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Linear Composites Limited
Vale Mills
Oakworth
Keighley
West Yorkshire BD22 0EB
Tel: 01535 643363 Fax: 01535 643605
e-mail: mail@linearcomposites.com
website: www.linearcomposites.com

Agrément Certificate No 03/4065

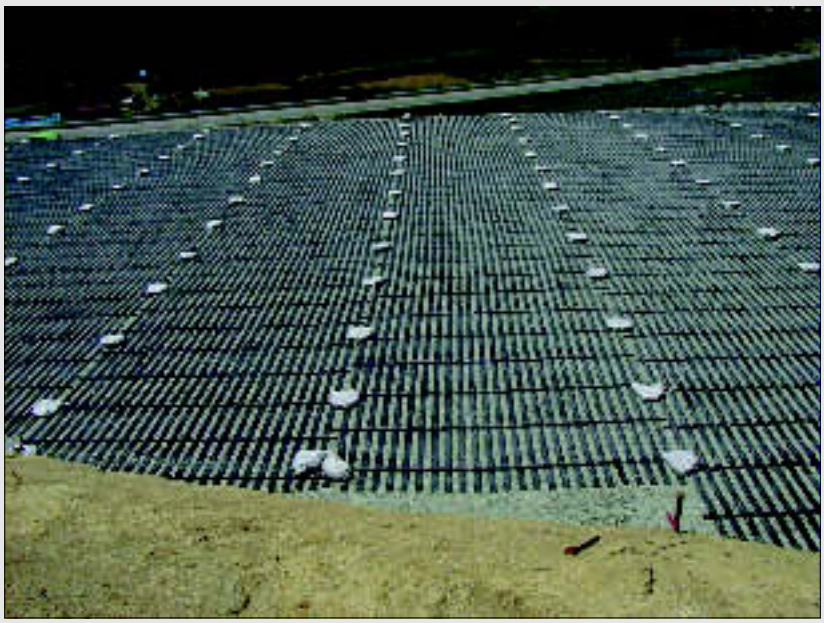
BBA BRITISH BOARD OF AGRÉMENT
TECHNICAL APPROVALS FOR CONSTRUCTION

Designated by Government to issue European Technical Approvals

PARALINK GEOCOMPOSITE PRODUCTS

Des produits géocomposite
Geocompositprodukte

Product



- *THIS CERTIFICATE REPLACES 97/3338 AND RELATES TO PARALINK GEOCOMPOSITE PRODUCTS, FOR USE AS BASAL REINFORCEMENT UNDER HIGHWAY EMBANKMENTS.*
- *Paralink geocomposites are planar structures consisting of a regular array of composite geosynthetic straps, nominally interconnected laterally to form soil reinforcement materials with high unidirectional strength.*
- *The products are for use as basal reinforcement for embankments constructed on or over:*
  - *soft foundation soils*
  - *piled foundations*
  - *areas prone to subsidence.*
- *The design and construction of embankments must be in accordance with the conditions set out in the* Design Data *and* Installation *parts of this Certificate, and should also follow the recommendations of BS 8006 : 1995.*

Regulations

1 The Building Regulations 2000 (as amended) (England and Wales)

In the opinion of the British Board of Agrément, Paralink Geocomposite Products for use as basal reinforcements are not subject to these Regulations.

2 The Building Standards (Scotland) Regulations 1990 (as amended)

In the opinion of the BBA, Paralink Geocomposite Products for use as basal reinforcements are not controlled under these Regulations.

3 The Building Regulations (Northern Ireland) 2000

In the opinion of the BBA, Paralink Geocomposite Products for use as basal reinforcements are not controlled under these Regulations.

4 Construction (Design and Management) Regulations 1994 (as amended) Construction (Design and Management) Regulations (Northern Ireland) 1995 (as amended)

Information in this Certificate may assist the client, planning supervisor, designer and contractors to address their obligations under these Regulations.

See section: 6 *Delivery to site, handling and storage* (6.1 and 6.2).

