
MACCAFERRI
PARAPRODUCTS
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TIMELESS EFFECTIVENESS
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MACCAFERRI

Webinar Agenda

5' *Introduction*

15' *Maccaferri Experience: projects from around the world*

10' *The BBA Certification*

5' *Conclusions*

Live Q&A Session

Speaker: ***Pietro Pezzano***
Technical Expertise Center of Excellence for the GSY & MacRes Business Unit


MACCAFERRI
PARAPRODUCTS
TIMELESS EFFECTIVENESS
INTRODUCTION

WHERE DO WE COME FROM

- Past civilisations (Assiryans, Egyptian, Ancient Romans…) utilized **natural materials** to stabilise steep slopes and unstable soils.
- Natural materials do not retain their properties over long periods of time due to **biodegradation**
- Starting from the 1960's, **polymers** began to be used. This enabled the construction of longer lasting structures

MACCAFERRI GEOSYNTHETICS

MACCAFERRI

> Over the years, we researched, designed and developed solutions to solve technical problems within the Civil Engineering, Geotechnical and Environmental Construction Markets.

1977
The first application
Construction of a full scale 6m wall commenced at the TRRL in the UK with the target to investigate the possible use of polymeric reinforcements and to set the optimum design criteria

1983
Taiwan, Keelung
Construction of retaining structures up to 32m high to build the keelung Container terminal

1997
New Horizonts
The first documented hybrid structure combining Paralink and Terramesh System Units was build in Scotland

1998
Italy, Genoa
Construction of first retaining structure build with raw material urban wastes reinforced with Paralink and ParaGrid and related development of the environmental geotechnical applications

1999
New development
The first retaining structure built with draining geogrid ParaDrain to reinforce cohesive clay soil in Taiwan

2005
Linear Ltd acquisition
Maccaferri; main customer of Linear Composites ltd and worldwide distributor of their ParaProducts acquire the control of the Company

2007
The expansion
An additional ParaProducts facility is build in India doubling the existing installed capacity

2015
The highest retaining wall in the world
Sikkim Airport is one of the most challenging projects of reinforced walls ever built (84 m high).

2018
New development
A new family of Paragrid geogrids is added to the existing range

HOW ARE PARAPRODUCTS MADE?

MACCAFERRI

ParaProducts are geogrids, planar structures consisting of a biaxial array of composite geosynthetic strips. The strips have a core of high tenacity **polyester** tendons encased in a tough **polyethylene** sheath

polymer granules

additives

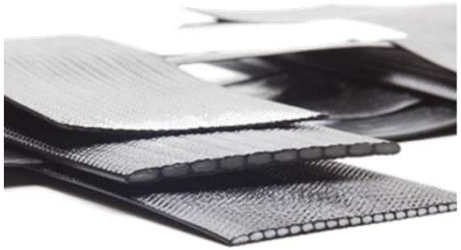
EPD®
THE INTERNATIONAL EPD® SYSTEM

Environmental Product Declaration
We communicate transparent, verified and comparable information about the environmental impact of ParaProducts

WHAT ARE THE PARAPRODUCTS?

ParaGrid

Geogrids for reinforced soil structures.



ParaLink

Geogrids for structures exposed to high loads.

ParaDrain

Geogrid combining reinforcement and drainage functions.

ParaGrid HF

Geogrids for reinforced soil structures with higher friction.

WHERE TO USE THE PARAPRODUCTS?

MACCAFERRI

RETAINING WALLS & SOIL STABILIZATION

ParaProduct solutions enable soil to **perform** better than it would in its unreinforced state, accommodating greater loads or standing at **steeper angles**

BASAL REINFORCEMENT

Whenever there are **large increases in overburden** on native ground, there is the potential of differential settlement or collapse. ParaProducts helps to manage the **settlement**

TO LEARN MORE ON OUR GSY APPLICATIONS, **DOWNLOAD** THE **BROCHURES** FROM THE DOCUMENTS SECTION


MACCAFERRI
PARAPRODUCTS
TIMELESS EFFECTIVENESS
CASE STUDIES

GLOBAL EXPERIENCE

MACCAFERRI

5000+ **GSY PROJECTS COMPLETED PER YEAR**

RETAINING WALL - PAKYONG AIRPORT

MACCAFERRI

An engineering marvel in the midst of the Himalayas

Sikkim, India

IMAGE SOURCE: cnn.com

RETAINING WALL - PAKYONG AIRPORT

An engineering marvel in the midst of the Himalayas

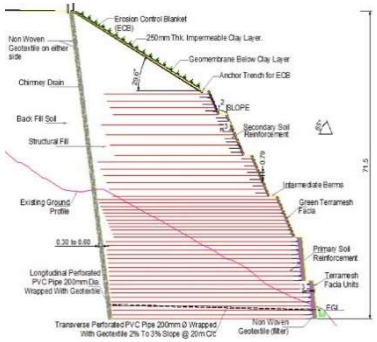
RETAINING WALL WITH PARALINK GEOGRIDS

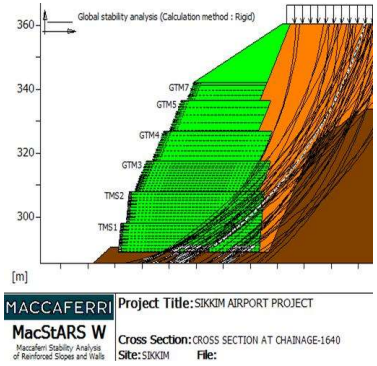
- 74-m high wall
- Challenging engineering conditions

