HAPAS

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HAPAS Certificate
13/H201
Product Sheet 1

TENSAR RETAINING WALL SYSTEMS

TENSAR RE AND RE500 GEOGRIDS

This HAPAS Certificate Product Sheet[1] is issued by the British Board of Agrément (BBA), supported by Highways England (HE) (acting on behalf of the Overseeing Organisations of the Department for Transport; Transport Scotland; the Welsh Government and the Department for Infrastructure, Northern Ireland), the Association of Directors of Environment, Economy, Planning and Transport (ADEPT), the Local Government Technical Advisers Group and industry bodies. HAPAS Certificates are normally each subject to a review every three years.
(1) Hereinafter referred to as 'Certificate'.

This Certificate relates to Tensar[1] RE and RE500 Geogrids, a range of uniaxial geogrids manufactured from polyethylene sheet, used in conjunction with precast concrete facing panels and compacted fill material to construct reinforced soil retaining walls and bridge abutments.
(1) Tensar is a registered trademark of the Certificate holder in the UK and other countries.

CERTIFICATION INCLUDES:
- factors relating to compliance with Building Regulations where applicable
- factors relating to additional non-regulatory information where applicable
- independently verified technical specification
- assessment criteria and technical investigations
- design considerations
- installation guidance
- regular surveillance of production
- formal three-yearly review.

KEY FACTORS ASSESSED

Design — interaction between the soil and geogrids has been considered and coefficients relating to direct sliding and pull-out resistance are proposed (see section 6).

Mechanical properties — the short- and long-term tensile strength and elongation properties of the geogrids, loss of strength due to installation damage and reduction in strength at the connection to the facing panels have been assessed and reduction factors established for use in design (see sections 7 and 9).

Durability — the resistance of the geogrids to the effects of oxidation, chemical and biological degradation and exposure to UV light normally encountered in reinforced soil retaining walls and bridge abutments has been assessed and reduction factors established for use in design. The precast concrete facing panels will have adequate durability for the proposed life of the structure (see sections 8 and 11).

The BBA has awarded this Certificate to the company named above for the products described herein. These products have been assessed by the BBA as being fit for their intended use provided they are installed, used and maintained as set out in this Certificate.

On behalf of the British Board of Agrément

Date of Third issue: 29 July 2021

Originally certificated on 3 July 2013

Hardy Giesler
Chief Executive Officer

The BBA is a UKAS accredited certification body – Number 113.
The schedule of the current scope of accreditation for product certification is available in pdf format via the UKAS link on the BBA website at www.bbacerts.co.uk
Readers MUST check the validity and latest issue number of this Agrément Certificate by either referring to the BBA website or contacting the BBA directly.
Any photographs are for illustrative purposes only, do not constitute advice and should not be relied upon.

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Requirements

In the opinion of the BBA, Tensar RE and RE500 Geogrids for reinforced soil retaining walls and bridge abutments, when used in conjunction with precast concrete facing panels and compacted fill material in accordance with the provisions of this Certificate, will satisfy the requirements of Highways England and local Highway Authorities for the design and construction of reinforced soil retaining walls and bridge abutments.

Regulations

Construction (Design and Management) Regulations 2015
Construction (Design and Management) Regulations (Northern Ireland) 2016

Information in this Certificate may assist the client, designer (including Principal Designer) and contractor (including Principal Contractor) to address their obligations under these Regulations.

See section: 1 *Description* (1.1 to 1.3) and the *Installation* part of this Certificate.

Additional Information

CE marking

The Certificate holder has taken the responsibility of CE marking the products in accordance with harmonised European Standard BS EN 13251 : 2016.

Technical Specification

1 Description

1.1 The system incorporating the products covered by this Certificate comprises:

- Tensar RE and RE500 Geogrids
- concrete facing panels
- Tensar Bodkins
- fill material
- Tensar RE and RE500 Geogrids.

1.2 Tensar RE and RE500 Geogrids are uniaxial geogrids manufactured from sheet polyethylene, punched and stretched under temperature-controlled conditions. The RE500 grades are manufactured to give enhanced long-term tensile strength performance, where required (see section 7).

1.3 The range and specification of the geogrids covered by this Certificate are shown Figure 1 and Tables 1 to 3. Each grade of geogrid is available in 1.0 or 1.3 m wide rolls and in either 50 or 75 m lengths, as shown in Tables 1 and 2.