Technical Specification

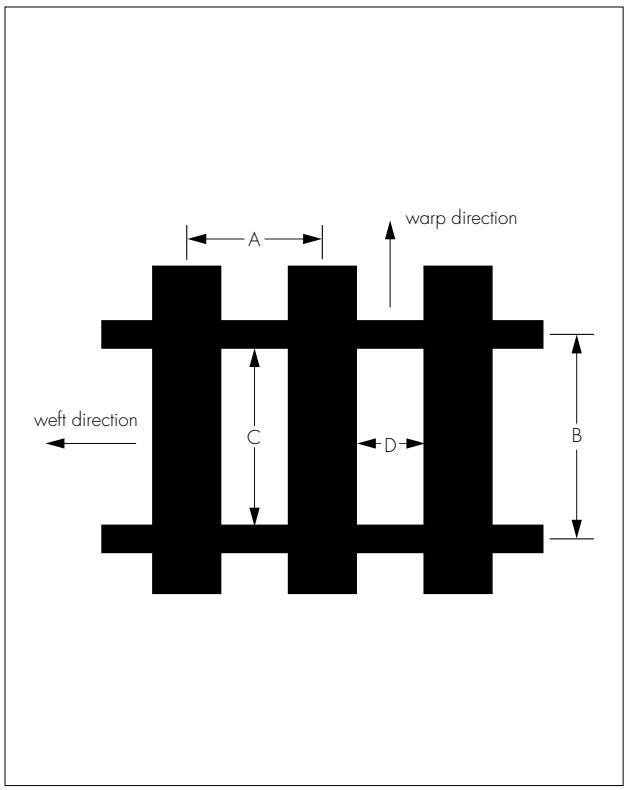
5 Description

5.1 Paralink geocomposites are planar structures consisting of a regular array of composite geosynthetic straps, nominally interconnected laterally to form soil reinforcement materials with high unidirectional strength.

5.2 The straps comprise polyester tendons, encased in a polyethylene sheath. The composite is passed through rollers to give a knurled finish on the sheath. They are cooled and cut to length. The products are formed by heat-bonding widely spaced composites of nominal strength across an array of the straps to produce a nominal 4.5 metre wide planar structure.

5.3 This Certificate relates to Paralink Type M geocomposites. The products are identified on site by clear marking of the product type and grade along the length of the roll. The range of specification of the geocomposites assessed by the BBA are given in Tables 1 and 2. A typical Paralink geocomposite is shown in Figure 1.

Figure 1 Paralink



5.4 Product quality is maintained by statistical process control at the point of manufacture.

Table 1 Paralink Type M — general specifications

Grade	Mass[1] (±5.0%) (gm^{-2})	Mean measured grid size[2] (mm) A x B	Mesh opening size (mm) C x D	Standard roll length (m) (±1/–0%)	Roll weight (kg) (kg ±5%)
100M	454	180 x 1000	921 x 98	100	270
150M	549	180 x 1000	921 x 95	100	310
200M	619	180 x 1000	921 x 95	100	340
250M	776	180 x 1000	921 x 92	100	410
300M	878	180 x 1000	921 x 92	100	460
350M	1012	180 x 1000	921 x 91	100	520
400M	1155	180 x 1000	921 x 90	100	590
450M	1305	180 x 1000	921 x 90	100	650
500M	1459	180 x 1000	921 x 90	100	720
550M	1584	180 x 1000	921 x 90	100	780
600M	1706	180 x 1000	921 x 90	100	840
650M	1861	180 x 1000	921 x 88	100	910
700M	1969	180 x 1000	921 x 89	50	510
750M	2134	150 x 1000	921 x 59	50	550
800M	2263	150 x 1000	921 x 59	50	580

(1) Mass/unit area measured in accordance with BS EN 965 : 1995.
(2) Reference dimensions (see Figure 1).

