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HAPAS Certificate
17/H272
Product Sheet 2

E'GRID GEOGRID-REINFORCED SOIL STRUCTURES

E'GRID R GEOGRID SYSTEM FOR EMBANKMENTS AND STEEP SLOPES

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 Assembly 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 the E'GRID(1) R Geogrid System for use in reinforced-soil embankments and slopes up to 70°. The system comprises high-density polyethylene (HDPE) uniaxial geogrids, HDPE bodkins for joining of geogrids, and compacted structural backfill material.

(1) E'GRID is a registered trademark

CERTIFICATION INCLUDES:

- factors relating to compliance with HAPAS requirements
- factors relating to compliance with Regulations 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

Performance of the geogrids — the short- and long-term tensile strength of the geogrids and connectors; resistance to installation damage, weathering and environmental effects; and soil/geogrid interaction, have been assessed (see sections 6 and 7).

Durability — when designed and installed in accordance with the provisions of this Certificate, the system will have adequate durability for its intended use in reinforced-soil embankments (see section 9).

The BBA has awarded this Certificate to the company named above for the system described herein. This system has been assessed by the BBA as being fit for its intended use provided it is installed, used and maintained as set out in this Certificate

On behalf of the British Board of Agrément

Date of Second issue: 4 June 2019

Originally certificated on 2 May 2018

Paul Valentine
Technical Excellence Director

Claire Curtis-Thomas
Chief Executive

The BBA is a UKAS accredited certification body – Number 113.
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Any photographs are for illustrative purposes only, do not constitute advice and should not be relied upon.

Requirements

In the opinion of the BBA, the E'GRID R Geogrid System for embankments and steep slopes, when designed and installed in accordance with the provisions of this Certificate, will satisfy or contribute to satisfying the requirements of Highways England and local Highway Authorities for the design and construction of reinforced-soil embankments in accordance with the *Design Manual for Roads and Bridges*(1) (DMRB), Volume 4.

(1) The DMRB is operated by the Overseeing Organisations: Highways England (HE), Transport Scotland, the Welsh Assembly Government and the Department for Infrastructure (Northern Ireland).

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 sections: *1 Description* (1.2 and 1.3) and 3 *Delivery and site handling* (3.1) of this Certificate.

Additional Information

CE marking

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

Technical Specification

1 Description

1.1 The E'GRID R Geogrid System for embankments and steep slopes comprises:

- E'GRID High-Density Polyethylene Uniaxial Geogrids
- E'GRID Bodkins — for joining geogrids.