RETAINING WALL - PAKYONG AIRPORT

An engineering marvel in the midst of the Himalayas

In September 2011, Sikkim was struck by a magnitude **6.8 earthquake**. While most other infrastructure in the area was damaged by the quake, the ParaMesh structure stood firm due to its flexibility and inherent robustness of these Paralink® reinforced soil structures.





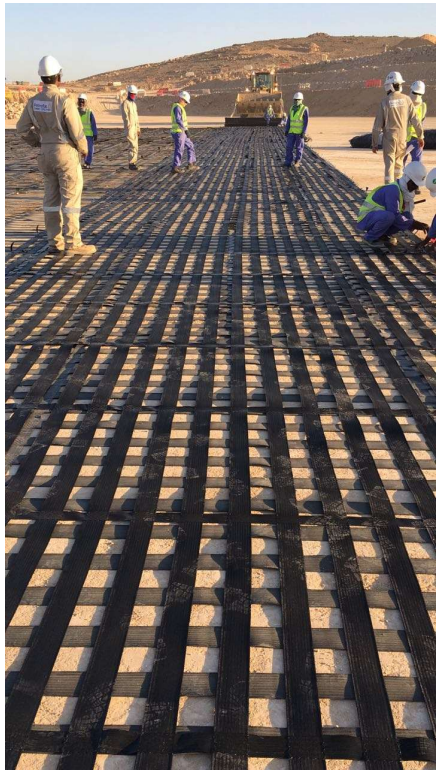
BASAL REINFORCEMENT – SALALAH LPG

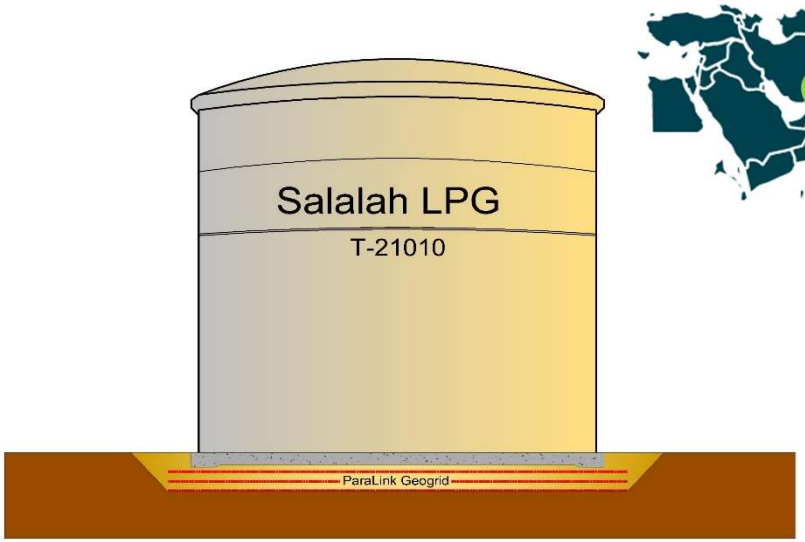
Bearing capacity and settlement improvement

Salalah, Oman

BASAL REINFORCEMENT – SALALAH LPG

Bearing capacity and settlement improvement



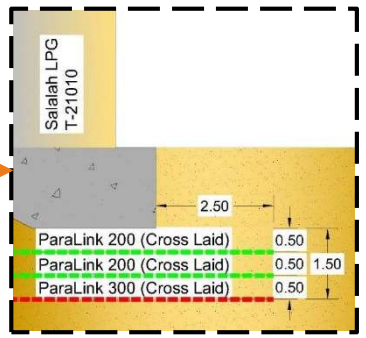


BASAL REINFORCEMENT WITH PARALINK GEOGRIDS

- Improvement of the soil bearing capacity
- Widening of the load distribution area