Figure 1 Dimensional details of Tensar Re and RE500 Geogrids

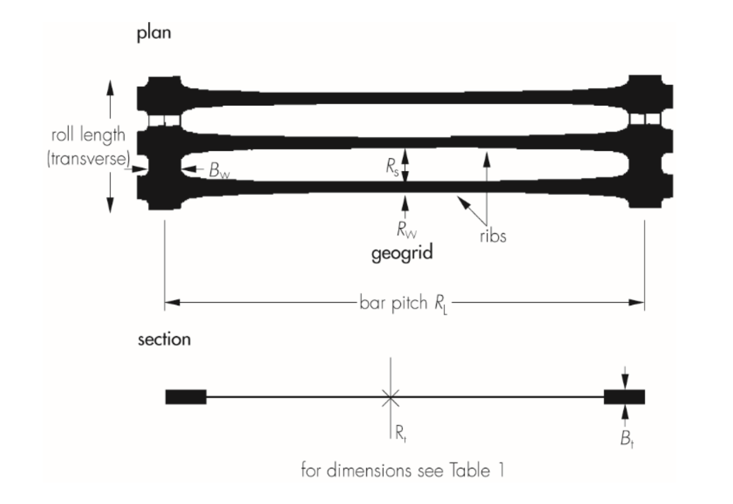


Table 1 Tensar RE Geogrid dimensional data

Dimension[(1)]	Geogrid grade			
	40RE	55RE	80RE	120RE
Bar pitch (R_L)	235	235	235	235
Rib width (R_W)	6.0	6.0	6.0	6.0
Rib thickness (R_t)	0.9	1.1	1.5	2.3
Clear space between ribs (R_S)	16	16	16	16
Bar width (B_W)	16	16	16	16
Bar thickness (B_t)	2.0 to 2.2	2.5 to 2.7	3.6 to 3.9	5.6 to 6.0
Grid mass ($kg \cdot m^{-2}$)	0.36	0.45	0.63	0.98
Mean grid size	22 x 235	22 x 235	22 x 235	22 x 235
Mean aperture size	16 x 219	16 x 219	16 x 219	16 x 219
Roll length (m)	75	50	50	50
Roll width (m)	1.0 or 1.3	1.0 or 1.3	1.0 or 1.3	1.0 or 1.3
Weight of roll (kg)[(2)]	28.0 or 37.0	24.0 or 31.0	34.0 or 45.0	51.0 or 67.0
Colour coding[(3)]	Blue	Yellow	Orange	Dark Green

(1) Dimensions in mm unless shown otherwise.
(2) Nominal roll weight dependent on roll width selected.
(3) Colour coding applied to label and roll end (see section 3).

Table 2 Tensar RE500 Geogrid dimensional data

Dimension[(1)]	Geogrid grade					
	RE510	RE520	RE540	RE560	RE570	RE580
Bar pitch (R_L)	235	235	235	235	235	235
Rib width (R_W)	6.0	6.0	6.0	6.0	6.0	6.0
Rib thickness (R_t)	0.8	0.9	1.1	1.5	2.0	2.3
Clear space between ribs (R_S)	16	16	16	16	16	16
Bar width (B_W)	16	16	16	16	16	16
Bar thickness (B_t)	1.8 to 2.0	2.0 to 2.2	2.5 to 2.7	3.6 to 3.9	4.8 to 5.2	5.6 to 6.0
Grid mass ($kg \cdot m^{-2}$)	0.29	0.36	0.45	0.63	0.87	0.98
Mean grid size	22 x 235	22 x 235	22 x 235	22 x 235	22 x 235	22 x 235
Mean aperture size	16 x 219	16 x 219	16 x 219	16 x 219	16 x 219	16 x 219
Roll length (m)	75	75	50	50	50	50
Roll width (m)	1.0 or 1.3	1.0 or 1.3	1.0 or 1.3	1.0 or 1.3	1.0 or 1.3	1.0 or 1.3
Weight of roll (kg)[(2)]	23.0 or 30.0	28.0 or 37.0	24.0 or 31.0	34.0 or 45.0	45.0 or 59.0	51.0 or 67.0
Colour coding[(3)]	Brown	Blue	Yellow	Orange	White	Green

(1) Dimensions in mm unless shown otherwise.
(2) Nominal roll weight dependent on roll width selected. All weights and dimensions are typical unless stated.
(3) Colour coding applied to label and roll end (see section 3 of this Certificate).

Table 3 Performance characteristics				
Product grade	Short-term tensile strength(1) (kN per m width)			Strain at maximum tensile strength(1) (%)
	Mean value(2)	Tolerance(2)	T_{char}	
40RE	57.0	-4.2	52.8	11.0 ± 3.0
55RE	68.0	-3.5	64.5	11.0 ± 3.0
80RE	93.0	-4.3	88.7	11.0 ± 3.0
120RE	142.0	-4.7	137.3	11.0 ± 3.0
RE510	46.2	-4.0	42.2	11.0 ± 3.0
RE520	57.0	-4.2	52.8	11.0 ± 3.0
RE540	68.0	-3.5	64.5	11.0 ± 3.0
RE560	93.0	-4.3	88.7	11.0 ± 3.0
RE570	123.0	-4.6	118.4	11.0 ± 3.0
RE580	142.0	-4.7	137.3	11.0 ± 3.0

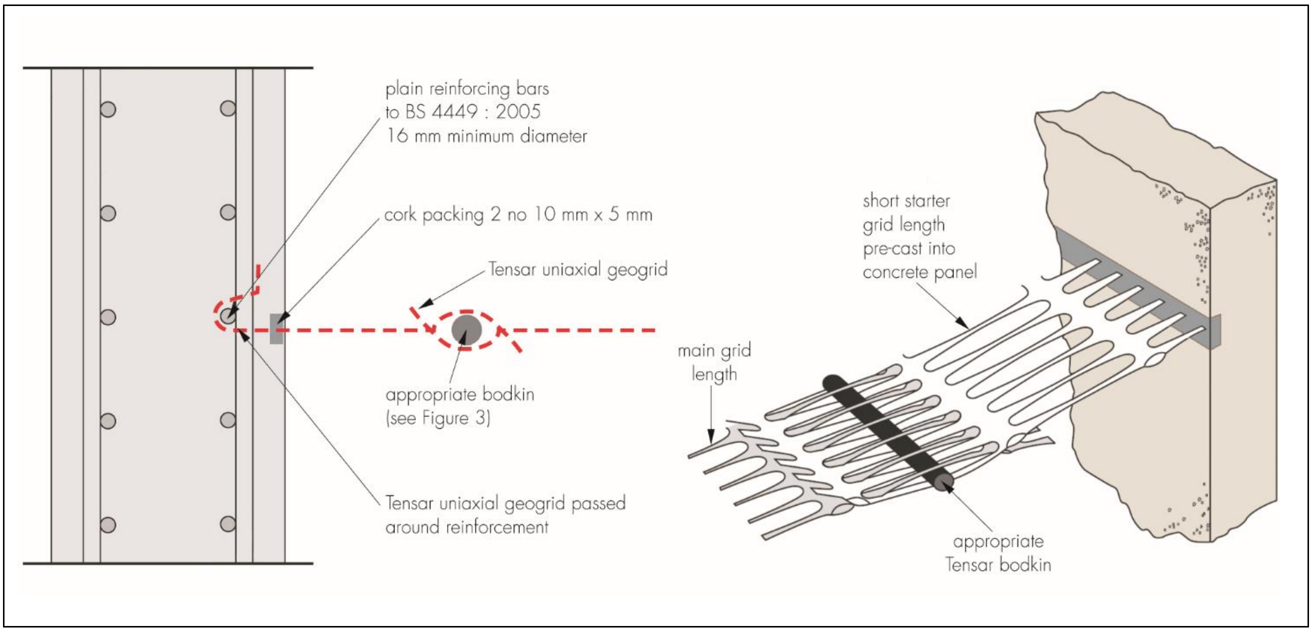
(1) Short-term tests are in accordance with BS EN ISO 10319 : 2008.
(2) Data shown is given in the manufacturer's CE Marked Declaration of Performance.