Table 2 Performance characteristics of Paralink Type M

Grade	Short-term tensile strength[1] P_{ult} (kNm^{-1} width)	a_s[2][3]	Ratio of bearing[4] surface to plan area a_b x B/2S	Strain at maximum tensile strength[5] (%)
100M	103–2.4	0.50	0.001	12 ± 2
150M	154–3.2	0.51	0.003	12 ± 2
200M	206–4.9	0.51	0.003	12 ± 2
250M	257–5.6	0.53	0.003	12 ± 2
300M	309–7.4	0.53	0.003	12 ± 2
350M	360–8.1	0.53	0.003	12 ± 2
400M	412–9.8	0.54	0.003	12 ± 2
450M	463–10.5	0.54	0.003	12 ± 2
500M	515–12.3	0.54	0.003	12 ± 2
550M	566–13	0.54	0.003	12 ± 2
600M	612–8.8	0.54	0.003	12 ± 2
650M	669–15.5	0.55	0.003	12 ± 2
700M	721–17.2	0.54	0.003	12 ± 2
750M	772–18	0.64	0.003	12 ± 2
800M	826–21.7	0.64	0.003	12 ± 2

(1) Short-term tests on virgin material in accordance with BS EN ISO 10319 : 1996, the values given are mean and tolerance (–) values of strength (P_{ult}) in accordance with EN 13251 : 2000.
(2) a_s is the proportion of the plane sliding area that is solid.
(3) a_s is required for the calculation of the bond coefficient f_b.
(4) The ratio is required to calculate bearing resistance in accordance with CIRIA SP123 : 1996 — *Soil Reinforcement with Geotextiles* (see section 10.2).
(5) Tests on virgin material in accordance with BS EN ISO 10319 : 1996, the values given are the mean and tolerance values (±) of strain in accordance with EN 13251 : 2000.

6 Delivery to site, handling and storage

6.1 Paralink geocomposites are delivered to site in rolls nominally 4.5 m wide, edge to edge of roll, and approximately 4.6 m wide end to end of the central lifting tube. The roll length is normally 50 m or 100 m depending upon the grade, although non-standard lengths can be produced on request. Roll diameters and weights vary, as indicated in Tables 1 and 2. Each roll is wrapped for transit and site protection in black polyethylene. Each package is labelled in accordance with BS EN ISO 10320 : 1999. Packaging should not be removed until immediately prior to installation. Each roll has the product grade marked on at regular intervals for identification.

6.2 Rolls should be stored in clean, dry conditions. The rolls should be protected from mechanical or chemical damage and extreme temperatures. Toxic fumes are given off if the geogrids catch fire and, therefore, the necessary precautions should be taken.

6.3 To prevent damage, care should be taken in the handling and lifting of the rolls. The weight of the rolls is such that mechanical lifting arrangements are necessary.

6.4 Rolls should be stacked no more than three rolls high. Other loads should not be stored on top of the stack.

Design Data

7 General

7.1 Paralink geocomposites are satisfactory for use as basal reinforcements under embankments (maximum slope angle of 70°) in situations where the following foundation conditions exist:

- soft foundation soils
- piled foundations
- areas prone to subsidence.

7.2 Design of basal reinforcements should be in accordance with the recommendations of BS 8006 : 1995. The design should be carried out by a suitably qualified engineer, taking account of all requisite partial material and load factors.

8 Practicability of installation

8.1 Provided the appropriate reduction factor for mechanical damage has been included at the design stage to allow for the installation methods employed and the type of fill permitted, Paralink geocomposites can be readily installed in accordance with the construction drawings.

8.2 Prior to, during and after installation, particular care should be taken to ensure:

- site preparation and embankment construction is as detailed in sections 12 to 14
- fill properties satisfy the design specification
- drainage is adequate at all stages of construction, as required by the contract documents
- the geocomposites are protected against damage from site traffic and installation equipment
- the stability of existing structures is not affected.

9 Design considerations

9.1 The embankment should be designed in accordance with the recommendations of BS 8006 : 1995.

9.2 Working drawings should show the correct orientation of the geocomposites.

9.3 Where the longitudinal run length is such that joints in the run are unavoidable, then these should be structural joints capable of carrying the full design tensile force and design lap lengths should be clearly shown on the drawings.