E'GRID High-Density Polyethylene Uniaxial Geogrids

1.2 The range and specification of the geogrids covered by this Certificate is shown in Figure 1, and Tables 1 and 2.

Figure 1 Geogrid detail

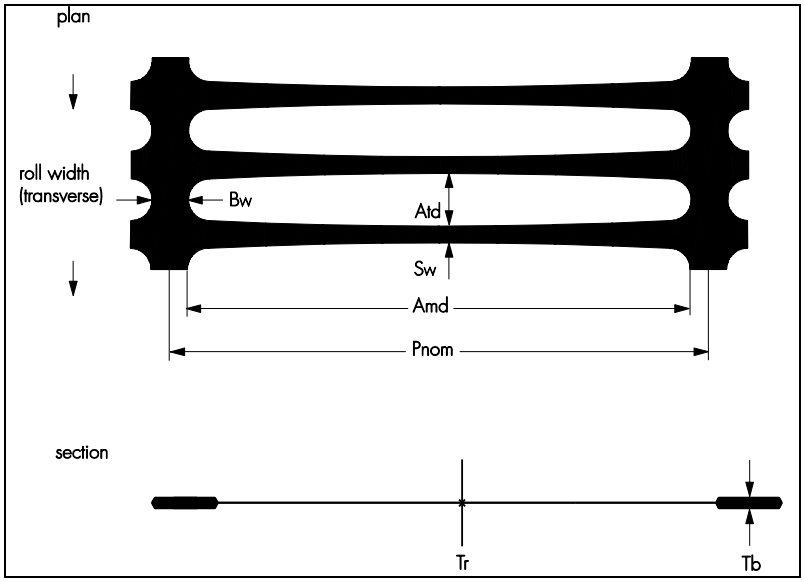


Table 1 Typical dimensions of geogrids

Product	Atd (mm)	Bw (mm)	Sw (mm)	Tb (mm)	Tr (mm)	Pnom (mm)	Standard Roll sizes[1]
E'GRID 50R	16	18	5.5	2.1	0.6	235	50 m^2 (1.0 x 50 m)
E'GRID 60R	16	18	5.5	2.8	0.7	245	50 m^2 (1.0 x 50 m)
E'GRID 70R	16	18	5.5	2.9	0.8	245	50 m^2 (1.0 x 50 m)
E'GRID 80R	16	18	5.5	3.4	0.9	255	50 m^2 (1.0 x 50 m)
E'GRID 95R	16	18	5.5	4.1	1.1	255	50 m^2 (1.0 x 50 m)
E'GRID 105R	16	18	5.5	4.5	1.2	260	50 m^2 (1.0 x 50 m)
E'GRID 120R	16	18	5.5	5.2	1.3	260	50 m^2 (1.0 x 50 m)
E'GRID 125R	16	18	5.5	5.3	1.4	260	50 m^2 (1.0 x 50 m)
E'GRID 145R	16	18	5.5	5.7	1.6	260	50 m^2 (1.0 x 50 m)
E'GRID 160R	16	18	5.5	6.7	1.8	260	50 m^2 (1.0 x 50 m)
E'GRID 170R	16	18	5.5	7.8	2.0	260	50 m^2 (1.0 x 50 m)
E'GRID 180R	16	18	5.5	8.0	2.3	260	50 m^2 (1.0 x 50 m)

(1) Roll width up to 1.3 m is available.

Table 2 Specification — Geogrid properties

Product	Short-term tensile strength ($kN \cdot m^{-1}$)[1]	Typical strain at peak load (%)[1]
E'GRID 50R	50.0	11 ± 3
E'GRID 60R	60.0	11 ± 3
E'GRID 70R	70.0	11 ± 3
E'GRID 80R	80.0	11 ± 3
E'GRID 95R	95.7	11 ± 3
E'GRID 105R	105.0	11 ± 3
E'GRID 120R	120.0	11 ± 3
E'GRID 125R	127.2	11 ± 3
E'GRID 145R	147.0	11 ± 3
E'GRID 160R	160.0	11 ± 3
E'GRID 170R	170.0	11 ± 3
E'GRID 180R	180.0	11 ± 3

(1) Tensile tests in accordance with ISO 10319 : 2015 at 21±1°C, and calculated as the 95% lower confidence limit in accordance with BS 2846-2 : 1981 and ISO 2602-1980.

