TensarTech® RockWall™ Earth Retaining Structures: Model Specification

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

1. GENERAL

This work shall consist of constructing reinforced soil structures (often referred to as strengthened earthworks or mechanically stabilised earth) typically using a proprietary Welded Mesh Facing Unit, 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 a 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 provider of the proposed system must demonstrate previous International experience for design and construction of reinforced soil systems with a minimum height of 20.0m and a minimum in service life of 20 years.

The geogrid 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 choice and specification of the system shall address the climatic and soil conditions existing specific to the site in question and provide a minimum design life of 60 years and up to 120 years if specifically required to do so. 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 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 reinforced soil 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. **BS EN 10218-2:2012** - Steel wire and wire products. General. Wire dimensions and tolerances
B. **BS EN 10244-2:2009** - Non-ferrous metallic coatings on steel wire – Part 2:Zinc or zinc alloy coatings on steel wire

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 reinforced soil system will comprise of structural steel mesh facing units, uniaxially orientated high density polyethylene (HDPE) geogrids and a high efficiency mechanical connection between facing and primary geogrid.

4.01 Steel Mesh Facing Units

A. Manufactured from steel mesh with nominal square openings of 75mm.

B. The steel shall be Galfan® coated and where required PVC coated to produce an extremely high level of corrosion resistance.

C. The nominal wire diameter shall be 3.0mm for the lid, base, back and internal panels and from 4.0mm wire diameter for the face panel.

D. The units when fabricated are jointed with Galfan® coated helical spirals for speed and security. Lacing wire of nominal diameter of 2.5mm may also be used.

E. The units are delivered folded flat ready for rapid fabrication in 2.025m long x 0.675m high units, complete with two internal diaphragms and corner ties.

F. Base panels extend 0.225m beyond the back of the 0.675m wide facing unit, ready to accept the geogrid and polymer bodkin connection.

G. All facing units are supplied with sufficient Galfan® coated helical spirals, internal corner ties and lacing wire for connection purposes on site.

4.02 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 (HDPE) 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 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 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 sample of the 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.

4.03 Steel Mesh Facing Unit to Geogrid Connection

A. The connection between the steel mesh facing units and the geogrid shall be a continuous mechanical connection. The full width of geogrid is connected to the horizontal base panel of the facing unit using a HDPE bodkin of minimum 12mm diameter. Friction only connections, those using tie wire or a combination of both will not be allowed.

4.04 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 (MCHW) VOLUME 1 SPECIFICATION FOR HIGHWAY WORKS (MCHW1) – Series 600 for Earthworks, Highways Agency document November 2009'
This preferred material should be well graded crushed and granular not sub-rounded, and should also comply with the following:

A. Minimum angle of friction ($ø_{cv}$') of 30 degrees

B. The contractor should provide the Reinforced soil 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.

C. The contractor may propose the use of an alternative fill material such as a consistent good quality cohesive or semi cohesive material as well as recycled materials. Proposals should also include provision for any additional drainage materials that may be necessary along with the design properties for use in the design.

4.05 Fill to Steel Mesh Facing Units

A. The fill shall be hard durable and non frost susceptible (rock or stone type) having a maximum dimension not less than the mesh opening and a maximum dimension of 200mm.

B. Placing the external layer of stone by hand can give a better appearance to the completed wall to be constructed without affecting the strength of the steel mesh facing unit structure.

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 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 Clients Engineer prior to placement of the steel mesh facing units and reinforced fill.

5.03 Steel Mesh Facing Units and Geogrid Installation

A. When handling wire or wire mesh, the cut ends may cause injury, therefore the installation Contractor should ensure that all operatives have and use the appropriate Personal Protective Equipment including: protective gloves, fluorescent jacket, eye wear and footwear.

B. Where mesh has been cut, any free ends should be trimmed or turned inwards so that they do not protrude outside the facing unit.

C. Guard rails should be installed where safety is an issue on unprotected embankment edges.

D. Open out the facing unit flat and rotate front, rear, ends and diaphragms vertically and join by manual lacing using tie wire provided by the supplier in accordance with Note [1].

E. Where helical binders are specified for use on vertical joints, the top and bottom helical turn should be rotated through 90 degrees to prevent movement. All horizontal joints are to be laced as described in Note [1].

F. Prepare the formation to line and level in accordance with the contract documents.

G. Cut the lengths of the required grade of geogrid from the roll as indicated by the design drawings. Place on to the formation with the leading edge at the front edge of the structure. Ensure that the geogrid is orientated in the correct direction.

H. Place the assembled facing units in position to the correct line, level and inclination as required by the design and form the joints to the adjacent units using either helical binders (where specified for vertical joints) or tie wire provided by the supplier referring to Note [1].

I. The same procedure is to be carried out to the rear of the unit. Ensure that the 'tail' at the base of the unit is facing backwards.

J. The geogrid should now be connected to the tail at the base of the facing units using the polymer bodkins provided by the supplier. The geogrid should run all the way through to the front of the unit with the bodkin joint formed at midpoint of the tail (refer to Figure 1). Adjacent lengths of geogrid are butt jointed at the face or a specified on the contract drawings.