9.4 The designer should specify the relevant properties of the fill material for the construction of the embankment deemed acceptable for the purposes of the design. Acceptable materials should meet the requirements of the Manual of Contract Documents for Highway Works (MCHW1) Volume 1, May 2001 Edition. The recommendations of BS 8006 : 1995 should also be considered.

10 Mechanical properties

Tensile strength — short-term

10.1 The short-term values of tensile strength and strain for the geocomposites are given in Table 2.

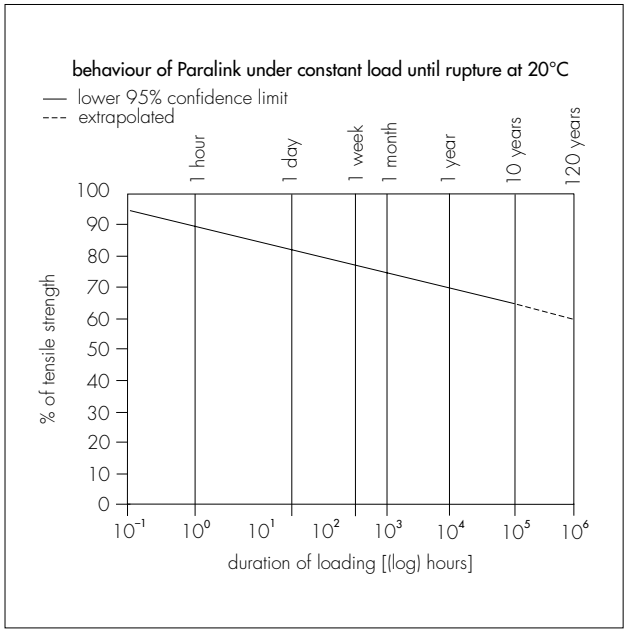
Tensile strength — long-term

10.2 Long-term creep strain and rupture testing, generally in accordance with the principles of EN ISO 13431 : 1999, has been carried out for periods in excess of 10000 hours and at varying test temperatures, to cover the range of Paralink detailed in this Certificate.

10.3 Real time data for the bar has been extrapolated by <1.0 log cycles to allow the characteristic long-term strength (P_c) for design lives of up to 120 years to be determined.

10.4 Paralink Type M for ultimate limit state, for a 120-year design life P_c is 60% P_{ult}, for a 60-year design life P_c is 64% of P_{ult} and for a 2-year design life, 68% of P_{ult} (see Figure 2).

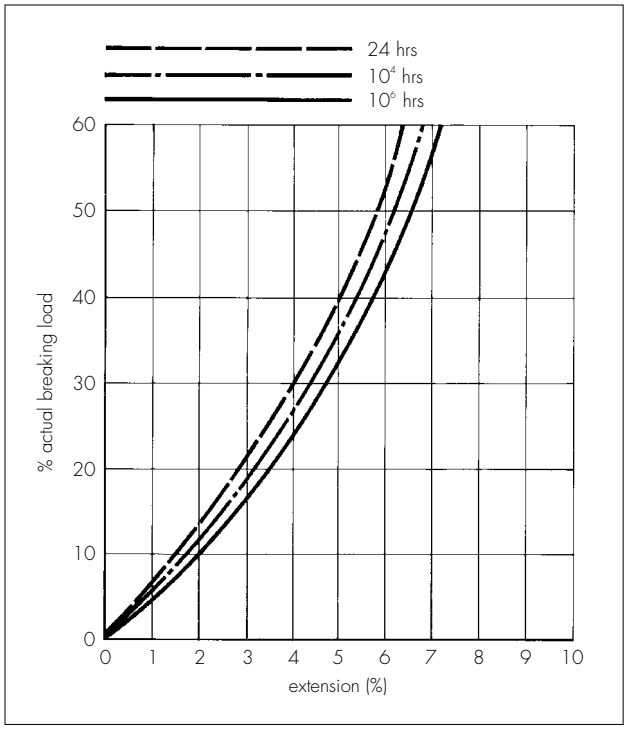
Figure 2 Time to rupture



Creep

10.5 The isochronous curves for Paralink are given in Figure 3 and can be used to predict strain under load over the design life of the embankment. Alternatively, if strain is limiting, the critical load can be established for a given design life.

