



Paraproducts

MACCAFERRI

Products Range

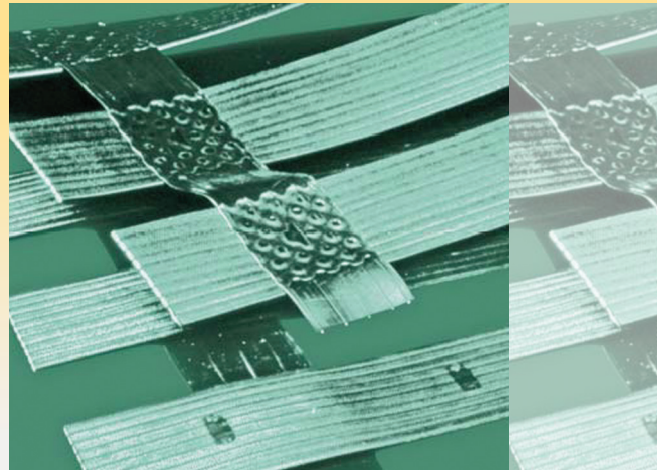
The basic technology of Paraproducts is the extrusion of polymeric materials around high tenacity polyester or aramid textile cores. The resulting composite products have a flat webbing configuration (strip). The textile type and content determines the physical characteristics of the

ParaLink

ParaLink geogrids are planar structure consisting of a monoaxial array of composite geosynthetics strips.

Each single longitudinal strip has a core of high modulus, low creep polyester yarn tendons encased in a tough, durable polyethylene sheath. The single strips are connected by low strength cross laid polyethylene elements which give a grid like shape to the composite. ParaLink has superior unidirectional strength and is available as a custom-made product in a range of strengths as between 100 kN/m ultimate up to 1350 kN/m.

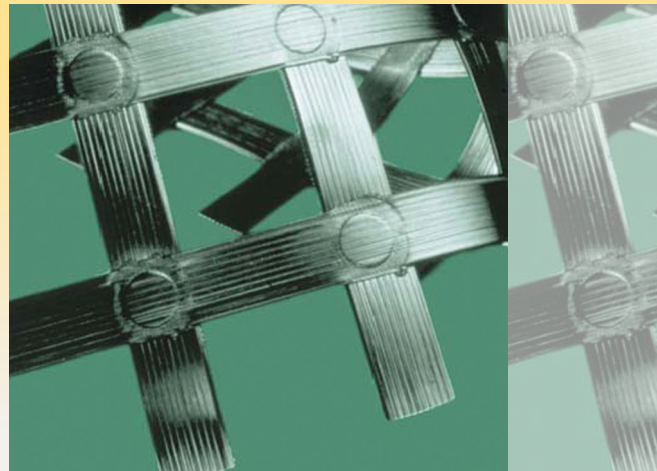
Bidirectional strength can be obtained by installing two ParaLink layers at right angles to each other.



ParaGrid

ParaGrid geogrids are planar structures consisting of a biaxial array of composite geosynthetic strips.

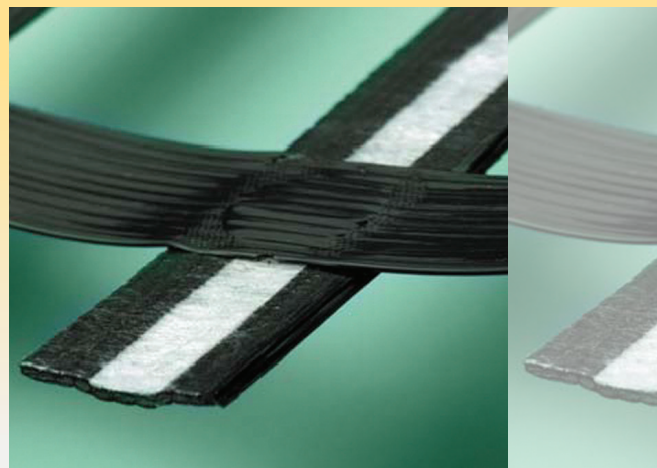
The strips comprise a core of high modulus, low creep polyester yarn tendons encased in a tough, durable polyethylene sheath. ParaGrid has good bidirectional strengths and is available in strength from 30 kN/m to 200 kN/m in the main direction (longitudinal) and from 5 to 100 kN/m in the secondary direction.



ParaDrain

ParaDrain has a unique combination of reinforcement and drainage. They are manufactured using a proven technology of the ParaGrid reinforcing products in combination with heat-bonded nonwoven continuous filament geotextiles as filters.

The reinforcing function is provided by high tenacity polyester yarns encased in a durable sheath of polyethylene which is profiled to provide a drainage channel. The nonwoven geotextile acts as a filter to allow pore water to escape into the drainage channel from the soil mass in which the product is placed. ParaDrain has good bidirectional strength and is available in strength from 50 kN/m to 200 kN/m in the main direction (longitudinal) and 5 or 15 kN/m in the secondary direction.



products in terms of tensile strength, extension, modulus etc. The polymeric sheath provides a physical and chemical barrier to external environments which pose a threat to product performance and durability. Core and sheath materials are chosen to suit specific customer requirements.