Specification for precast concrete facing panels

1.4 The precast concrete facing panels used in conjunction with the geogrids must be designed and manufactured in accordance with BS 8006-1 : 2010 + A1 : 2016, BS EN 14475 : 2006, BS EN 1992-2 : 2005 and the requirements in sections 6.8 to 6.11 of this Certificate.

1.5 The connection detail assessed and approved by the BBA for connection of the geogrids to the concrete facing panels is shown in Figure 2.

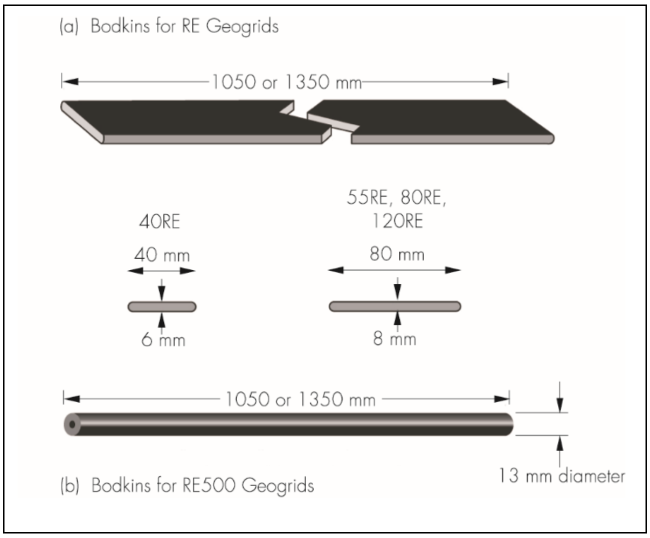
Figure 2 Connection to concrete facing panels



Tensar Bodkins

1.6 Tensar Bodkins manufactured from high-density polyethylene (HDPE) bars (see Figure 3) are used to join lengths of Tensar RE and RE500 Geogrids when a full strength connection is necessary.

Figure 3 Tensar bodkins



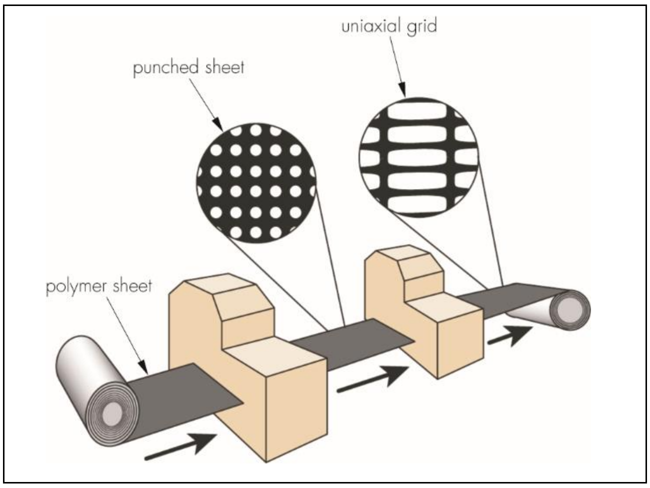
Specification for fill materials

1.7 The fill materials must comply with the requirements set out in BS 8006-1 : 2010 + A1 : 2016 and the *Manual of Contract Documents for Highways Works* (MCHW), Volume 1 *Specification for Highways Works* (SHW).

2 Manufacture

2.1 Tensar RE and RE500 Geogrids are manufactured from an approved list of polyethylene sheet polymers, which are punched and stretched under temperature-controlled conditions to give the required dimensions and short- and long-term tensile strength (see Figure 4).

Figure 4 Manufacturing process



2.2 Tensar Bodkins are bought-in to one agreed specification.

2.3 As part of the assessment and ongoing surveillance of product quality, the BBA has:

- agreed with the manufacturer the quality control procedures and product testing to be undertaken
- assessed and agreed the quality control operated over batches of incoming materials
- monitored the production process and verified that it is in accordance with the documented process
- evaluated the process for management of nonconformities
- checked that equipment has been properly tested and calibrated
- undertaken to carry out the above measures on a regular basis through a surveillance process, to verify that the specifications and quality control operated by the manufacturer are being maintained.

2.4 The management systems of Tensar International Limited have been assessed and registered as meeting the requirements of BS EN ISO 9001 : 2015 and BS EN ISO 14001 : 2015 by the British Standards Institute Quality Assurance (Certificates Q05288 and EMS86463 respectively).