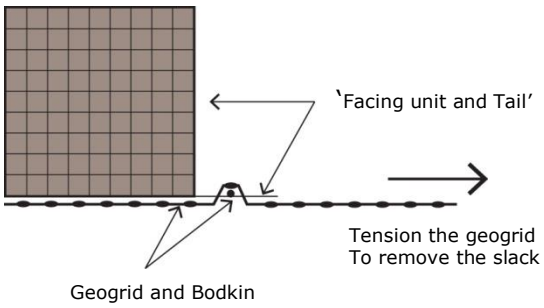

Figure 1 – Positive connection between geogrid and facing unit using bodkin detail

K. Insert the tensioning beam [2] through the apertures at the free end of the geogrid & apply a load sufficient to remove any slack. Further tensioning will be required once facing unit is filled (refer to step V).

L. Where specified and supplied geotextile should be cut and fixed to the inside rear face of the facing unit. It should be turned back through 90°into the facing unit at the top, bottom and sides by a minimum of 150mm. It may be located carefully using the wire provided or with plastic cable ties.

M. Selected rock fill for the facing unit should be hard, durable, non-frost susceptible rock, stone or clean crushed concrete as specified by design. The grading of the fill is to be 100 to 150mm or 100 to 200mm.

N. Rock fill material at the face should be hand placed to achieve a neat finish as possible and with the effect of a dry-stone wall. Working in this fashion will help to control bulging and movement at the face.

O. Fill the facing unit to half height ensuring no large voids are present. The fill should be manually redistributed to ensure, as far as possible, that the fill is tightly packed to avoid later internal settlement. The internal pre formed corner ties must now be installed.

P. Hook the pre formed corner tie, 3 meshes in from the corner around a mesh joint intersection on the face and rear panel. Diagonally brace to the side panels, 5 meshes back and rotate the free end around a mesh joint intersection wrapping around to secure by twisting the return end over its own stem (refer to Figures 2 & 3).

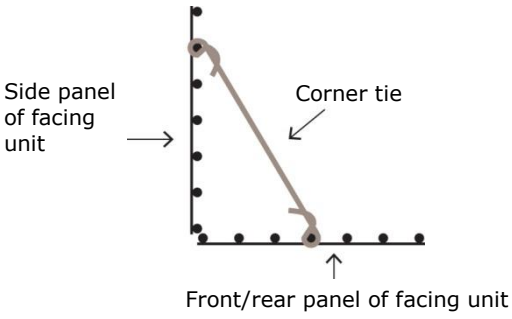

Figure 2 – Plan view of corner tie location

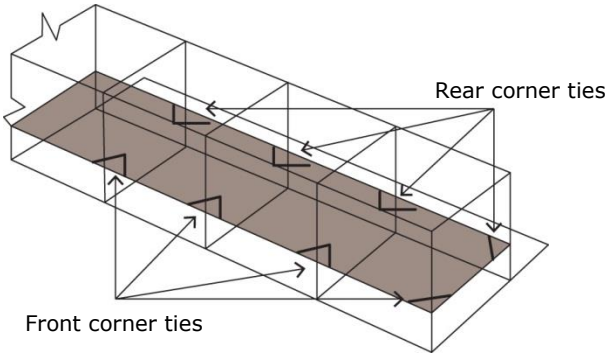

Figure 3 – corner ties installed

Q. Should bulging of the face occur, then ensure the corner ties are correctly installed. Loose or over-tightened ties will cause bulging to occur. Timbers or scaffold tubes can be temporarily wired to the face externally to act as a shuttering to prevent bulging and removed when filling is complete.

R. Repeat the filling operation to the full height of the facing unit. Ensure that the cells are filled sequentially such that the difference in fill in adjacent cells is never greater than half of the cell height.

S. If a run of facing units is not filled to each level in one go, then always step down the filling at the end otherwise facing unit distortion will occur. This also allows further facing units to be connected later (refer to Figure 4). At no time try to completely fill one cell at a time, unless the unit has internal bracing in both directions.

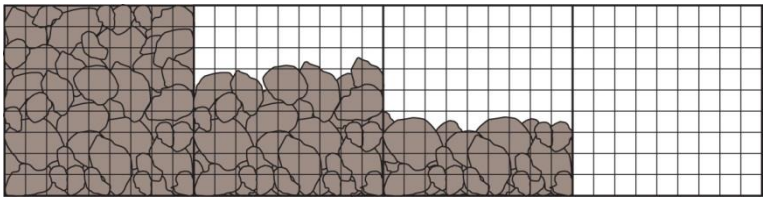

Figure 4 – Stepping down the fill at the end to avoid distortion

T. When filling to full height, ensure that when the lid is closed the mesh is a tight fit onto the rock without the need to apply too much force so as to cause the facing unit to distort or risk breaking the welds in the lid. Use the tie wire provided to lace all sides, end and diaphragm panels as per Note [1].

U. When the first course of facing units is filled and the lids fixed into position the structural fill may be placed behind. Selected structural fill material should be in full compliance with the needs of the design and have the approval of the Engineer.