E'GRID Bodkins

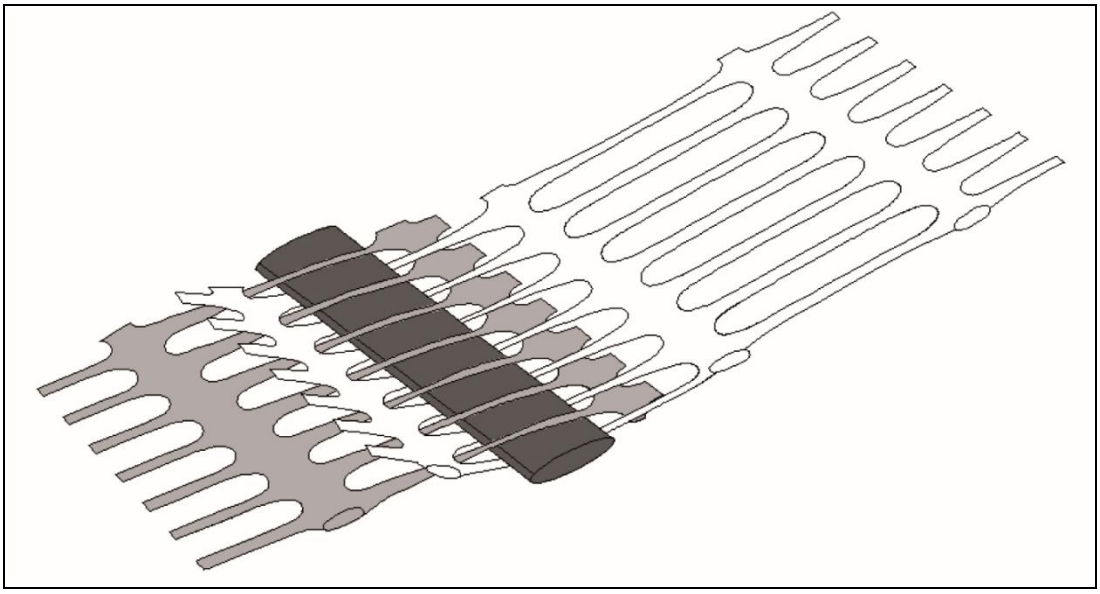
1.3 E'GRID Bodkins are used for joining lengths of geogrid together end-to-end, as illustrated in Figure 2. The bodkins have the specifications given in Table 3.

Table 3 E'GRID EGB 5046[(1)] Bodkin specifications

Cross-section dimensions	Width: 50+/-3 mm Edge thickness: 4.0 +/- 0.5 mm Middle thickness: 6.0 +/- 0.5 mm
Length	1045+/- 5 mm or 1345+/- 5 mm
Polymer	HDPE to one specification
Yield strength[(2)]	22 $MN \cdot m^{-2}$ minimum
Elongation at break[(2)]	250 % minimum
Minimum carbon black content[(3)]	2.0 %

(1) The E'GRID EGB 5046 Bodkin can be used with any grade of E'GRID R Geogrid.
(2) Measured in accordance with BS 3412 : 1992, Type 2, Speed D.
(3) Measured in accordance with BS 2782-4 : Method 452B : 1993.

Figure 2 Bodkin connection



1.4 Ancillary items for use with the system, but outside the scope of this Certificate, are:

- structural backfill material — to be placed and compacted behind the retaining structure. Structural backfill material must satisfy the requirements of BS 8006-1 : 2010 and the *Manual of Contract Documents for Highways Works* (MCHW), Volume 1 *Specification for Highways Works* (SHW)
- foundation below the structure — to be designed by a suitably qualified and experienced person
- granular drainage system — if required, to be designed by a suitably qualified and experienced person
- temporary formwork, steel mesh, geotextiles, sand bags or organic material — used to construct the front face of the embankment, according to local design requirements.

2 Manufacture

2.1 The geogrids are manufactured by the Certificate holder, by punching and stretching continuous extruded sheets of HDPE and masterbatch containing carbon black.

2.2 The bodkins are manufactured from extruded HDPE polymer to one 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 system of BOSTD Geosynthetics Qingdao Ltd has been assessed and registered as meeting the requirements of BS EN ISO 9001 : 2015 and BS EN ISO 14001 : 2015 by the Quality Assurance Centre of China Association for Quality (Certificates 00617Q31529R5M and 00617E30388R0M respectively).

3 Delivery and site handling

Geogrids and bodkins

3.1 The geogrids are delivered to site in rolls bearing the product grade and batch identification references.

3.2 CE marking in accordance with harmonised standard BS EN 13251 : 2016 is incorporated on the product label.

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

Assessment and Technical Investigations

The following is a summary of the assessment and technical investigations carried out on the E'GRID R Geogrid System for embankments and steep slopes.

Design Considerations

4 Use

4.1 When designed and installed in accordance with this Certificate, the system is satisfactory for the construction of reinforced-soil embankments with a maximum slope of 70°.