BASAL REINFORCEMENT – SALALAH LPG

Bearing capacity and settlement improvement



RETAINING STRUCTURES – CAPE PRESTON MINE

MACCAFERRI

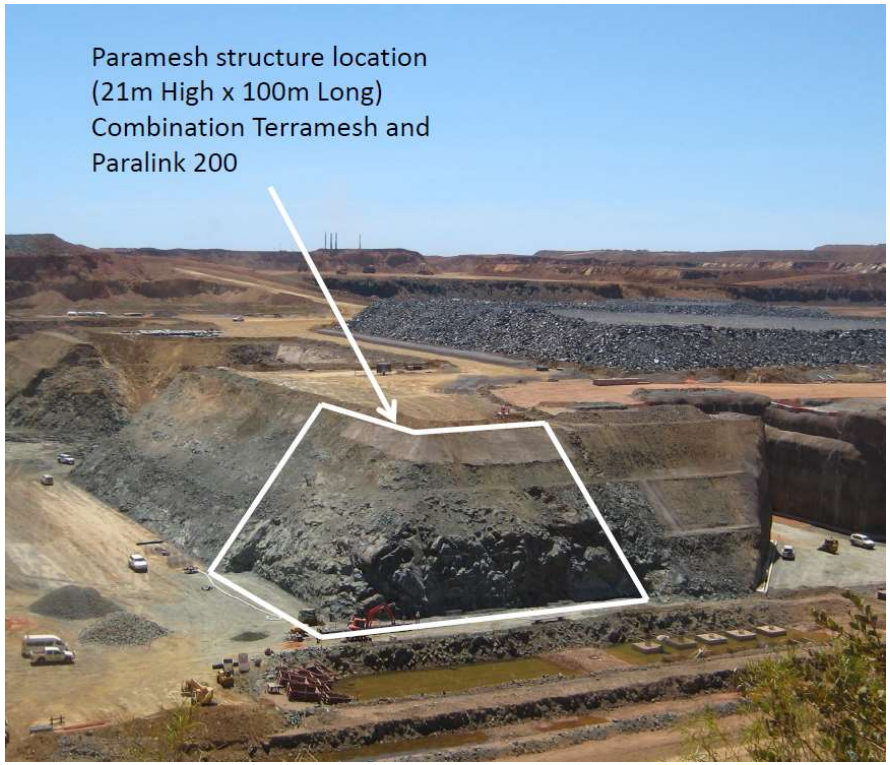
Paramesh: the combination of TerraMesh and Paralink

Cape Preston, Australia

RETAINING STRUCTURES – CAPE PRESTON MINE

MACCAFERRI

Paramesh: the combination of TerraMesh and Paralink



RETAINING STRUCTURES – CAPE PRESTON MINE

MACCAFERRI

Paramesh: the combination of TerraMesh and Paralink

RETAINING STRUCTURES – RESIDENTIAL DEVELOPMENT

Nice looking and environmentally friendly solutions

British Columbia, Canada

RETAINING STRUCTURES – RESIDENTIAL DEVELOPMENT

Nice looking and environmentally friendly solutions

- Ease of installation
- Nice looking integration into the sourrounding environment

RETAINING STRUCTURES – RESIDENTIAL DEVELOPMENT

MACCAFERRI

Nice looking and environmentally friendly solutions

BASAL REINFORCEMENT – CONTAINER STORAGE AREA

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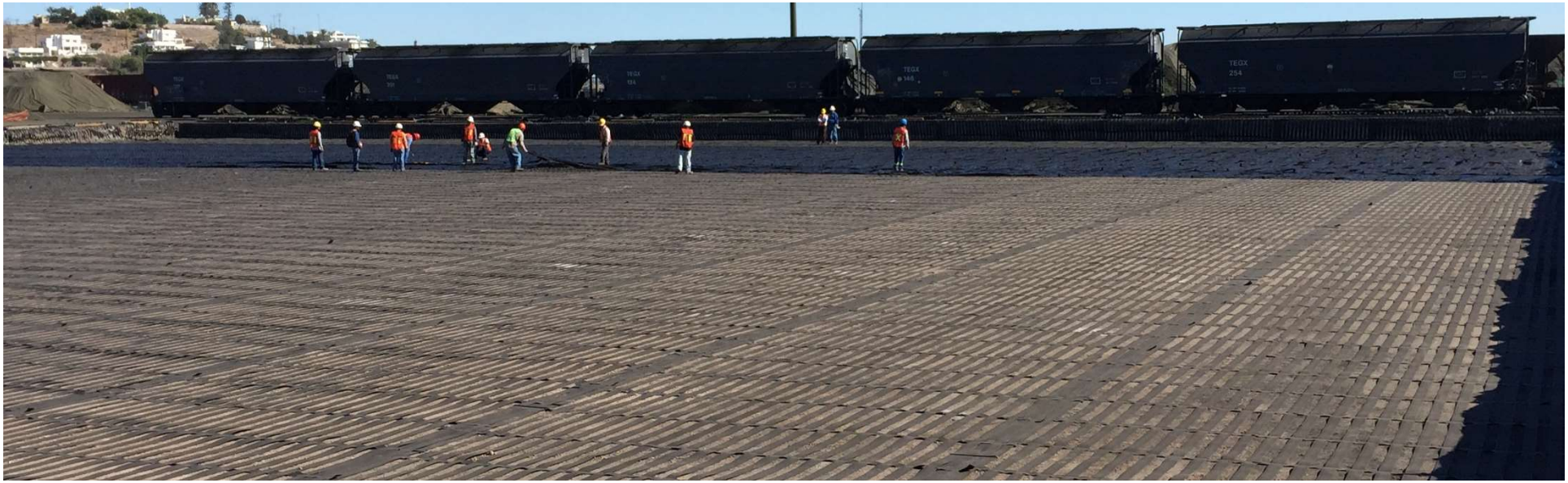
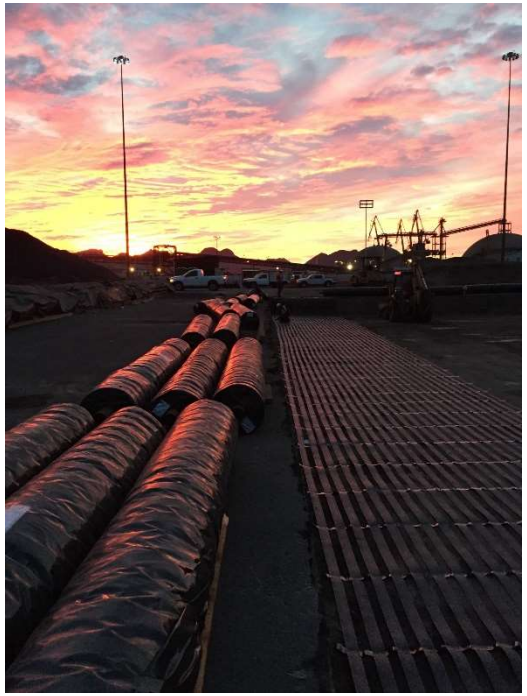
Port of Guayamas, Mexico