3 Delivery and site handling

3.1 Tensar RE and RE500 Geogrids are delivered to site in rolls, bound with self-adhesive tape, bearing the product grade and batch identification references (see Figure 5). In accordance with the recommendations of BS EN ISO 10320 : 2019, the self-adhesive tape is colour coded as identified in Tables 1 and 2. The ends of the rolls are also spray painted to the same colour-coding scheme, to ease identification of the geogrid grade on site.

3.2 In accordance with harmonised European Standard BS EN 13251 : 2016, CE marking is incorporated into the product label.

Figure 5 Label

3.3 The geogrids and bodkins should be stored under cover in clean, dry conditions, protected from mechanical or chemical damage, exposure to direct sunlight and extreme temperatures.

3.4 The concrete facing panels and other components should be handled and stored in accordance with the manufacturers' instructions, the requirements of BS 8006-1 : 2010, BS EN 14475 : 2006 and the MCHW, Volume 1.

Assessment and Technical Investigations

The following is a summary of the assessment and technical investigations carried out on Tensar RE and RE500 Geogrids for reinforced soil retaining walls and bridge abutments.

Design Considerations

4 Use

4.1 When designed and installed in accordance with this Certificate, Tensar Retaining Wall Systems constructed from Tensar RE and RE500 Geogrids, precast concrete facing panels and Tensar Bodkins (see sections 1.2 to 1.4) are satisfactory for use in the construction of reinforced soil retaining walls and bridge abutments.

4.2 Structural stability is achieved through the strength of the geogrid, the connection strength between the geogrid and concrete facing panels and by the frictional interaction between the soil particles and geogrid.

4.3 The design of the concrete facing panels, the fill specification and method of placement and compaction, the design strength of the geogrids and the length of embedment within the compacted fill are key design factors.

4.4 Prior to the commencement of work, the designer must satisfy the design approval and certification procedures of the relevant Highway Authority.

4.5 The BBA has not assessed the structures for supporting parapet loading caused by vehicle collision at the top of the facing units.

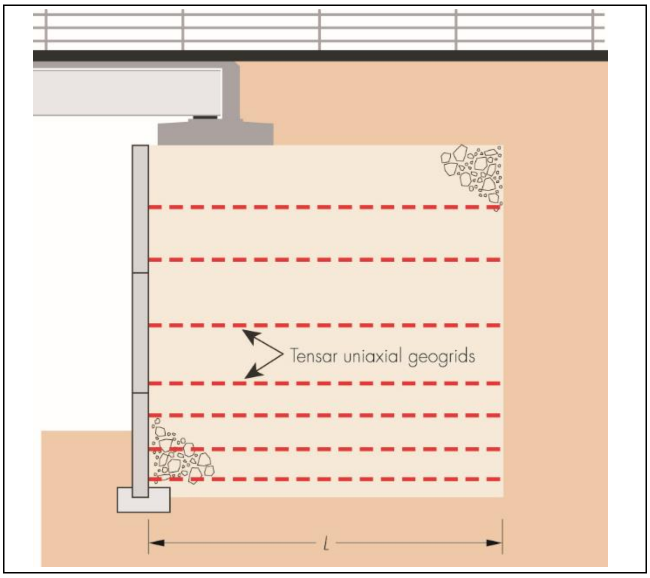
4.6 In addition to those items covered in section 6 of this Certificate, attention must be paid in design to the following issues:

- site preparation
- fill material properties
- specification for placing and compaction of the fill material
- drainage
- protection of the geogrid against damage during installation
- design of the facing units
- the required construction tolerances for the completed structure.

4.7 The working drawings must show the correct orientation of the geogrids.

4.8 A typical sectional view through a reinforced soil structure constructed using Tensar RE and RE500 Geogrids is shown in Figure 6.

Figure 6 Typical diagrammatic sectional view



5 Practicability of installation

The products are designed to be installed by trained contractors in accordance with the specifications and construction drawings.

6 Design

Design methodology

6.1 Reinforced soil retaining walls and bridge abutments constructed using the products must be designed in accordance with BS 8006-1 : 2010 and the MCHW, Volume 1.

6.2 In accordance with BS 8006-1 : 2010, Annex B, the required design life for permanent walls and bridge abutments is 120 years.

Geogrids

6.3 The design strength of the geogrids (T_D) is calculated as:

- for ultimate limit state (ULS): $T_{D(ULS)} = T_{CR} / (f_n \times f_m)$
- for serviceability limit state (SLS): $T_{D(SLS)} = T_{CS} / f_m$

where:

T_{CR} is the long-term tensile creep rupture strength of the reinforcement at the specified design life and design temperature
T_{CS} is the maximum allowable tensile load to ensure that the prescribed post-construction, limiting strain specified for the SLS is not exceeded
f_n is the partial factor for ramification of failure in accordance with BS 8006-1 : 2010, Table 9
f_m is the material safety factor to allow for the strength reducing effects of installation damage, weathering (including exposure to sunlight), chemical and other environmental effects and to allow for the extrapolation of data used to establish the above reduction factors.

6.4 The long-term tensile creep rupture strength (T_{CR}) for each grade of geogrid is calculated using the formula:

$T_{CR} = T_{char} / RF_{CR}$

where:

T_{char} is the characteristic short-term strength taken from Table 3
RF_{CR} is the reduction factor for creep (see section 7).

6.5 The maximum allowable tensile load (T_{CS}) to ensure that prescribed post-construction strain limits are not exceeded is determined as set out in sections 7.4 and 7.5.