4.2 Structural stability of the embankment is achieved through the:

- tensile strength of the geogrids
- anchorage of the geogrids at the front face of the embankment
- embedment and resistance to sliding and pull-out of the geogrids from the compacted backfill material.

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

4.4 Reinforced-soil structures constructed using the system should be protected with suitable barriers to protect the structure against potential damage from vehicle impacts. The barrier is to be specified by a suitably competent person.

4.5 In addition to the factors covered in section 6, attention must also be paid in design to:

- site preparation
- fill material
- specification for placing and compacting fill material
- drainage issues
- protection of the geogrid during construction.

4.6 It is considered that with correct design and workmanship, a reinforced-soil embankment constructed in accordance with this Certificate, can satisfy the tolerances for line and level detailed in BS EN 14475 : 2006, Annex C.

4.7 Where there are changes in the alignment of slopes, the guidance given in BS 8006-1 : 2010 concerning overlapping of geogrids should be followed.

5 Practicability of installation

The system is designed to be installed by suitably trained contractors in accordance with the specifications and construction drawings (see section 11).

6 Design

Design methodology

6.1 Reinforced-soil embankments constructed using the system 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 embankments is 60 years.

Geogrids

6.3 In accordance with the methodology set out in BS 8006-1 : 2010, Annex 3, the design strength of the geogrids (T_D) is calculated as:

- for ultimate limit state (ULS): $T_{D(ULS)} = T_{CR}/(f_n x f_m)$
- 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),and 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 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 2

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 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 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 section 7. 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 layer of 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 a coefficient for resistance to direct sliding is:

$f_{DS} \times \tan \varphi'$

where:
f_{DS} is the direct sliding coefficient
φ' is the effective angle of friction of soil.

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

$f_{DS} = \alpha_s \times (\tan\delta/\tan \varphi') + (1 - \alpha_s)$

where:
α_s is the proportion of plane sliding area that is solid
$\tan\delta/\tan \varphi'$ is the coefficient of skin friction between the soil and the geogrid material.

6.11 For initial design purposes, the coefficient of skin friction ($\tan\delta/\tan \varphi'$) for determining the bond coefficient for the geogrid when buried in frictional fill may be conservatively assumed to be 0.6. Values for the proportion of plane sliding area that is solid (α_s) and for the ratio of bearing surface to plan area $\alpha_b \times B/2S$ are given in Table 4, below. Typical values for the bearing stress ratio σ'_b/σ'_n are given in CIRIA SP123 : 1996, Table 4.1.

Table 4 Soil geogrid interaction parameters

Product	**α_s**(1)	**Ratio of bearing**(2) **surface area to plan area α_b x B/2S**
E'GRID 50R	0.41	0.003
E'GRID 60R	0.40	0.004
E'GRID 70R	0.40	0.004
E'GRID 80R	0.39	0.005
E'GRID 95R	0.39	0.006
E'GRID 105R	0.38	0.006
E'GRID 120R	0.38	0.007
E'GRID 125R	0.38	0.007
E'GRID 145R	0.38	0.008
E'GRID 160R	0.38	0.010
E'GRID 170R	0.37	0.010
E'GRID 180R	0.37	0.011

(1) α_s is the proportion of 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})
(2) The ratio is required to calculate the bond coefficient in accordance with CIRIA SP123 : 1996:
- α_b is the thickness of a transverse member of a grid taking bearing
- B is the thickness of a longitudinal member of a grid taking bearing
- S is the spacing between transverse members taking bearing.