BASAL REINFORCEMENT – CONTAINER STORAGE AREA

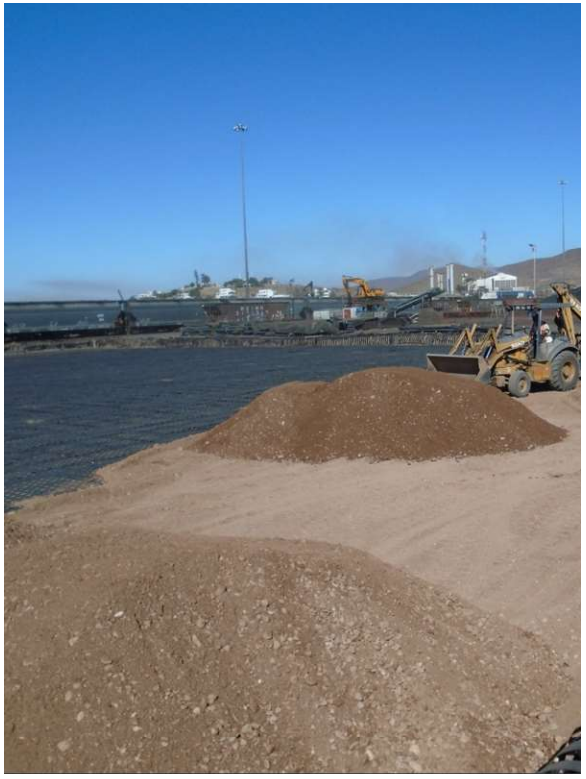
Prevention of differential settlment



- Ease of installation
- Long term performance

BASAL REINFORCEMENT – CONTAINER STORAGE AREA

MACCAFERRI



BASAL REINFORCEMENT – ITALY

Prevention of foundation failure and differential settlement

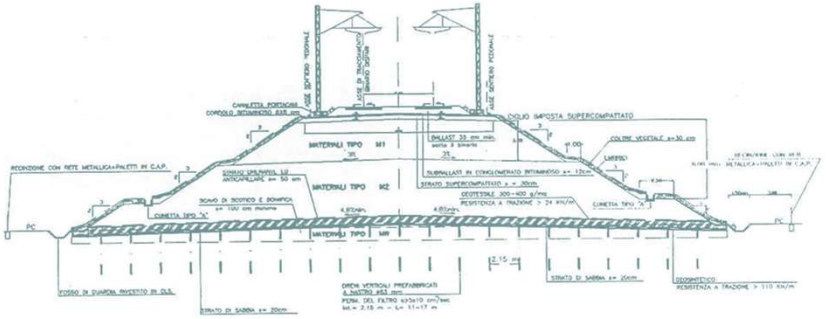
High Speed Railway, Italy

BASAL REINFORCEMENT – ITALY

Prevention of foundation failure and differential settlement

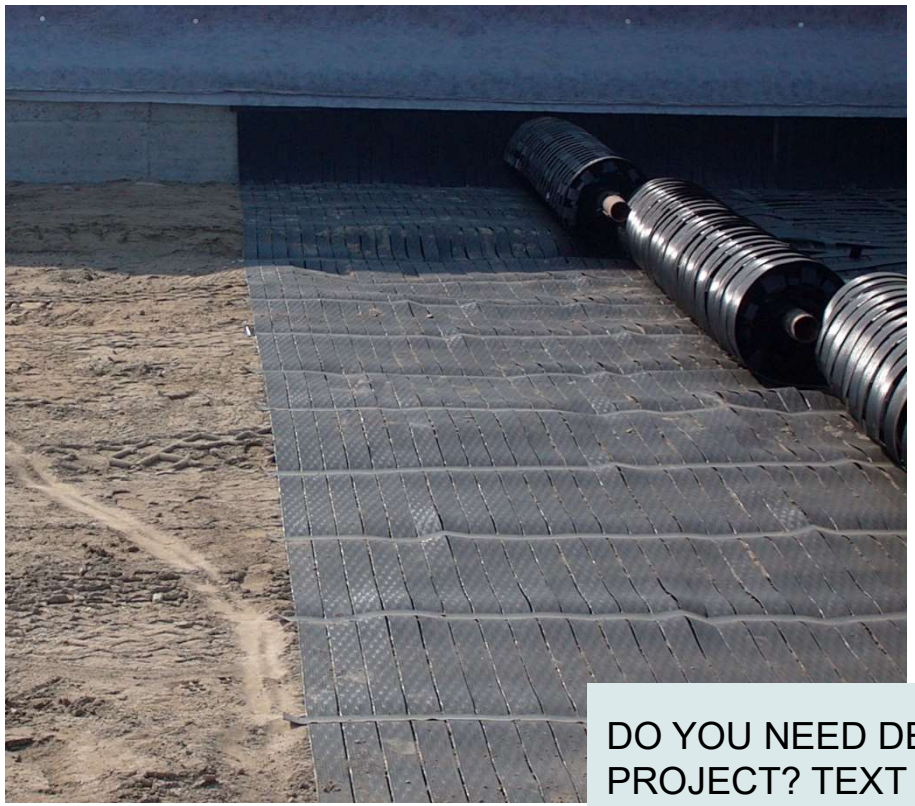
BASAL REINFORCEMENT OF THE EMBANKMENTS

- Improvement of the stability of the railway embankments
- Limiting the differential settlements.



BASAL REINFORCEMENT – ITALY

Prevention of foundation failure and differential settlement



DO YOU NEED DEDICATED ASSISTANCE FOR YOUR DESIGN PROJECT? TEXT «**PROJECT**» IN THE CHAT BOX

THE BBA CERTIFICATION

CERTIFICATION

MACCAFERRI

ParaProducts are among the most tried and tested geogrids in the world. This not only refers to **performance** certifications but also to **environmental** and **digital** ones.

CE

NTPEP
AASHTO | NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM

BBA APPROVAL INSPECTION TESTING CERTIFICATION
CERTIFICATE 16/H249

BIM
CERTIFICATE
19-BI001/2

EPD®
THE INTERNATIONAL EPD® SYSTEM

BBA CERTIFICATION: WHAT IT IS

MACCAFERRI

HAPAS

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Vale Mills
Oakworth
Keighley
West Yorkshire BD22 0EB

Tel: 01535 643363 Fax: 01535 643605
e-mail: mail@linearcomposites.com
website: www.linearcomposites.com

BBA APPROVAL INSPECTION TESTING CERTIFICATION
TECHNICAL APPROVALS FOR CONSTRUCTION

HAPAS Certificate
16/H249
Product Sheet 1

LINEAR COMPOSITES SOIL REINFORCEMENT PRODUCTS

PARAGRID, PARAGRID HF AND PARADRAIN GEOCOMPOSITES

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 Paragrid, Paragrid HF and Paradrain [1] Geocomposites, comprising an open network of integrally connected straps of high tenacity polyester (PET) yarn coated with polyethylene, for use as reinforcement in embankments with slope angles up to 70°.