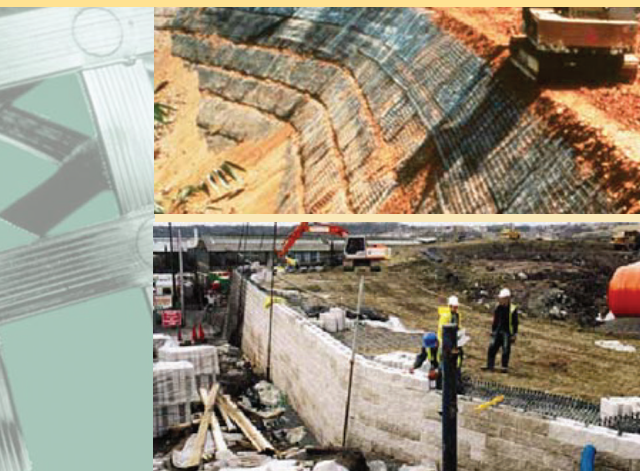


ParaLink is suitable for structural applications where a long term design life (50-120 years typically depending on the different existing regulations) is required.

Typical applications are:

- **Reinforcement of embankments over soft soils.**
- **Reinforcement of embankments constructed over areas prone to subsidence;** if subsidence occurs then the ParaLink bridges across the void (so formed) thus maintaining support for the embankment.
- **Reinforcement of the foundation of piled embankments;** ParaLink assists in the transfer of the embankment loadings directly onto the piles so that the foundation soil supports a negligible load improving the stability and reducing settlements.
- **Steep slope construction** as main reinforcement in combination with Terramesh units or ParaGrid.

ParaLink



ParaGrid is suitable for structural applications where a long term design life (50-120 years typically depending on the different existing regulations) is required.

Typical applications are:

- **Reinforcement of the fill of steep slopes;** ParaGrid steep slopes can be built using different types of facings according to the Contractor's preference.
- **Reinforcement of the fill in segmental block walls;** ParaGrid can be used in combination with any type of block.
- **Reinforcement of low embankments on soft soils** to limit and manage differential settlements.
- **Reinforcement in soil veneer applications;** ParaGrid is typically used as reinforcement to stabilize soil layers on sliding sloped surfaces (e.g. Landfill cappings are the most typical application)

ParaGrid



ParaDrain is for use in traditional geogrids applications (as ParaGrid) but **in conditions in which the soil to be reinforced has particularly poor drainage properties.** Such soils include those with a high fines content whose shear strength and reinforcement bond characteristics are adversely affected by the presence of water.

By providing a regular array of positive drainage ParaDrain allows water, trapped in the soil to be reinforced to rapidly dissipate thus enabling it to gain early strength and improve its bond with the reinforcement thereby stabilising the soil mass quickly and effectively.

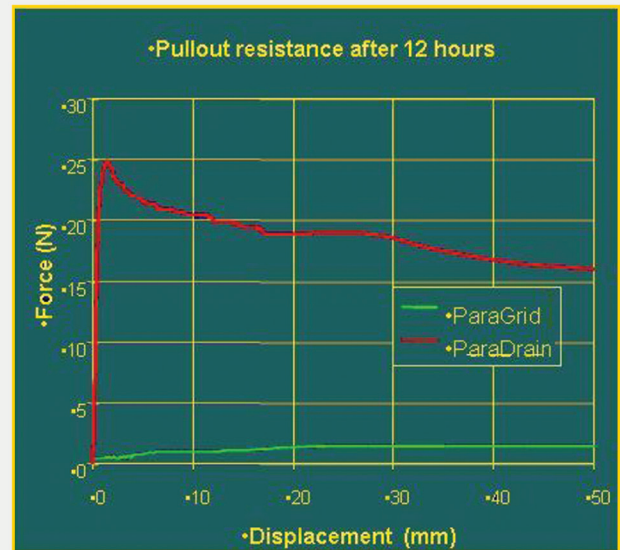
ParaDrain enables the use of marginal filling materials which would be otherwise removed from the site and replaced with high quality soil. ParaDrain is suitable for structural applications where a long term design life (50-120 years typically depending on the different existing regulations) is required; it's typically used for the reinforcement of steep fill slopes.

ParaDrain

Soil Reinforcement: Concepts

Soils suitable for reinforcing

All soils develop tensile strain during shear deformation, consequently the reinforcement can develop tensile forces when placed in any soil, provided the reinforcement is in an appropriate orientation. It follows then that all soils may be reinforced. However it requires much less reinforcement to stabilise good quality granular soils than mixed or clay soils. This is the reason why compact granular soils are the standard construction material for reinforced soil applications and the significant opportunity which opens up by the use of the ParaDrain range to reinforce cohesive soils.