6.12 The theoretical expression for a coefficient for the maximum allowable bond stress generated by soil-geogrid interaction is:

$f_b \times \tan \varphi'$

where:

f_b *is the bond coefficient*

φ' *is the effective friction angle of the soil.*

6.13 The bond coefficient may be calculated as:

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

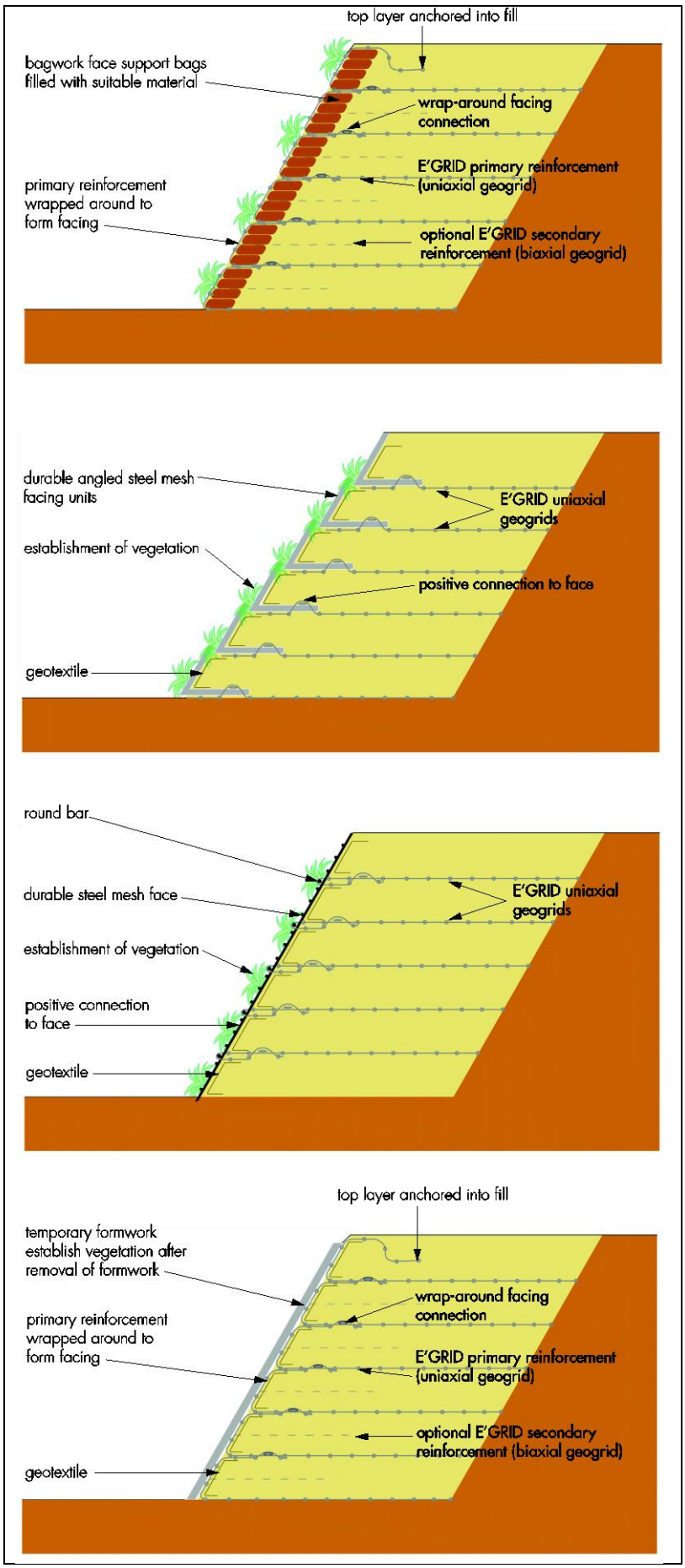
where:

α_s	is the proportion of plane sliding area that is solid
φ'	is the effective friction angle of the soil
$\tan\delta / \tan \varphi'$	is the coefficient of skin friction between the soil and the 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.

6.14 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.

6.15 Typical configurations for the anchorage of the geogrid at the front face of the embankment are shown in Figure 3.

Figure 3 Geogrid and facing configurations for embankments



7 Mechanical properties

7.1 Characteristic short-term tensile strength *(T_{char})* values and strain values at a maximum load for the geogrids are given in Table 2.