Figure 3 Stress/strain isochronous curves



Material safety factors

10.6 In establishing the permissible tensile strength of Paralink M and ensuring that during the life of the embankment the geogrid will not fail in tension, the BBA recommends that, a set of partial material safety factors should be applied to P_c. Conditions of use outside the scope for which partial safety factors are defined (see also sections 10.9 to 10.10) are not covered by this Certificate and advice should be sought from the manufacturer.

Manufacture and extrapolation of data — partial safety factor (f_m)

10.7 To allow for variation in manufacture and product dimensions and to account for extrapolation of data the value for the safety factor (f_m) is given in Table 3.

Table 3 Partial material safety factor — manufacture and extrapolation of data

Design life (years)	Partial safety factor (f_m)
2 (Paralink M)	1.05
60 (Paralink M)	1.05
120 (Paralink M)	1.05

Installation damage and environmental effects — partial safety factors (f_d and f_e)

10.8 To allow for loss of strength due to mechanical damage that may be sustained during installation, the appropriate value for f_d may be selected from Table 4. The partial safety factors given for site damage assume that well-graded material is used (coefficient of uniformity >5) with a minimum compacted depth of 200 mm. For soils not covered by Table 4, appropriate values of f_d may be determined from site specific trials or the engineer may exercise engineering judgement to interpolate between the values given.

Table 4 Partial safety factor — mechanical installation damage (f_d)(1)

Paralink type	Paralink strength grade (kNm^{-1})	Partial safety factor (f_d)
M	200–250	1.10
M	300–450	1.05
M	>500	1.05

(1) All data relate to non-angular, well-graded material with maximum particle size <125 mm.

10.9 To account for environmental conditions the appropriate value for f_e should be selected from Table 5.

Table 5 Partial safety factor — environmental effects (f_e)

Design life (years)	Soil pH level (pH)	Partial safety factor (f_e)
2	2.0–9.5	1.00
60	2.0–4.0	1.05
60	4.1–8.9	1.00
60	9.0–9.5	1.05
120	2.0–4.0	1.10
120	4.1–8.9	1.05
120	9.0–9.5	1.10

Hydrolysis

10.10 Within a soil environment where pH ranges from pH 2.0 to 10.0 and temperatures are typical of those normally found in embankments in the United Kingdom, the strength of Paralink geocomposites is not adversely affected by hydrolysis, for applications where sustained soil temperatures are below 30°C.

Chemical resistance

10.11 Paralink geocomposites have a high resistance to degradation from the types of chemicals typically found in soils used for civil engineering purposes.

Microbial attack

10.12 Paralink geocomposites are highly resistant to microbial attack.

Effects of temperature

10.13 The long-term creep performance of Paralink geocomposites is not adversely affected by the range of soil temperatures typical of embankments in the UK for service loads up to the design tensile load.

10.14 Where Paralink geocomposites may be exposed to temperatures higher than 30°C or lower than 0°C for significant periods of time, consideration should be given to the temperature levels, the range of temperatures, period of exposure and stress levels at the location in question.

10.15 Sustained temperatures of greater than 30°C can increase the rate of hydrolysis of polyester and further reduction factors may be necessary.

Resistance to ultraviolet light

10.16 The black polyethylene sheath covering the polyester tendon will not deteriorate from exposure to natural daylight on construction sites, providing the product is stored prior to use in accordance with the requirements of this Certificate.

Design load (p_{des})

10.17 The maximum design load (p_{des}) that the reinforcement can be relied upon to deliver at the end of the design life and at the design temperature, can be calculated from:

$$P_{des} = \frac{P_c}{f_d f_e f_m}$$

Soil/geocomposite interaction

Bond strength

10.18 The bond strength for geocomposite reinforcement may be expressed as:

$f_b \tan\phi'$ where f_b is the bond coefficient[1].

(1) Synonymous with the term bearing factor (∝').