Behaviour of geosynthetic reinforcements under long term loads

There are four main requirements for geosynthetic reinforcement materials:

Strength

- Initial strength (nominal breaking load)
- Reduction of initial strength due to installation damage
- Adjustment of initial strength due to the creep behaviour of the reinforcement
- Effect of temperature on the short and long term tensile properties

Durability

- Effect of ultra-violet light
- Effect of oxidation on polyolefins (PP and PE)
- Effect of hydrolysis on polyester

Stiffness

- Initial elongation compatible with the serviceability requirements of the reinforced soil structure
- Effects of installation damage on the elongation behaviour of the product
- Effect of creep on the long term elongation properties
- Effect of temperature on the short and long term tensile properties

Bond

- Depending on soil type

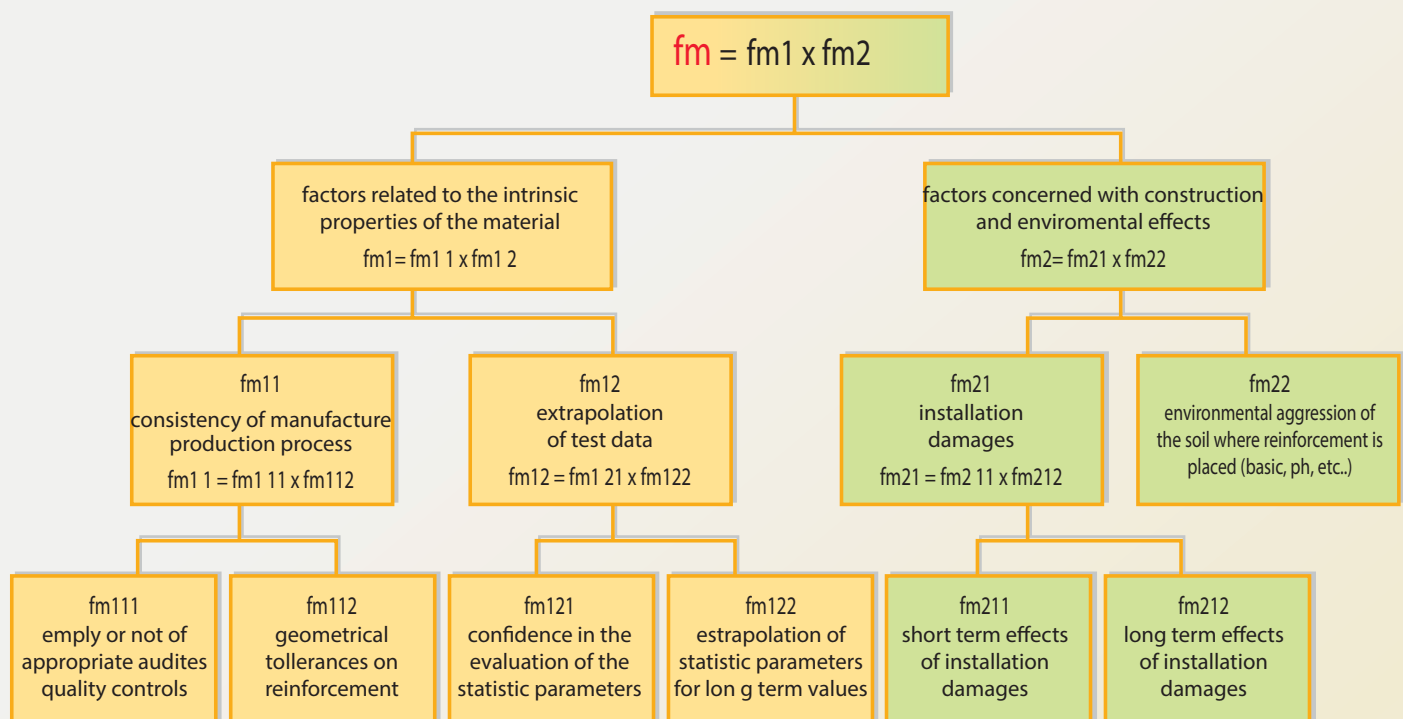


Design load

The maximum design load (T_{design}), that the reinforcement can be relied to deliver at the end of the design life and at a design temperature, can be calculated from the formula:

$$T_{design} = \frac{T_{nominal}}{f_{creep} \times f_m}$$

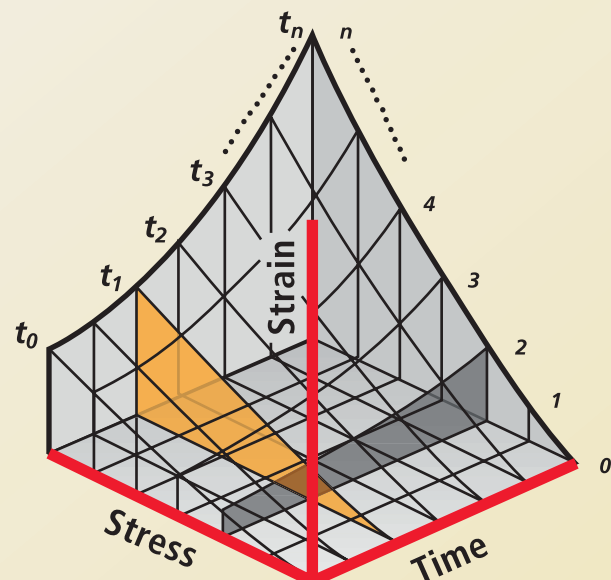
where $T_{nominal}$ is the nominal breaking load corresponding to the short term tensile strength; F_{creep} is the safety factor due to the creep behaviour at the fixed design life and F_m is the safety factor depending on the product itself and from the construction and environmental effects.



according to BS8006

For most polymeric materials, ambient temperatures coincide with , or are close to, their visco-elastic phase. Thus creep becomes a significant consideration in assessing the long term properties of the reinforcement.

The stress/strain /time characteristics (at constant temperature) of reinforcement geosynthetics can be visualised in terms of a three-dimensional body with stress, strain and time comprising the three axes. By projecting this body into each of the three planes we obtain the information required to develop the correct design.



Product main properties

Creep behaviour

Creep is the increase in elongation of a material under a constant applied load; this performance is influenced by temperature.

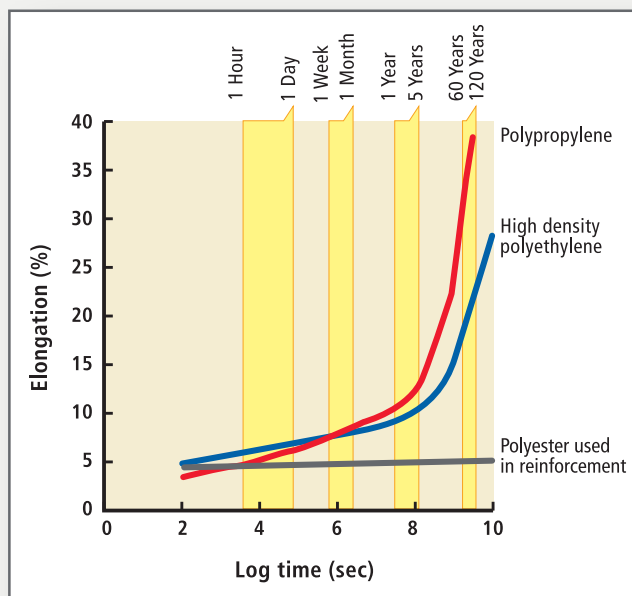
The long-term performance of a geosynthetic is highly dependent on its creep behaviour.

Over a service life of 100-120 years Paraproducts can sustain over 64% of their initial strength; compared with polyolephine reinforcements (polypropylene or polyethylene geogrids or fabrics) of identical nominal strength they can resist 50% more load.

Product durability

The polyethylene outer coating of the Paraproduct materials provides the best protection from chemical attack.

Whilst the polyester core is highly resistant to chemical degradation, the outer coating provides added security such that the geogrid will continue to perform throughout the design life in the most adverse conditions associated with waste materials and "brown field" sites.