Tensile strength — long-term

7.2 Long-term tensile strength performance has been established from a programme of creep testing carried out across a range of different test temperatures in accordance with BS EN ISO 13431 : 1999. Test durations in excess of 90,000 hours have been considered.

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 geogrid, for a design life of 60 and 120 years and a design temperature of 10°C and 20°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-limited strength (T_{CR})

Product	Long-term creep rupture strength (T_{CR}) ($kN \cdot m^{-1}$)			
	Design life of 60 years		**Design life of 120 years**	
	Design temperature of 20°C	**Design temperature of 10°C**	**Design temperature of 20°C**	**Design temperature of 10°C**
E'GRID 50R	22.9	25.6	22.4	25.1
E'GRID 60R	27.5	30.7	26.9	30.1
E'GRID 70R	32.1	35.8	31.4	35.1
E'GRID 80R	36.7	40.9	35.9	40.1
E'GRID 95R	43.9	48.9	43.0	48.0
E'GRID 105R	48.2	53.7	47.1	52.6
E'GRID 120R	55.1	61.4	53.9	60.2
E'GRID 125R	58.4	65.0	57.1	63.8
E'GRID 145R	67.5	75.2	66.0	73.7
E'GRID 160R	73.4	81.8	71.8	80.2
E'GRID 170R	78.0	86.9	76.3	85.2
E'GRID 180R	82.6	92.0	80.8	90.2

Post-construction strain

7.4 The prescribed maximum allowable post-construction creep strains should be calculated according to Figure 43 of BS 8006-1 : 2010 and the isochronus curve in section 7.5 of this Certificate. Strains of up to 5% may be allowable but must be assessed on a site-specific basis. Where special tolerances apply due to settlement-sensitive applications, the limits for retaining walls and bridge abutments detailed in Product Sheet 1 of this Certificate may be used.

7.5 Values for T_{CS} may be estimated from the appropriate isochronus curves as illustrated in Figure 4. Values of T_{CS} for use in design are given in Table 6. Further details on the SLS and the application of T_{CS} should be obtained from BS 8006-1 : 2010, Clause 5.3.3.

Figure 4 Definition of T_{CS}

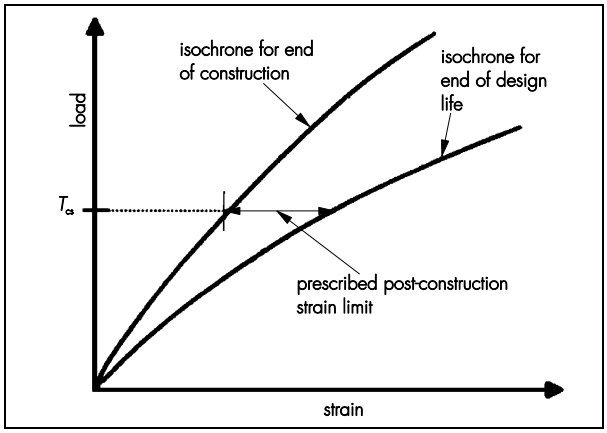


Table 6 Tensile load (T_{CS}) including prescribed post-construction strain limits

Product	**Tensile load (T_{CS}) (kN·m^{-1}) prescribed post-construction strain limits**			
	Design life of 60 years		Design life of 120 years	
	Design temperature of 20°C	Design temperature of 10°C	Design temperature of 20°C	Design temperature of 10°C
	5%	**5%**	**5%**	**5%**
E'GRID 50R	20.7	23.1	20.1	22.4
E'GRID 60R	24.8	27.7	24.1	26.9
E'GRID 70R	29.0	32.3	28.1	31.4
E'GRID 80R	33.1	36.9	32.1	35.9
E'GRID 95R	39.6	44.2	38.4	42.9
E'GRID 105R	43.5	48.4	42.1	47.1
E'GRID 120R	49.7	55.4	48.1	53.8
E'GRID 125R	52.7	58.7	51.0	57.0
E'GRID 145R	60.9	67.8	58.9	65.9
E'GRID 160R	66.2	73.8	64.2	71.7
E'GRID 170R	70.4	78.4	68.2	76.2
E'GRID 180R	74.5	83.0	72.2	80.7