6.6 The material safety factor (f_m) used in determining ($T_{D(ULS)}$) and ($T_{D(SLS)}$) is calculated as:

$f_m = RF_{ID} \times RF_W \times RF_{CH} \times f_S$

where:

RF_{ID} is the reduction factor for installation damage
RF_W is the reduction factor for weathering, including exposure to ultraviolet (UV) light
RF_{CH} is the reduction factor for chemical/environmental effects
f_S is the factor of safety for the extrapolation of data.

6.7 Recommended values for RF_{CR}, RF_{ID}, RF_W, RF_{CH} and f_S, are given in sections 7, 8 and 9. Conditions of use outside the scope for which the reduction factors are defined are not covered by this Certificate and advice should be sought from the Certificate holder.

Soil/geogrid interaction

6.8 There are two limiting modes of interaction between the soil and the reinforcement that need to be considered and for which the length of reinforcement necessary to maintain equilibrium needs to be determined:
- direct sliding — where the soil slides over the layer of reinforcement
- pull-out — where the layer of reinforcement pulls out of the soil after it has mobilised the maximum available bond stress.

6.9 CIRIA SP123 : 1996, sections 4.5 and 4.6, describes the following methods for determining resistance to direct sliding and maximum available bond.

The theoretical expression for resistance to direct sliding is:

$f_{ds} \times \tan \phi'$

where:

f_{ds} is the direct sliding coefficient
f' is the effective angle of friction of soil.

6.10 The direct sliding coefficient (f_{ds}) is calculated as:

$f_{ds} = a_s \times (\tan \delta/\tan \phi') + (1 - a_s)$

where:

α_s is the proportion of plane sliding area that is solid

$\tan \delta/\tan \phi'$ is the coefficient of skin friction between the soil and geogrid material.

6.11 For initial design purposes, the coefficient of skin friction (tan d/tan f') for determining the resistance to direct sliding for the geogrid when buried in compacted frictional fill may be conservatively assumed to be 0.6. Values for the proportion of plane sliding area that is solid (α_s) are given in Table 4. Soil specific testing has shown that values approaching 1.0 can be achieved.

Table 4 Soil geogrid interaction parameters for Tensar RE and RE500 Geogrids

Grade	α_s(1)	Ratio of bearing(2) surface to plan area $\alpha_b \times B/2S$
40RE	0.41	0.003
55RE	0.41	0.004
80RE	0.41	0.005
120RE	0.41	0.008
RE510	0.41	0.003
RE520	0.41	0.003
RE540	0.41	0.004
RE560	0.41	0.005
RE570	0.41	0.007
RE580	0.41	0.008

(1) α_s is the proportion of the plane sliding area that is solid and is required for the calculation of the bond coefficient (f_b) and the direct sliding coefficient (f_{ds}) (see sections 6.8 and 6.11).
(2) The ratio is required to calculate the bond coefficient in accordance with CIRIA SP123 : 1996 (see section 6.11):
- α_b the thickness of a transverse member of a grid taking bearing
- S is the spacing between transverse members taking bearing.

6.12 For detailed design, the resistance to direct sliding should be determined from soil and geogrid specific shear box testing.

6.13 The theoretical expression for maximum available bond stress is:

$f_b \times \tan \phi'$

where:

f_b is the bond coefficient

ϕ' is the effective angle of friction of soil.

6.14 The bond coefficient may be calculated as:

$f_b = \alpha_s \times (\tan \delta/\tan \phi') + (\sigma'_b/\sigma'_n) \times (\alpha_b \times B/2S) \times (1/\tan \phi')$

where:

α_s is the proportion of plane sliding area that is solid

ϕ' is the effective angle of friction of soil

$\tan \delta/\tan \phi'$ is the coefficient of skin friction between the soil and geogrid material

σ'_b/σ'_n is the bearing stress ratio

$\alpha_b \times B/2S$ is the ratio of bearing surface to plan area.

6.15 For initial design purposes the coefficient of skin friction (tan d/tan f') for determining the bond coefficient for the geogrid when buried in frictional fill may be conservatively assumed to be 0.6. Values for the ratio of bearing surface to plan area (α_b x *B/2S*) are given in Table 4. Typical values for the bearing stress ratio (s'_b/s'_n) are given in CIRIA SP123 : 1996, Table 4.1.

6.16 The BBA recommends that site-specific pull-out tests are carried out to confirm the value of bond coefficient (f_b) used in the final design.

Concrete facing panels

6.17 The precast concrete facing units must be designed in accordance with the relevant provisions of BS 8006-1 : 2010, BS EN 14475 : 2006 and BS EN 1992-2 : 2005.

6.18 The appropriate combination of concrete exposure classes should be selected from Table A.1 of BS 8500-1 : 2015 and Table 1 of BS EN 206-1: 2013 to suit the proposed location and level of exposure of the proposed structure.

6.19 Where concrete facing units are to be embedded in soils which could be potentially aggressive, the guidance in BRE Special Digest 1 : 2005, Part C should be followed.

7 Mechanical properties

Tensile strength – short-term

7.1 Characteristic short-term tensile strength (T_{char}) values and strain values at a maximum load for the geogrids are given in Table 3.

Tensile strength – long-term

7.2 Long-term tensile strength performance has been established from an extensive programme of creep testing carried out across a range of different test temperatures, including test durations of up to 102,000 hours for the RE Geogrids and up to 100,000 hours for the RE500 Geogrids.

7.3 Using this data and standard time-temperature shift methods (TTS), the Certificate holder has determined the predicted long-term strengths (T_{CR}) given in Table 5 for each grade of RE and RE500 Geogrid, for a design life of 120 years and a design temperature of 10°C. These values have been independently verified by the BBA using the methodology given in PD ISO/TR 20432 : 2007 and may be used for design.