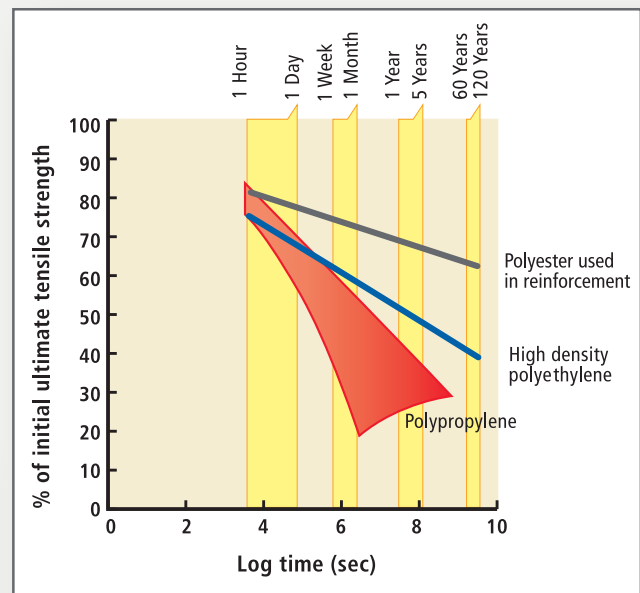


Elongation of polymers at 20°C at 30% of nominal breaking load

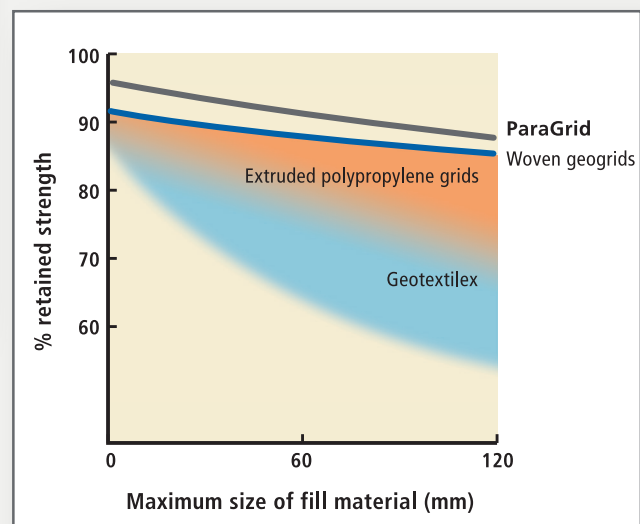
Resistance to installation damage

The high tenacity polyester fibres of the Paraproducts are protected by a tough and durable polyethylene coating that prevents the load carrying yarns from being damaged during the installation.

Paraproducts are resilient to the destructive forces encountered during installation with negligible loss in strength. In contrast, fabrics used for reinforcement can lose up to 60% of their ultimate strength during construction because of their vulnerable unprotected structure.



Load to rupture behaviour of polymers at 20°C



Retained strength following installation

Product certifications

ParaLink BBA certifications

- Agreement Certificate No 03/4065 relates to the ParaLink geocomposite products, for use as basal reinforcement under highway embankments constructed on or over
 - soft foundation soils
 - piled foundations
 - areas prone to subsidence.

ParaGrid BBA certifications

- Roads and Bridges Agreement Certificate No 98/R098 relates to ParaGrid geocomposites for use as reinforcement in embankments with slope angles up to 70°.
- Agreement Certificate No 03/4032 relates to the anchor vertical wall system for ParaGrid reinforced soil retaining walls.

CE marking

- Paraproducts range conforms to the Construction Products Directive - Council Directive 89/106/EEC as reinforcement material - R - according to EN13249, EN13250, EN13251, EN13253, EN13255, EN13257, EN13265.



PARAGRID	
TYPE 100/15	SPECIFICATION No 7259
WIDTH 3.9 metre	LENGTH 50 metre
COLOUR BLACK	RUN NUMBER xxxxx/xx
ROLL WEIGHT 103 kg	MASS 490 gm ²
ROLL No	xxxx
POLYMERS : PET : PE	
MANUFACTURED IN THE UNITED KINGDOM LINEAR COMPOSITES LTD	
xxxx-CPD-xxxx	
Paragrid 100/15	
Spec no 7259	

Steep Slopes

Slope construction using Paraproducts

There are various methods available for slope construction using Paraproducts.

The type of facing used is largely dependent on Contractor preference and desired aesthetics of the slope.



• Standard wrap around

The method can be used with larger vertical spacings between geogrid reinforcement layers resulting in a slight curvature at the slope face. This produces a more natural looking slope with increased variation in terms of light, shade, and moisture conditions.



• Permanent shuttering

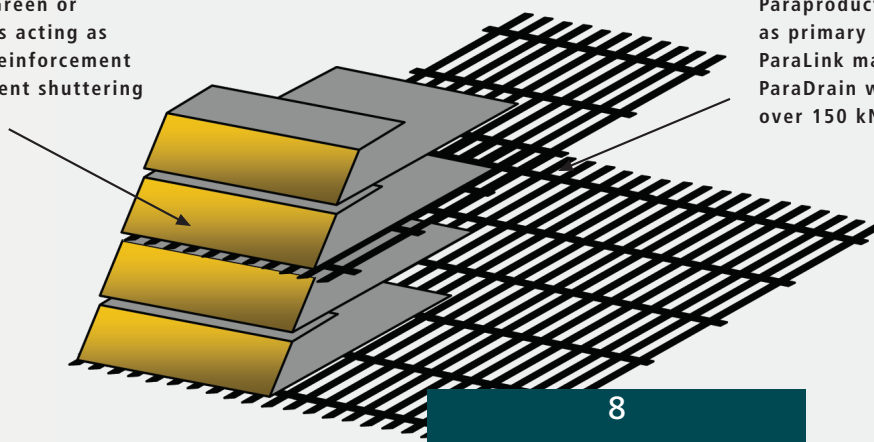
A permanent shutter at the front face provide an increase in the rate of construction with an even front face. This form of construction is ideally suitable where the designer wishes to achieve a grass finish with minimum variation across.



• Para-Mesh solution

The ideal solution designed by Maccaferri which joins the advantages of the combined use of Paraproducts with the steel Terramesh units. Paraproduct materials provide the necessary strength to guarantee the overall stability of the structure while performed Terramesh units act as secondary reinforcement and permanent shuttering maximising the speed of construction. The system is recommended for high structures.

