any lengths of geogrid fitted into the wall face above the level of fill should be temporarily folded over the top of the wall to provide a free working area.

T. Repeat steps E-S to construct the wall to the required height. The drainage material should be excluded from behind the upper 0.5m of wall height.

U. The top course of blocks should be bonded to the course below using engineering adhesive. Extrude a line of adhesive either side of the rebate of the lower units & place the top course, pressing firmly to locate.

V. In order to achieve good line & level, the coping units should be bedded on mortar. When alignment of the wall is curved or angled, the coping units require cutting on site to achieve best fit.

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

5.05 Construction Adjacent to Completed Wall

A. The contractor is responsible for ensuring that construction adjacent to the wall by others does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of 1m behind the back of the wall face. Equipment with equivalent loading in excess of 15kN/m^2 live load shall not be operated within 3m of the face of the retaining wall during construction. Care should be taken by the General Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems and erosion protection measures are completed.

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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