(1) Paragrid and Paradrain are registered trademarks.

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.

- Independently verified technical specification
- Assessment criteria and technical investigations
- Design considerations
- Installation guidance
- Regular surveillance of production
- Formal three-yearly review

PARALINK and **PARAWEB** are respectively covered by BBA certificates 03/4065 and 12/H191 **PARAGRID, PARAGRID HF and PARADRAIN** are in the 16/H249

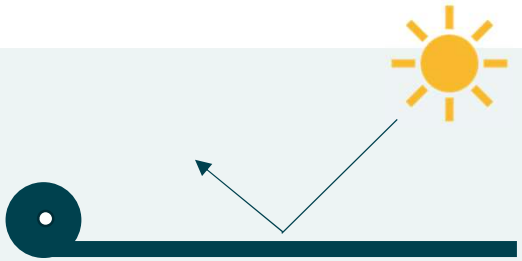
BBA CERTIFICATION: KEY FACTORS ASSESSED

MACCAFERRI

Design
Interaction between the soil and geocomposites has been considered and coefficients relating to direct sliding and pull-out resistance are proposed.

Mechanical properties
The short- and long-term tensile strength and elongation properties of the geocomposites and loss of strength owing to installation damage have been assessed and reduction factors established for use in design.

Effects of environmental conditions and durability
The resistance of the geocomposites to the effects of hydrolysis, chemical and biological degradation, UV exposure and temperature conditions normally encountered in civil engineering practice has been assessed and reduction factors established for use in design.



BBA CERTIFICATION: THE DESIGN

MACCAFERRI

Design strength of the reinforcement (T_D)

$$T_D = T_{CR} / f_m$$

T_{CR} is the **long-term tensile creep rupture strength** of the reinforcement at the specified design life and design temperature

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 required to establish the above reduction factors

BBA CERTIFICATION: THE DESIGN

Long-term tensile creep rupture strength of the reinforcement

$$T_D = T_{CR} / f_m$$

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

T_{char} is the characteristic short-term strength of the reinforcement

RF_{CR} is the reduction factor for creep (see section 7).