Terramesh Green or System units acting as secondary reinforcement and permanent shuttering



Paraproduct reinforcement acting as primary reinforcement; typically ParaLink materials or ParaGrids-ParaDrain with tensile strength over 150 kN/m



• Soil bag technique

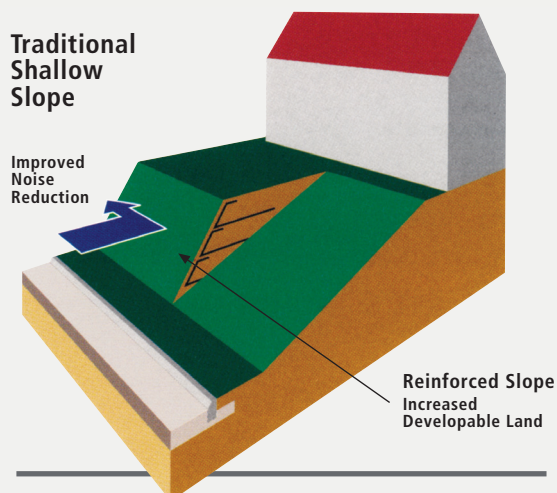
The front face of the structure may be constructed using open net soil bags filled with suitable pre-seeded topsoil. This allows exact placement of bags at the front space resulting in the to shape the slope with an high degree of accuracy.

• Shallow slope

Reinforced slopes less than 45 degrees may be designed without the wrap around detail or a permanent shuttering system. In such cases a three dimensional erosion mat (like MAC MAT) can be installed at the front face at the time of the final top soiling operation to resist surface erosion and to promote the growth of the vegetation.

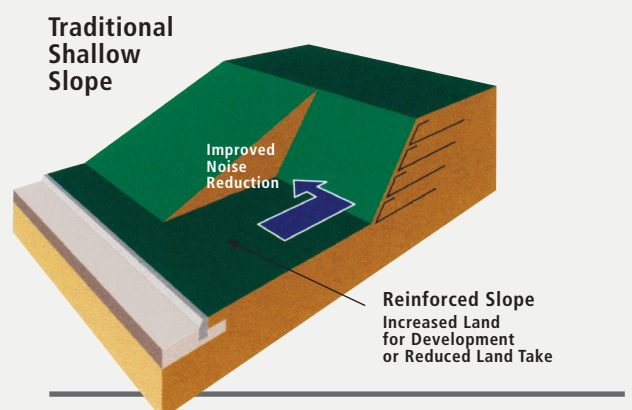
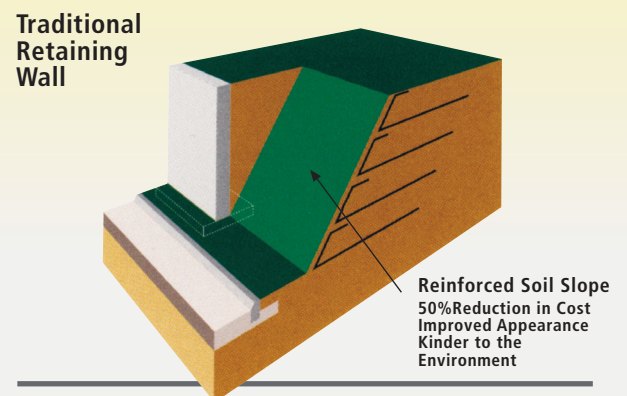
Cost benefits

- Reinforced soil structures provide a practical solution for steep slope construction without incurring the additional cost associated with a conventional retaining wall. A reinforced steep slope will typically be less than half the cost of a conventional retaining wall
- ParaDrain reinforcement enables the use of marginal soils improving the typical saving of a soil reinforced structure and makes this solution feasible with any locally available filling.



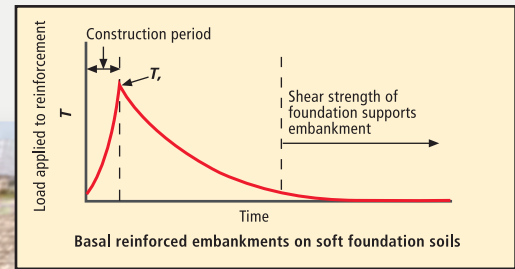
Environmental benefits

- Paraproduct solutions reduce the demand on non-renewable materials used to construct reinforced concrete structures. Furthermore, green faced slopes minimise the visual impact on our environment and provide habitat for our fauna and flora.



