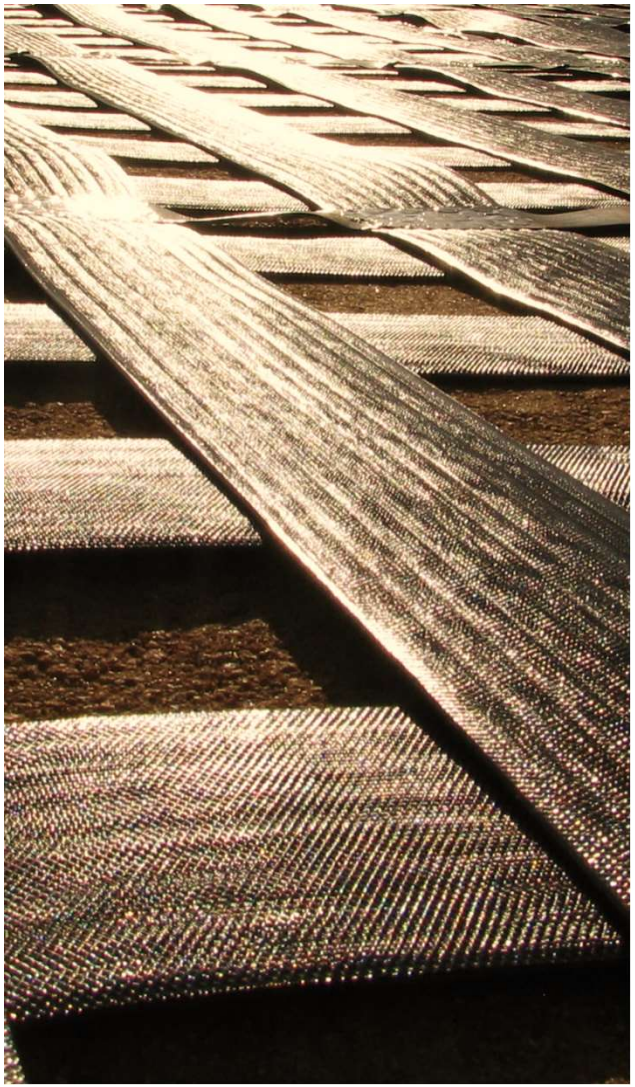


ParaProducts: Proven Durability in High-Alkalinity Environments

MACCAFERRI

WEBINAR AGENDA

15’ *ParaProducts and BBA*