10.19 The use of laboratory pull-out testing to determine the value of the bond coefficient (f_b) is not recommended at present. For routine design purposes, values may be estimated using the theoretical method of Jewell (CIRIA SP123, 1996). For Paralink geocomposites, calculated conservative values may be assumed to be 0.6 for compacted frictional fill (ϕ' = 30°). The BBA recommend that site specific pull-out testing is carried out to confirm the value of bond coefficient (f_b) used in the final design.

Direct sliding

10.20 The direct sliding resistance of geogrid reinforcement may be expressed as:

$f_{ds} \tan\phi$ where f_{ds} is a direct sliding coefficient[1]

$$f_{ds} = a_s \left(\frac{\tan\delta}{\tan\phi}\right) + (1 - a_s)$$

where $\left(\frac{\tan\delta}{\tan\phi}\right)$ is the coefficient of skin friction (f_{sf}), and

a_s is the proportion of plane sliding area that is solid (see Table 2).

(1) Synonymous with the term interface sliding factor (∝).

10.21 For Paralink geocomposites the coefficient of skin friction (f_{sf}) may be assumed, for routine design purposes, to be 0.6 for compacted frictional fill (ϕ' = 30°). This is a conservative value. Where more precise values are required, for use in design, suitable soil and geogrid specific shear box testing may be carried out.

Formulae notation

δ = angle of friction between soil and plane reinforcement surface

ϕ' = effective angle of friction of soil.

11 Durability

11.1 Paralink geocomposites may be used in fills normally encountered in civil engineering practice (see section 9.4).

11.2 Evidence from tests show that Paralink geocomposites have good resistance to chemical corrosion, biodegradation, temperature, hydrolysis, and ultraviolet exposure (see sections 10.8 to 10.16).

Installation

12 General

12.1 Care should be exercised to ensure geocomposites are laid with the longitudinal direction parallel to the direction of principal stress. Design drawings should indicate geocomposite orientation.

12.2 Rolls should be placed on the formation in the position where the length of Paralink is required

to start and with the roll as closely as possible at right angles to the line of the run. Accurate alignment at the start is essential to ensure a satisfactory positioning of the laid material.

13 Preparation

To ease the laying and proper performance of the run the formation on which it is to be laid should be flat without ruts and sharp undulations.

14 Procedure

14.1 The roll should be unwound a small amount by pushing the roll in the direction of the run. The loose end of the Paralink now exposed should be secured by weighting or pinning it to the formation. The roll should then be unwound carefully, ensuring that no slack or undulations occur as it is laid. If these do occur they should be corrected immediately before proceeding. When the roll is completely unwound, the free end of the Paralink should be hand tensioned and secured by weighting or pinning.

14.2 The run of Paralink should be straight and all strip elements should be flat and not twisted. No undulations should be evident.

14.3 Where Paralink is to be used in two layers at right angles to each other, the edge joints will normally be simple butt joints. The drawings should be consulted to verify this as certain circumstances may dictate otherwise.

14.4 Where a number of rolls are to be laid at one time, this should be done with the rolls slightly in a staggered formation to avoid the lifting tubes interfering with one another.

14.5 Fill material in immediate contact with the Paralink should be placed and spread in the longitudinal direction only. If this results in some undulations of the Paralink, the secured end should be released and the undulations removed by pulling the free end.

14.6 Site vehicles should not be allowed to traffic over the laid, unprotected Paralink.

14.7 Paralink is a structural material and, where joints are necessary in its longitudinal direction, such joints should be full structural joints capable of carrying the full design tensile force. This will normally be shown as a full anchorage bond length on the drawings. The anchorage bond length depends on the type and characteristics of the fill in which the Paralink is being used. In the case of spanning pile caps, this length is unlikely to be less than the distance across three pile caps. Where the products are being used to span subsidence voids it will depend upon the size of the void anticipated by the designer.

Technical Investigations

The following is a summary of the technical investigations carried out on Paralink Geocomposite Products.