Basal Reinforcement

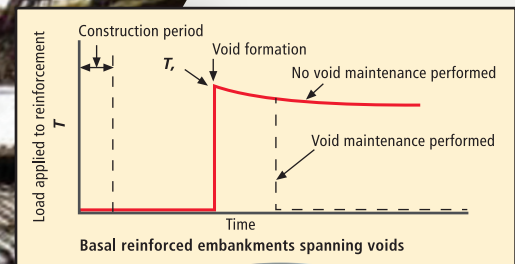
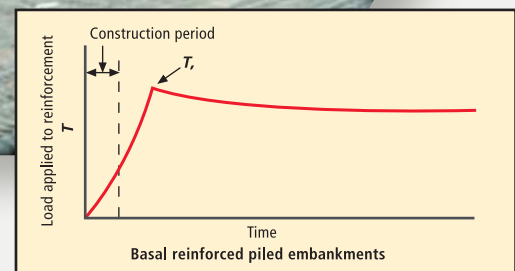
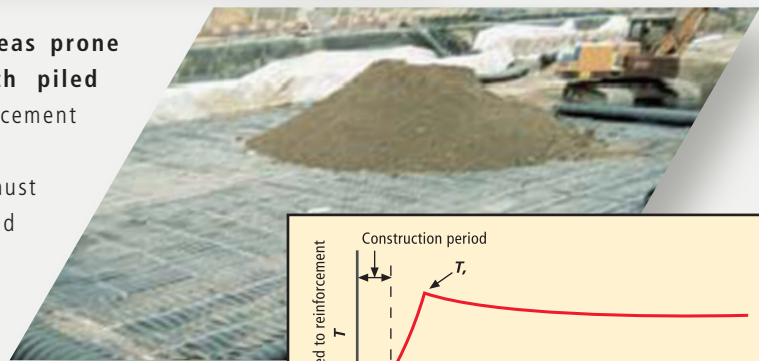
Basal reinforced embankments on soft foundations are "short term reinforcement applications" with a limited effect of creep. The very high strength and the low reduction factors make ParaLink ideal for use as a reinforcement in such applications.



Either in the case of construction **over areas prone to subsidence or in combination with piled foundations** are being "long term reinforcement applications designed".

In both cases the ParaLink reinforcement must guarantee long term structural behaviour and fit the design requirements.

ParaLink materials have been used in such applications since the 80's and there is a large data base of successfully applications demonstrating the efficiency and high value performance of ParaLink geogrids; ParaLink is BBA certified for use as basal reinforcement in important structures as highway embankments.



Cost benefits

- Reinforced soil foundations provide a practical solution for reinforcement under embankments on soft soils. The first saving is in time because reducing construction time can give substantial cost benefits.
- The use in combination with piles reduces the cost of the concrete part of the solution and enables embankments to be constructed to any height at an unrestricted rate.

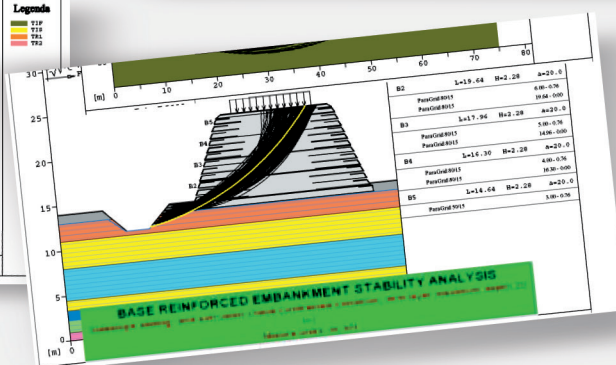
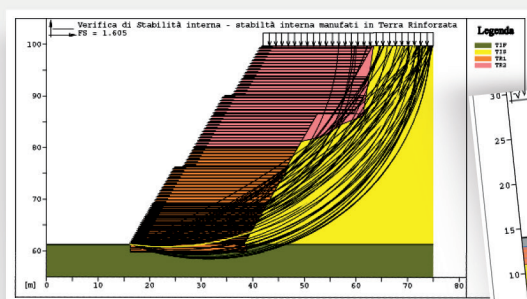
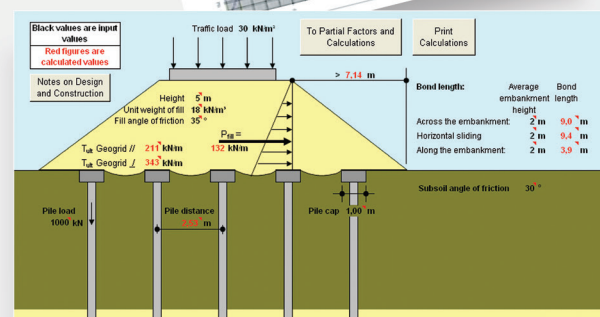


Maccaferri software for design

To assist the designers Maccaferri developed a range of customised software dedicated to soil reinforcement applications.

For each basal reinforcement application software has been developed which enables - according to the design criteria detailed in technician 8 of BS 8006 - the definition of the appropriate type of ParaLink needed in the foundation of the embankment.

Much more complex and sophisticated is the software **MAC.ST.A.R.S.** which enables a large number of stability analysis using different types of reinforcement (metallics like Terramesh and synthetics like ParaGrid and ParaLink) in combination with any type of soils and surrounding conditions. This software has been fully validated by full scale tests and is actually one of the most powerful software for stability analysis available on the market.