BBA CERTIFICATION: MECHANICAL PROPERTIES

MACCAFERRI

Tensile strength — short-term (T_{char})

*Typical short-term stress/strain curve for **Paragrid** and **Paradrain** geocomposites*

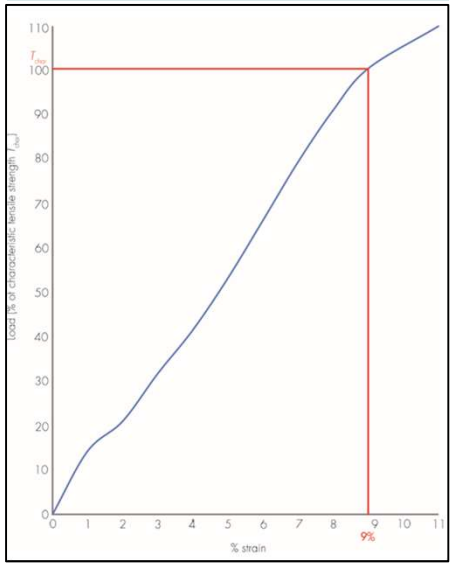


Table 13 Typical short-term strain against load (as percentage of the T_{char})

Strain	% of T_{char}
At 2%	21
At 3%	32
At 4%	42
At 5%	53
At 6%	66

*Typical short-term stress/strain curve for **Paragrid HF***

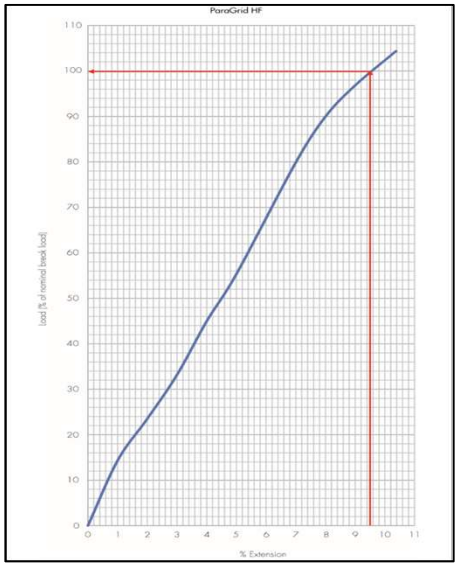


Table 14 Typical short-term strain against load (as percentage of the T_{char})

Strain	% of T_{char}
At 2%	23
At 3%	34
At 4%	45
At 5%	55
At 6%	69

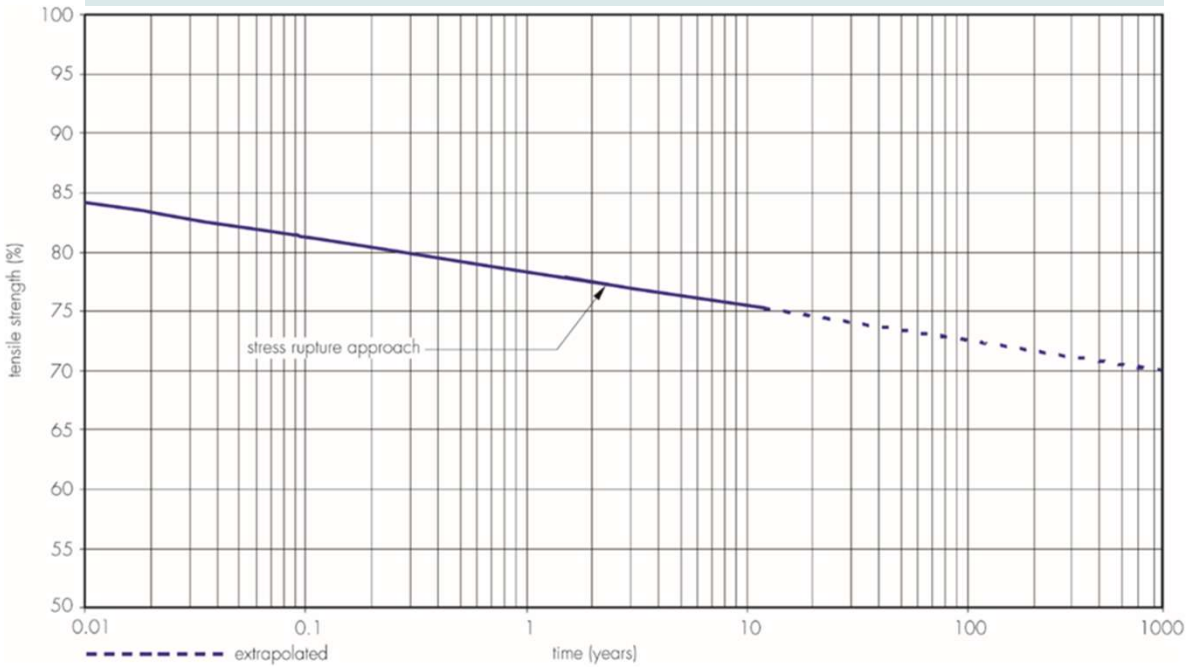
- **Characteristic short-term tensile strength** (T_{char}) and strain values for the products are given
- A typical short-term stress/strain curve is shown
- **Short-term strain** at varying percentages of characteristic strength is given in Tables 13 and 14.