V. Tension from the free end of geogrid using tensioning beam [2] inserted through the apertures until the geogrid is tight and laying flat.

W. Whilst maintaining tension, place a layer of fill on the geogrid, which will be sufficient to restrain it when the load is removed. Release the tension and remove the beam and compact the fill in accordance with Contract specification, up to the level of the next 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 geogrid. A minimum of 150mm thick cover of fill must be maintained between the tracks of any plant and the geogrid to avoid damage. Care should be taken during this operation to maintain the alignment of the facing units.

X. All construction plant, including compaction equipment with a mass exceeding 1000kg should be kept at least 2m from the face of the wall. Compaction plant within 2m of the wall should be restricted to vibrating rollers having a mass per metre width not exceeding 1300kg or plate compactors with a mass less than 1000kg.

Y. Compaction should always commence nearest the facing units, working away towards the free end of the geogrid.

Z. Once the structural fill has reached the top of the facing unit, the next geogrid layer and course of facing units may be placed. It is recommended that the facing units are tiered to achieve the necessary face angle and they should be continually joined using tie wire supplied to the course below along all horizontal joints at the front of the wall. Refer to Note [1] for lacing requirements. The facing units should be aligned so that the bottom edge wire of the upper unit lines up with a longitudinal wire on the mesh of the lower facing unit.

AA. Wherever possible the next course should be offset horizontally by a half unit width to ensure vertical joints are not coincident (effectively stretcher bond).

BB. Construction should proceed as described in steps A to AA.

CC. So far it has been assumed that the geogrid has been located at base level of each of the facing units. However in some circumstances such as in particularly high structures geogrid reinforcement may be detailed at half or even third height of the facing units. In this situation the geogrid may be connected to the rear face of the facing unit with a bodkin (refer to Figure 5).

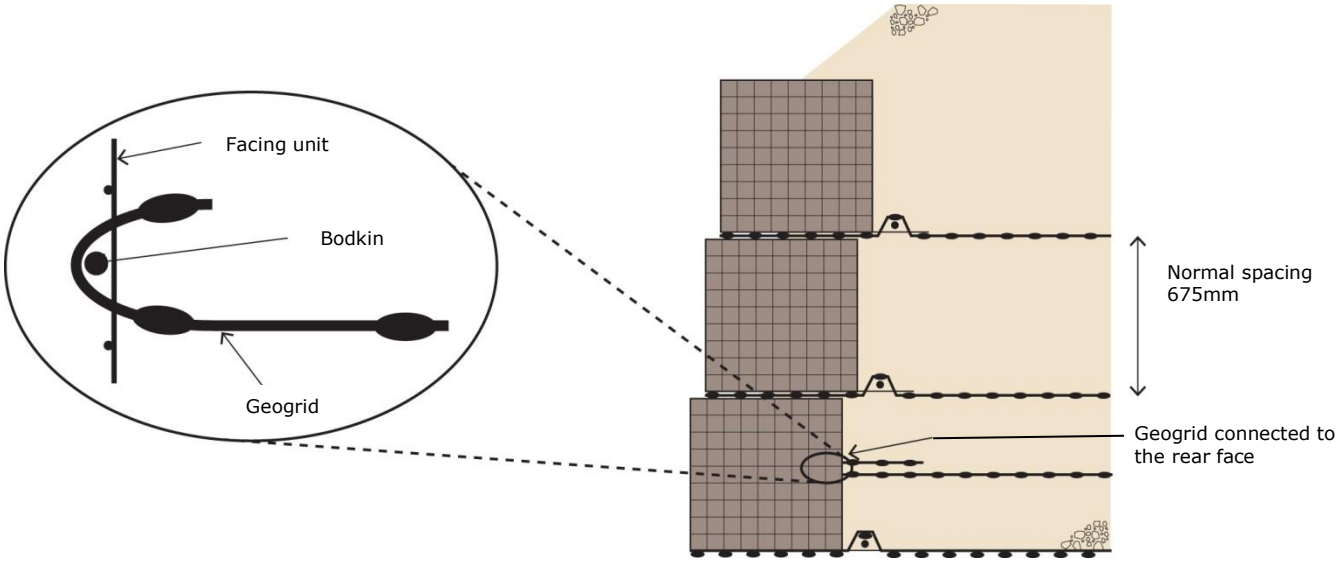

Figure 5 – additional geogrid connected to rear of facing unit if required

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

EE. The contractor is responsible for checking wall geometry during construction and taking all necessary actions to ensure that wall tolerance is met in accordance with Tensar recommendations.

Notes

1. Lacing is to be one continuous wiring operation along all joints both vertically and horizontally using single and double twists on alternative apertures ensuring that it forms a tight joint. Start and termination of lacing is formed by three turns ensuring the free end is turned into the unit. Tie wire supplied is 2.5mm diameter.

2. A suitable tensioning beam should be used to remove the slack from the geogrid and bodkin joint. The Reinforced soil supplier should supply a proprietary item for this purpose.

6. Submission of Alternatives

6.01 Any alternative to the specified system for Reinforced Soil 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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