Quality Assurance & Research and Development

Extensive computer controlled tests are carried out to determine the essential properties of the polyester yarns prior to manufacture. On line quality controls and post-manufacture testing ensures that the material properties fall within tight manufacturing tolerances. Extensive research and development has been undertaken by different laboratories and Universities all over the world to assess the performances of the different Paraproducts. Detailed studies on the ParaDrain draining performances with English China Clay by the University of Newcastle who designed the specific apparatus to measure the rate of pore water dissipation and the pullout resistance of ParaDrain under various conditions.



May 3, 2002

Randy Edwards, P.E.
Maccaferri
10303 Governor Lane Blvd.
Millersport, MD 21795-3116

Re: QPL Product Evaluation, QPL2001-063

Dear Mr. Edwards:


The evaluation of ParaGrid, a geosynthetic reinforcement for inclusion in the Washington State Department of Transportation Product List (OPL) under General Special Provision (

Tony Allen, WSDOT State Geotechnical Engineer, c/wSDOT General Special Provision (GSP) 120271.C 2002, he indicated the ParaGrid series geogrid products the QPL. Therefore, these products have been added to the listing is enclosed. The acceptance code "Conditionally Approved" and acceptance on the part from WSDOT Materials Lab indicating that the ParaGrid WSDOT General Special Provision 120271.GR2

This information is also available on the Internet

If there are any questions concerning this matter, please call 5441.

Sincerely,

Sincerely,

James P. Walter, P.E.
Construction Materials Engineer

JW/BP
Enclosure

Materials Document
Geotechnical
2002-073.doc

**Environmental & Engineering
Programs Division**
Materials Laboratory
PO Box 47365
Olympia, WA 98504-7365
360-709-5400
360-709-5588
TTY: 1-800-833-6388
1-800-833-6388

CERTIFICATE OF APPROVAL

Linear Composites Ltd. (including Epitropic Fibres Ltd.)
Vale Mills, Oakworth, Keighley
United Kingdom

has been approved by Lloyd's Register Quality Assurance
to the following Quality Management System Standard:

ISO 9001:2000



SGI TESTING SERVICE
A Georgia Limited Liability Company

Mr. Robert Lozano
Linear Composites, Ltd
7830 Laurelton Drive
Chattanooga, TN 37421-1953

Subject: Laboratory Test Results Transmittal
Pullout Testing
ParaGrid 30/5, 80/5, 80/5K, 150/5 and
ParaLink 300L, 500L, 700L Geogrids
Within Concrete Sand

Officine Maccaferri Group Profile

Founded in 1879, **Officine Maccaferri** soon became a technical reference in the design and development of solutions for erosion control and retaining structures. Since then, through technological innovation, geographical expansion and focussed diversification, Maccaferri now offers solutions at a global level for a wide range of **civil and environmental engineering** applications.

Consultancy and Partnership

Maccaferri's motto is 'Engineering a Better Solution'; We do not merely supply products, but work in **partnership** with our clients, offering technical expertise to deliver versatile, cost effective and environmentally sound solutions. We aim to build mutually beneficial relationships with clients through the **quality of our service and solutions**.

Officine Maccaferri is at the heart of the Maccaferri Industrial Group. Its continued growth is based upon long-held values of innovation, integrity, excellent service and respect for the environment.

Maccaferri's vision is to become a leading international provider of advanced solutions to the civil engineering and construction market. Implementing a strategy of vertical integration, Maccaferri researches, manufactures, designs, supplies and constructs solutions within its target markets. The capability of the business continues to expand due to a strategic plan to open new markets and grow existing ones; Maccaferri now offers advanced engineered solutions from **beach nourishment to reinforced soil structures** and from **rockfall mitigation to tunnelling systems**. With over 2000 employees, 26 manufacturing facilities and local operations in 100 countries around the world, Maccaferri can truly claim to have a global presence with local focus.

Maccaferri: Engineering a better solution



ANY REPRODUCTION, INCLUDING PHOTOCOPY, FILM AND MICROFILM, IS FORBIDDEN. ALL RIGHTS RESERVED.

Bureau Veritas Certified Quality System Company with
ACCREDIA's and UKAS's accreditation



Maccaferri
Industrial
Group

MACCAFERRI

Officine Maccaferri S.p.A.
Via J. F. Kennedy, 10
40069 Zola Predosa (Bologna) - Italy
Phone ++39 051 6436000
Fax ++39 051 6436201
comes@maccaferri.com
www.maccaferri.com

B BIANCHINI INGENIERO

Oficinas y fábrica
Gran Vial, 8 - Pol. Ind. C.I.V
08170 Montornès del Vallès.
Tel. +34 93 568 65 10
Fax. +34 93 568 65 11
bianchini@bianchini.es
www.abianchini.es