BBA CERTIFICATION: MECHANICAL PROPERTIES

MACCAFERRI

Tensile strength — Long-term

Regression line for life expectancy at constant stress defined by percentage of characteristic short-term strength at 20°C



- The **long-term tensile creep rupture strength** performance of Paragrid, Paragrid HF and Paradrain Geocomposites has been determined in accordance with the principles of PD ISO/TR 20432 : 2007.
- A **stress rupture line** has been determined using conventional long-term creep rupture test data (up to 41,945 hours) and time-shifted stepped isothermal method (SIM) test data (up to 7.8 x 10^6 hours) for a design temperature of 20°C.
- From this graph the value of the **tensile creep rupture strength (T_{CR})** can be determined for the appropriate design life.

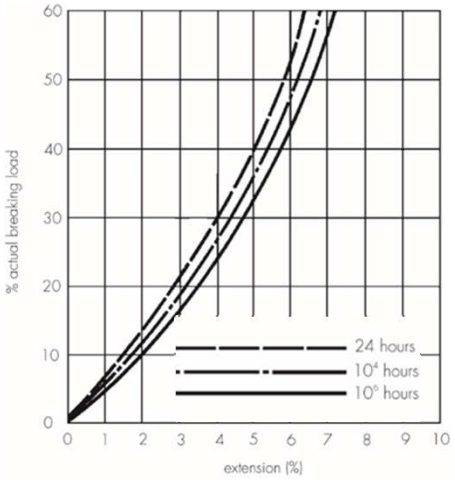
BBA CERTIFICATION: MECHANICAL PROPERTIES

Creep Strain

Table 15: Long-term creep reduction (RF_{CR}) for Paragrid, Paragrid HF and Paradrain Geocomposites at various temperatures and design life

Design temperature (°C)	Creep reduction factor (RF_{CR})	
	60-year design life	120-year design life
0	1.28	1.30
20	1.37	1.38
25	1.39	1.40
30	1.41	1.43
40	1.46	1.48

Figure 6: Load extension curve



- **Long-term tensile strength** (T_{CR}) for Paragrid, Paragrid HF and Paradrain Geocomposites can be derived for a 60- and 120-year design life and design temperatures of 0, 20, 25, 30 and 40°C, using the formula given in section 6.4 and the **long-term creep reduction factors (RF_{CR})** shown in Table 15.

- **Creep strain** is not normally considered an issue for the design of embankments and slopes. However, for situations where creep strain is applicable, the **isochronous curves** for Paragrid, Paragrid HF and Paradrain Geocomposites are shown in Figure 6.

BBA CERTIFICATION: THE DESIGN

The material safety factor (f_m)

$$T_D = T_{CR} / f_m$$

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

RF_{ID} is the reduction factor for installation damage

RF_W is the reduction factor for weathering, including exposure to UV light

RF_{CH} is the reduction factor for chemical/environmental effects

f_S is the factor of safety for the extrapolation of data.

BBA CERTIFICATION: MECHANICAL PROPERTIES

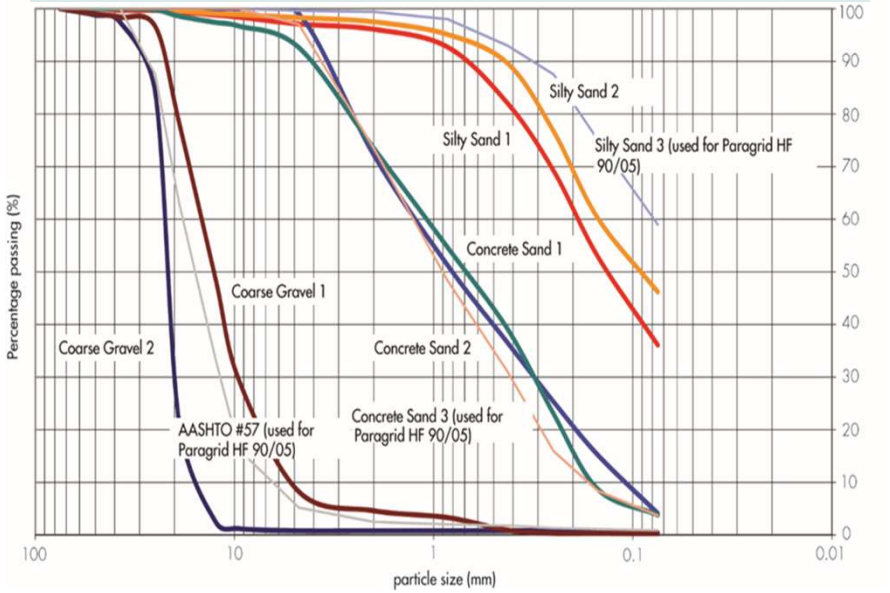
Table 16: Reduction factor – installation damage for Paragrid and Paradrain (RFID)