Table 5 Long-term creep rupture strengths[(1)] (T_{CR})

Grade	Long-term creep rupture strength (T_{CR}) (kN·m^{-1})
40RE	24.0
55RE	29.5
80RE	39.0
120RE	63.1
RE510	20.7
RE520	27.3
RE540	33.4
RE560	45.9
RE570	61.3
RE580	71.1

Post construction strain

7.4 The prescribed maximum allowable post-construction creep strains allowed by BS 8006-1 : 2010 for the serviceability limit state of reinforced soil retaining walls and bridge abutments are shown in Table 6.

Table 6 Serviceability limits on post-construction internal strains for soil retaining walls and bridge abutments

Structure	Strain (%)	Design period for the purposes of determining limiting strain
Bridge abutments and retaining walls with permanent structural loading	0.5	2 months – 120 years
Retaining walls, with no applied structural loading, ie transient live loadings only	1.0	1 month – 120 years

7.5 Values for T_{CS} may be estimated from the appropriate isochronous curves. A typical isochronous curve is shown in Figure 7. Values of T_{CS} for Tensar RE and Tensar RE500 Geogrids for use in design are given in Table 7.

Figure 7 Definition of T_{cs}

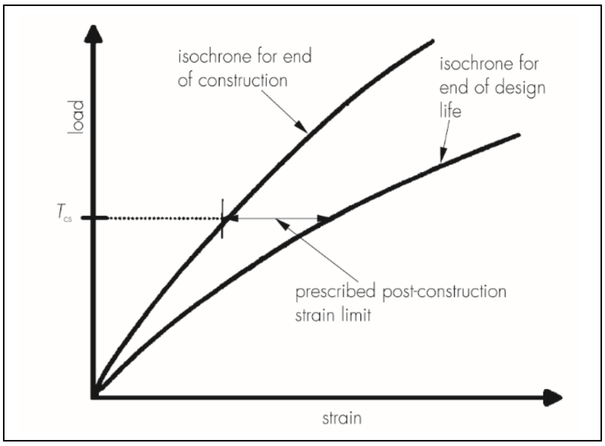


Table 7 Tensile load (T_{CS}) inducing prescribed post-construction strain limits(1)

Grade	Tensile load (T_{CS}) (kN.m^{-1}) Prescribed post-construction strain limits	
	0.5%	1.0%
40RE	7.6	11.9
55RE	9.2	14.5
80RE	12.7	19.9
120RE	19.7	30.9
RE510	5.7	9.0
RE520	7.6	11.9
RE540	9.2	14.5
RE560	12.7	19.9
RE570	17.0	26.6
RE580	19.7	30.9

(1) For a design life of 120 years and a design temperature of 10°C.

Reduction factor for installation damage (RF_{ID})

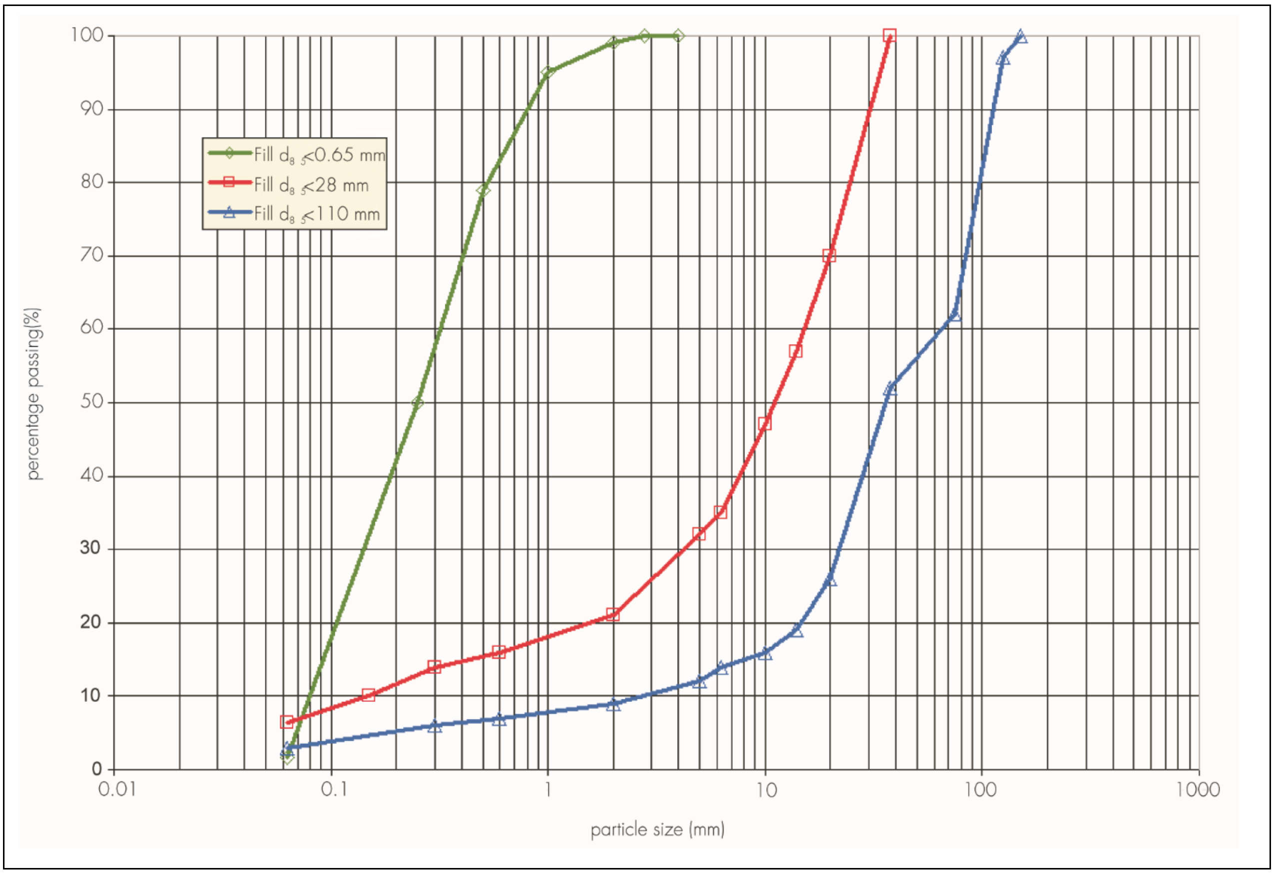
7.6 To allow for loss of strength due to mechanical damage that may be sustained during installation, the appropriate value for RF_{ID} should be selected from Table 8. These reduction factors have been established from full-scale installation damage tests using a range of materials whose gradings can be seen in Figure 8. The reduction factors shown assume a well-graded material (coefficient of uniformity >5) and minimum compacted depth of 150 mm. For fills not covered by Table 4, appropriate values of RF_{ID} may be determined from site-specific trials.