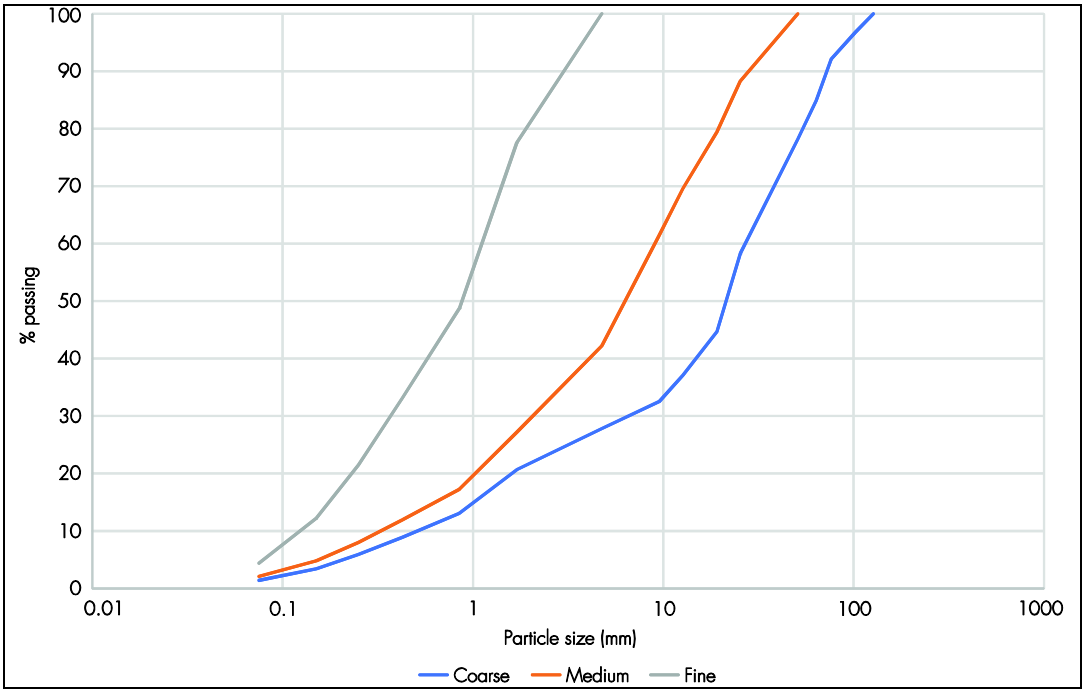
Reduction factors for installation damage

7.6 To allow for the loss of strength due to mechanical damage that may be sustained during installation, the appropriate value for RF_{ID} should be selected from Table 7. These reduction factors have been established from full-scale tests using a range of materials whose grading can be seen in Figure 5. The reduction factors assume a well-graded material (coefficient of uniformity >5) and minimum compacted depth above the geogrid of 150 mm. For fills not covered by Table 7, the appropriate RF_{ID} values may be determined from site-specific trials.

Table 7 Partial safety factor — installation damage RF_{ID}

Crushed aggregate		**Reduction factor for installation damage (RF_{ID})**											
d_{max} particle size (mm)	d_{85} particle size (mm)	E'GRID 50R	E'GRID 60R	E'GRID 70R	E'GRID 80R	E'GRID 95R	E'GRID 105R	E'GRID 120R	E'GRID 125R	E'GRID 145R	E'GRID 160R	E'GRID 170R	E'GRID 180R
4.75	2.25	1.01	1.03	1.03	1.03	1.03	1.03	1.03	1.01	1.01	1.01	1.01	1.01
50.8	40	1.06	1.08	1.09	1.09	1.06	1.06	1.06	1.05	1.06	1.06	1.06	1.06
127	75	1.10	1.15	1.19	1.19	1.16	1.16	1.16	1.12	1.11	1.11	1.09	1.09

Figure 5 Particle size distributions of fills used in installation damage testing



Reduction factor for the effects of environmental conditions

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

7.8 A reduction factor (RF_W) of 1.00 may be used for design, provided that the geogrids are protected from exposure to sunlight in accordance with the recommendations contained in section 3, and provided the periods of exposure are limited to one month.