Soil type	Paragrid and Paradrain grade	Reduction factor (RF_{ID})
Silty sand 1 [2]	30/5	1.04
	80/5	1.01
	150/5	1.01
Silty sand 2 [3]	30/5	1.05
	50/5	1.04
	80/5	1.03
	100/5	1.02
Concrete sand 1[2]	30/5	1.08
	50/5	1.02
	150/5	1.01
Concrete sand 2[3]	30/5	1.05
	50/5	1.04
	80/5	1.03
	100/5	1.02
Coarse gravel 1 [2]	30/5	1.10
	50/5	1.03
	150/5	1.02
Coarse gravel 2 [3]	30/5	1.16
	50/5	1.15
	80/5	1.12
	100/5	1.10

Table 17: Reduction factor – installation damage for Paragrid HF (RFID)

Soil type	Paragrid HF grade	Reduction factor (RF_{ID})
Silty sand 3 [2]	90/5	1.01
Concrete sand 3[2]	90/5	1.02
Coarse gravel 3 [2]	90/5	1.04

Figure 7: Particle size distributions of soils used in installation damage testing



- To allow for loss of strength owing to **mechanical damage** that might be sustained during installation, the appropriate value for RFID may be selected
- These reduction factors have been established from **full-scale installation damage tests** using a range of materials, the gradings of which can be seen in Figure 7.

BBA CERTIFICATION: ENVIRONMENTAL CONDITIONS

Reduction factor for weathering, including exposure to UV light (RF_W)

A reduction factor (RF_W) of 1.00 may be used for design provided the geocomposites 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. Further investigation is required for exposure periods exceeding one month.

BBA CERTIFICATION: ENVIRONMENTAL CONDITIONS

Reduction factor for chemical/environmental effects (RF_{CH})

Table 18 Reduction factor RF_{CH}

Design temperature (°C)	Reduction Factors (RF_{CH})					
	60 year service life			120 year service life		
	4<pH<9	9.1<pH<9.5	9.6<pH<11	4<pH<9	9.1<pH<9.5	9.6<pH<11
20	1.02	1.03	1.07	1.03	1.05	1.12
25	1.03	1.05	1.09	1.07	1.09	1.15
30	1.06	1.10	1.14	1.15	1.17	1.25

- The polyethylene sheath used on Paragrid, Paragrid HF and Paradrain acts as a chemical barrier which, if not broken or damaged, will reduce the risk of chemical attack on the polyester fibres
- Paragrid, Paragrid HF and Paradrain Geocomposites are highly resistant to microbial attack.
- To account for environmental conditions, the appropriate reduction factors (RF_{CH}) should be selected from Table

BBA CERTIFICATION: SF FOR THE EXTRAPOLATION OF DATA

Factor of safety for the extrapolation of data

Table 19 Factors of safety for extrapolation of data

Design life (years)	f_s
60	1.02
120	1.05

- For Paragrid, Paragrid HF and Paradrain Geocomposites, **the factor of safety for the extrapolation of data** (f_s) should be taken as given in Table 19 of the BBA

Table 20 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	1.02	1.05

- The values in Table 19 have been calculated in accordance with PD ISO/TR 20432 : 2007, using the R_1 and R_2 values given in Table 20.

BBA CERTIFICATION: THE DESIGN

MACCAFERRI

Design strength of the reinforcement (T_D)

$$T_D = T_{CR} / f_m$$

T_{CR} is the **long-term tensile creep rupture strength** of the reinforcement at the specified design life and design temperature

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

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 required to establish the above reduction factors

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

BBA CERTIFICATION: DURABILITY & SUSTAINABILITY

MACCAFERRI

120 YEARS
SERVICE LIFE

When designed and installed in accordance with the requirements of BS 8006-1 : 2010, BS EN 14475 : 2006 and this Certificate, Paragrid, Paragrid HF and Paradrain Geocomposites will have a service life of up to **120 years, exceeding the typical design life required for reinforced soil embankments**

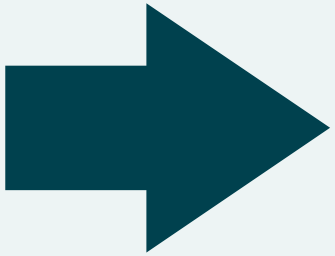
EPD®
THE INTERNATIONAL EPD® SYSTEM

With **Environmental Product Declaration** (EPD) we provide reliable and comparable information on the environmental impacts of the product life cycle **reducing energy** and **material consumption**

CONCLUSIONS

- ParaProducts are among the **most tried and tested geogrids** in the world
- Thousands of reference cases available that prove the **cost effectiveness**
- Used and tested for more than 40 years
- Trusted and **certified performances**

TEXT «**PROJECT**» IN THE CHAT BOX FOR DEDICATED ASSISTANCE ON YOUR DESIGN PROJECT!




PARAPRODUCTS
$
TIMELESS EFFECTIVENESS

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LIVE Q&A

TIMELESS EFFECTIVENESS

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