15 Investigations

15.1 The manufacturing process of the geocomposite materials was examined, 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:

- coefficient of friction between Paralink and the fill and pull-out test results
- evaluation of long- and short-term tensile properties
- resistance to mechanical damage
- load/strain characteristics
- abrasion resistance
- resistance to ultraviolet light
- effects of temperature.

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

Additional Information

The management systems of Linear Composites Limited have been assessed and registered as meeting the requirements of BS EN ISO 9002 : 1994 by Lloyds Register Quality Assurance, Approval Certificate No LRQ 0902157.

Bibliography

BS 8006 : 1995 *Code of practice for strengthened/reinforced soils and other fills*

BS EN 965 : 1995 *Geotextiles and geotextile-related products — Determination of mass per unit area*

BS EN ISO 9002 : 1994 *Quality systems — Model for quality assurance in production, installation and servicing*

BS EN ISO 10319 : 1996 *Geotextiles — Wide-width tensile test*

BS EN ISO 10320 : 1999 *Geotextiles and geotextile-related products. Identification on site*

EN 13251 : 2000 *Geotextiles and geotextile-related products — Characteristics required for use in earthworks, foundations and retaining structures*

EN ISO 13431 : 1999 *Geotextiles and geotextile-related products — Determination of tensile creep and creep rupture behaviour*

Manual of Contract Documents for Highway Works, Volume 1 : *Specification for Highway Works :* May 2001 edition

Conditions of Certification

16 Conditions

16.1 This Certificate:

(a) relates only to the product that is described, installed, used and maintained as set out in this Certificate;

(b) is granted only to the company, firm or person identified on the front cover — no other company, firm or person may hold or claim any entitlement to this Certificate;

(c) is valid only within the UK;

(d) has to be read, considered and used as a whole document — it may be misleading and will be incomplete to be selective;

(e) is copyright of the BBA;

(f) is subject to English law.

16.2 References in this Certificate to any Act of Parliament, Regulation made thereunder, Directive or Regulation of the European Union, Statutory Instrument, Code of Practice, British Standard, manufacturers' instructions or similar publication, are references to such publication in the form in which it was current at the date of this Certificate.

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

(a) are maintained at or above the levels which have been assessed and found to be satisfactory by the BBA;

(b) continue to be checked as and when deemed appropriate by the BBA under arrangements that it will determine; and

(c) are reviewed by the BBA as and when it considers appropriate.

16.4 In granting this Certificate, the BBA is not responsible for:

(a) the presence or absence of any patent or similar rights subsisting in the product or any other product;

(b) the right of the Certificate holder to market, supply, install or maintain the product; and

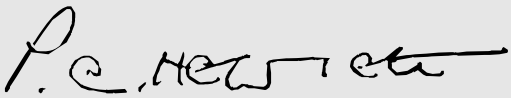
(c) the nature or standard of individual installations of the product or any maintenance thereto, including methods and workmanship.

16.5 Any recommendations relating to the use or installation of this product which are contained or referred to in this Certificate are the minimum standards required to be met when the product is used. They do not purport in any way to restate the requirements of the Health & Safety at Work etc Act 1974, or of any other statutory, common law or other duty which may exist at the date of this Certificate or in the future; nor is conformity with such recommendations to be taken as satisfying the requirements of the 1974 Act or of any present or future statutory, common law or other duty of care. In granting this Certificate, the BBA does not accept responsibility to any person or body for any loss or damage, including personal injury, arising as a direct or indirect result of the installation and use of this product.

BBA BRITISH BOARD OF AGRÉMENT
TECHNICAL APPROVALS FOR CONSTRUCTION

In the opinion of the British Board of Agrément, Paralink Geocomposite Products are fit for their intended use provided they are installed, used and maintained as set out in this Certificate. Certificate No 03/4065 is accordingly awarded to Linear Composites Limited.

On behalf of the British Board of Agrément



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Chief Executive

British Board of Agrément
P O Box No 195, Bucknalls Lane
Garston, Watford, Herts WD25 9BA
Fax: 01923 665301

e-mail: mail@bba.star.co.uk
website: www.bbacerts.co.uk