7.9 The 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 8 may be used for a design life of up to 120 years and a design temperature of up to 20°C.

Table 8 Reduction factors for environmental exposure, RF_{CH}

Soil pH value	RF_{CH}
2 to 4	1.05
4 to 9	1.00

7.10 For the 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 at a design temperature up to 20°C.

7.11 This 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 9 of this Certificate.

Table 9 R_1 and R_2 values for determination of f_s for a 120 year design life

Factor	Taking account of	Value
R1	Extrapolation of creep rupture data	1.0
R2	Extrapolation of chemical data	1.0

Bodkin connection

7.12 A full-strength connection between lengths of geogrid can be obtained using the bodkin; a reduction factor is therefore not required.

8 Maintenance

The system is contained within the soil structure and should not require maintenance for the lifetime of the structure.

9 Durability

The geogrids, when designed and installed in accordance with this Certificate, will have adequate durability for a design life of up to 120 years, exceeding the typical design life required for reinforced-soil embankments.

10 Reuse and recyclability

The system components (geogrids and bodkins) contain HDPE, which can be recycled.

Installation

11 General

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

11.2 Installation of the system, within the context of this Certificate, must be carried out by installers recommended or recognised by the Certificate holder. Such an installer is a company which:

- employs operatives who have been trained and approved by the Certificate holder to install the system
- has undertaken to comply with the Certificate holder's installation procedure
- is subject to supervision by the Certificate holder, including site inspections.

12 Preparation

12.1 The foundation for the embankment and the drainage system, if required, must be prepared in accordance with the designer's instructions.

12.2 The surface onto which the geogrid is laid must be free from debris, tree roots, frozen matter and other sharp objects that could damage the geogrid.

13 Procedure

13.1 The foundation onto which the embankment is to be constructed and any drainage system to be incorporated are prepared. The first formation level, up to the level of the first layer of geogrid, is laid and compacted. Any temporary formwork for the finished face is installed.

13.2 The front face of the embankment is constructed using the appropriate facing materials according to local design requirements, to provide the finished face and anchorage of the geogrid. The geogrid is laid and held taut at the rear of the reinforced embankment using a tension beam. The fill material is then laid on top and compacted to the height specified by the designer.

13.3 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 material, heavy compaction plant should not be used within two metres of the face. Here, the depth of fill before each pass may be less than 150 mm, to suit the compaction method used.

13.4 To minimise wastage of the geogrid, the bodkins may be used to join shorter lengths of geogrid to form a layer.

13.5 The next layers of geogrid can then be installed and the process repeated, up to the finished level and the temporary formwork, if any, at the front face can be removed.

Technical Investigations

14 Tests

A series of tests was carried out to establish the short- and long-term properties of the E'GRID R Geogrid System for embankments and steep slopes. These included:

- short-term tensile strength and elongation of the geogrids
- long-term tensile strength and creep rupture performance
- creep elongation of the geogrids
- soil/geogrid interaction with pull-out
- resistance of the geogrids to installation damage
- resistance of the geogrids to oxidation (chemical and weathering)
- efficiency of the geogrid and bodkin connection.

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 of data was made to establish that the system is fit for purpose in use in reinforced-soil embankments. This included:

- evaluation of the short- and long-term tensile properties
- the effects of temperature
- the effects of ultraviolet light and environmental degradation
- the friction coefficient between the products and the soil fill
- the effects of chemical degradation.

15.3 An assessment was made of the system's practicability of installation, ease of construction and resistance to installation damage.

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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.

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