Table 8 Partial safety factor – installation damage (RF*ID*)

Crushed gritstone (d_{85} particle size) (mm)	Reduction factor for installation damage (RF_{ID})[1]									
	40RE	55RE	80RE	120RE	RE510	RE520	RE540	RE560	RE570	RE580
<0.65	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00
<28	1.07	1.07	1.07	1.00	1.18	1.07	1.07	1.07	1.07	1.00
<69[2]	1.25	1.20	1.15	1.06	1.30	1.25	1.20	1.15	1.12	
<110	1.48	1.36	1.25	1.12	1.60	1.48	1.36	1.25	1.19	1.12

(1) Determined via full-scale installation test following the method of Annex D of BS 8006 : 1995.
(2) RF_{ID} values interpolated for 69 mm material.

Figure 8 Particle size distributions of fills used in installation damage testing



Connection strength

7.7 A full strength connection can be achieved between the geogrids and precast concrete facing panels using the method described in sections 1.4 and 1.5 and Figure 2. A reduction factor for connection strength is not required where Tensar RE and RE500 Geogrids are connected to the facing panels in this manner.

8 Effects of environmental conditions

Weathering (including exposure to UV light)

8.1 The geogrids do not show significant reductions in strength after exposure to natural daylight and weathering.

8.2 A reduction factor (RF_W) of 1.00 may be used for design, provided the geogrids are protected from exposure to sunlight in accordance with the recommendations of this Certificate and provided the periods of exposure are limited to a maximum of one month.

Chemical/environmental effects

8.3 Tensar RE and RE500 Geogrids have good resistance to the effects of chemical and environmental action, including oxidation, resistance to acids and alkaline liquids and microbiological attack. The reduction factors (RF_{CH}) given in Table 9 may be used for a design life up to 120 years and a design temperature up to 20°C.

Table 9 Reduction factors	
Soil pH value	RF_{CH}
2 to 4	1.05
4 to 12.5	1.00

9 Factor of safety for the extrapolation of data (f_s)

9.1 For Tensar RE and RE500 Geogrids, the factor of safety for the extrapolation of data (f_S) may be taken as 1.00 for a design life of up to 120 years and a design temperature of up to 20°C.

9.2 The above value has been calculated in accordance with PD ISO/TR 20432 : 2007 as specified in BS 8006-1 : 2010, using the R_1 and R_2 values given in Table 10.

Table 10 R_1 and R_2 values for determination of f_s

Factor	Taking account of:	Design life (years)	
		60	120
R_1	Extrapolation of creep rupture data	1.00	1.00
R_2	Extrapolation of chemical data	1.00	1.00

10 Maintenance

The exposed faces of the concrete facing panels may require occasional maintenance, to remove dirt build up, mould and moss growth. All other components of the system incorporating the products are confined within the fill and do not require maintenance.

11 Durability

11.1 The geogrids will have adequate durability for a design life of 120 years when used and installed in accordance with the provisions of this Certificate.

11.2 The precast concrete facing panels will have adequate durability for the proposed life of the structure under exposure conditions normally encountered in reinforced earth retaining walls and bridge abutments in the UK when designed and installed in accordance with the provisions of BS 8006-1 : 2010, BS EN 14475 : 2006 and the requirements of this Certificate (see sections 6.17 to 6.19).

Installation

12 General

The construction of reinforced soil structures must be carried out in accordance with BS 8006-1 : 2010 and BS EN 14475 : 2006.

13 Preparation

The surface must be free of root growth, logs, frozen matter and any other obstacles that may damage the geogrids.

14 Procedure

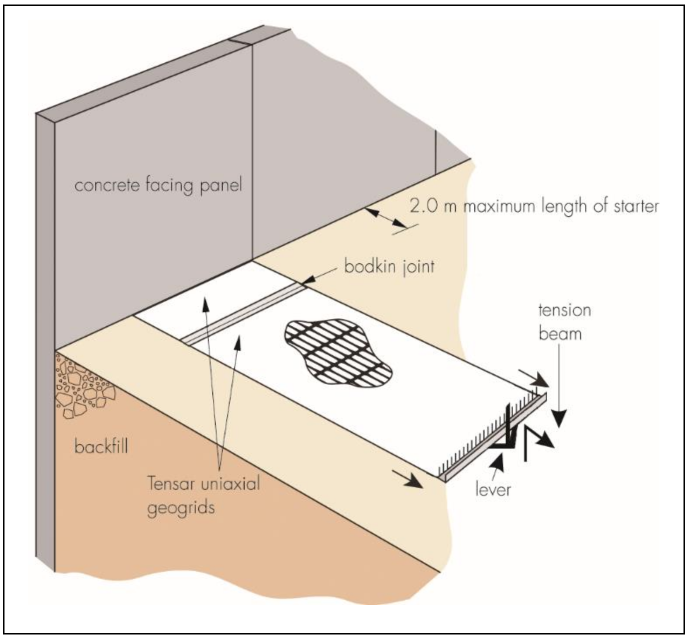
14.1 Formation levels are prepared and a concrete strip foundation is laid for the first course of facing panels, which are temporarily propped. Fill material is placed and compacted behind the facing up to the level of the first layer of geogrid.

14.2 The geogrid is then laid and, using a Tensar Bodkin, is attached to the starter length of geogrid which is cast into the concrete facing panel. The newly-laid geogrid is pulled and held taut, preferably with a tension beam device as shown in Figure 9, prior to fill being placed. Further facing panels are fixed as necessary and fill material is placed and compacted to specified heights, particular care being taken to ensure that the geogrids are adequately tightened and covered before compaction or use by traffic. The sequence is repeated up to the formation level for the parapet base or finished level as appropriate.

14.3 Fill is placed to a depth not less than 150 mm before each pass of the compaction plant. To avoid excessive movement of the facing panels, heavy compaction plant should not be used within two metres of the face, where the depth of fill before each pass may be less than 150 mm to suit the compaction method used.

14.4 Tensar Bodkins are used to join lengths of geogrid and to form a connection with the starter length of geogrid which is cast into the concrete facing panel, as shown in Figures 2 and 9.

Figure 9 Installation



Technical Investigations

15 Investigations

15.1 The manufacturing process was evaluated, including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

15.2 An examination was made of data relating to:

- evaluation of long- and short-term tensile properties
- assessment of the test method used for determining tensile creep rupture and creep strain results in comparison with the method given in EN ISO 13431 : 1999
- chemical resistance
- UV and environmental degradation
- the effects of temperature
- site damage trials and resistance to mechanical damage, assessed according to Annex D of BS 8006 : 2010
- the friction coefficient between the products and the soil fill.

15.3 An assessment has been made of the method for anchoring the geogrid to the concrete facing panels and the connection of geogrid using Tensar Bodkins.

15.4 The practicability and ease of handling and installation were assessed.

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BS 8006-1 : 2010 + A1 : 2016 *Code of practice for strengthened/reinforced soils and other fills*

BS 8500-1 : 2015 + A1 : 2016 *Concrete — Complementary British Standard to BS EN 206-1 — Method of specifying and guidance for the specifier*

BS EN 206-1 : 2013 + A1 : 2016 *Concrete — Specification, performance, production and conformity*

BS EN 1992-2 : 2005 *Eurocode 2 — Design of concrete structures — Concrete bridges — Design and detailing rules*

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BS EN 14475 : 2006 *Execution of special geotechnical works — Reinforced fill*

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Manual of Contract Documents for Highway Works, Volume 1 *Specification for Highway Works*

Conditions of Certification

16 Conditions

16.1 This Certificate:

- relates only to the product/system that is named and described on the front page
- is issued only to the company, firm, organisation or person named on the front page – no other company, firm, organisation or person may hold or claim that this Certificate has been issued to them
- is valid only within the UK
- has to be read, considered and used as a whole document – it may be misleading and will be incomplete to be selective
- is copyright of the BBA
- is subject to English Law.

16.2 Publications, documents, specifications, legislation, regulations, standards and the like referenced in this Certificate are those that were current and/or deemed relevant by the BBA at the date of issue or reissue of this Certificate.

16.3 This Certificate will remain valid for an unlimited period provided that the product/system and its manufacture and/or fabrication, including all related and relevant parts and processes thereof:

- are maintained at or above the levels which have been assessed and found to be satisfactory by the BBA
- continue to be checked as and when deemed appropriate by the BBA under arrangements that it will determine
- are reviewed by the BBA as and when it considers appropriate.

16.4 The BBA has used due skill, care and diligence in preparing this Certificate, but no warranty is provided.

16.5 In issuing this Certificate the BBA is not responsible and is excluded from any liability to any company, firm, organisation or person, for any matters arising directly or indirectly from:

- the presence or absence of any patent, intellectual property or similar rights subsisting in the product/system or any other product/system
- the right of the Certificate holder to manufacture, supply, install, maintain or market the product/system
- actual installations of the product/system, including their nature, design, methods, performance, workmanship and maintenance
- any works and constructions in which the product/system is installed, including their nature, design, methods, performance, workmanship and maintenance
- any loss or damage, including personal injury, howsoever caused by the product/system, including its manufacture, supply, installation, use, maintenance and removal
- any claims by the manufacturer relating to CE marking.

16.6 Any information relating to the manufacture, supply, installation, use, maintenance and removal of this product/system which is contained or referred to in this Certificate is the minimum required to be met when the product/system is manufactured, supplied, installed, used, maintained and removed. It does not purport in any way to restate the requirements of the Health and Safety at Work etc. Act 1974, or of any other statutory, common law or other duty which may exist at the date of issue or reissue of this Certificate; nor is conformity with such information to be taken as satisfying the requirements of the 1974 Act or of any statutory, common law or other duty of care.