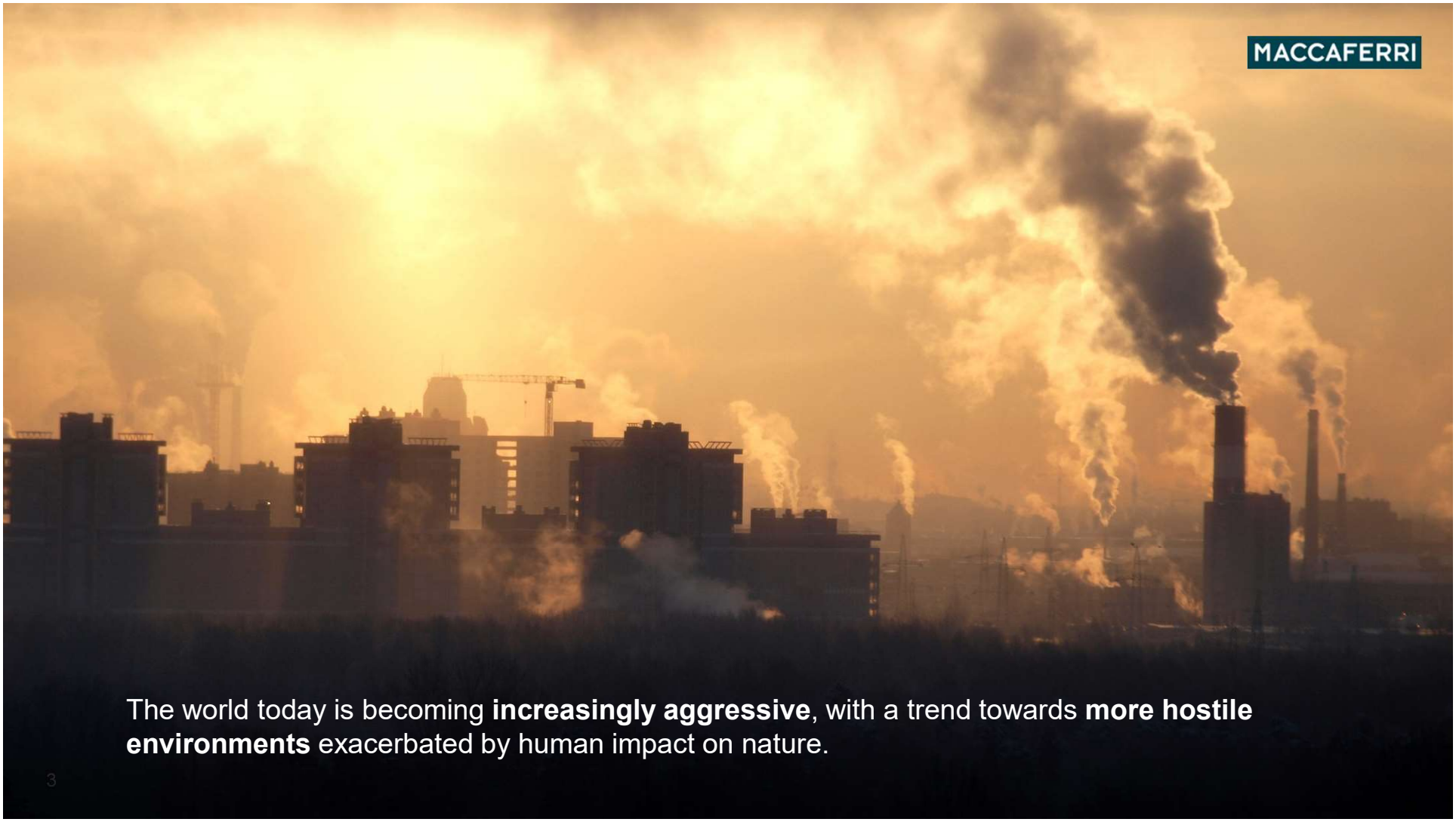
20’ *Test Campaigns*

5’ *Conclusions*

Live Q&A Session

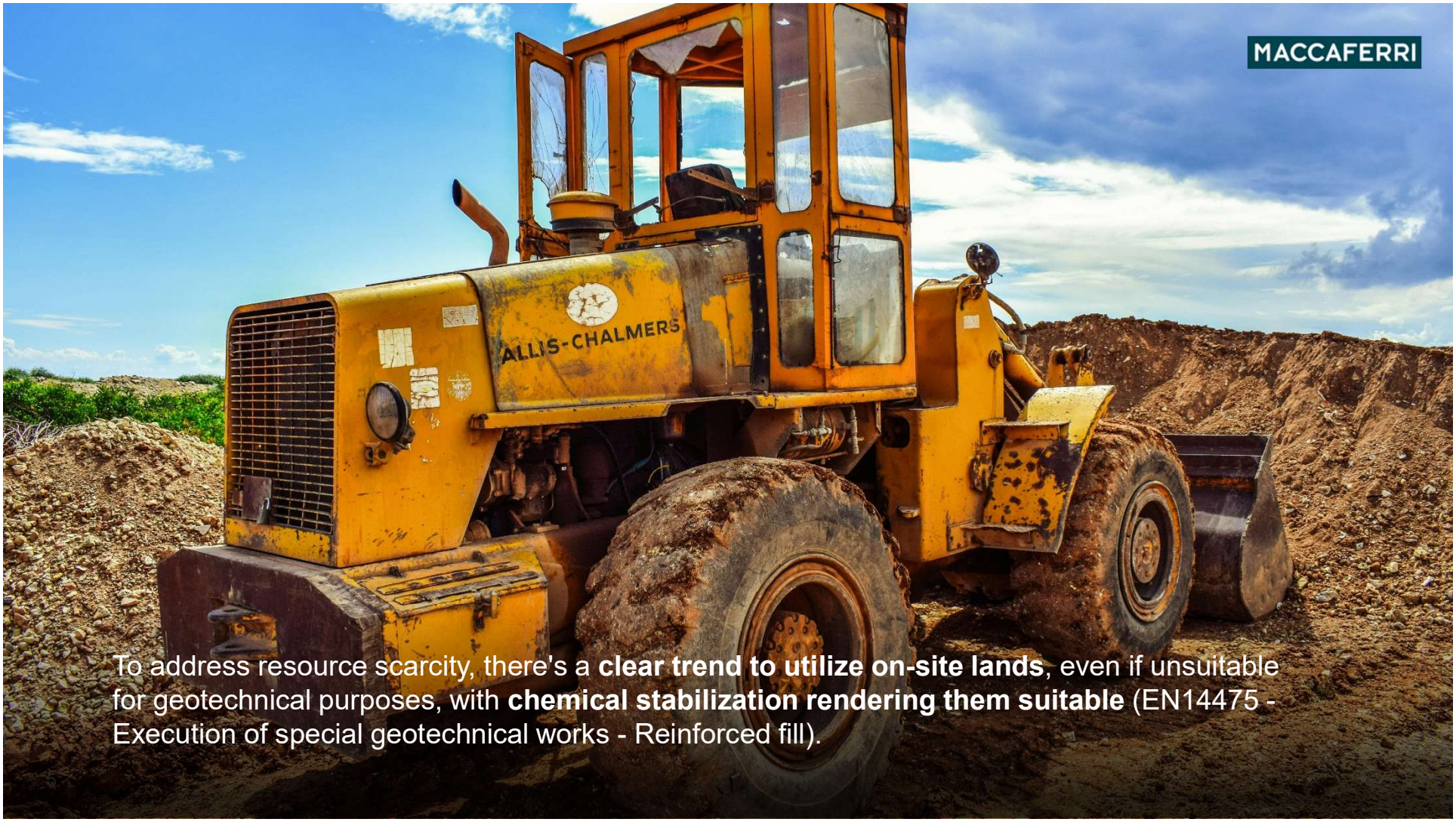
Speaker

G. Lugli − Group Business Development GSY Unit

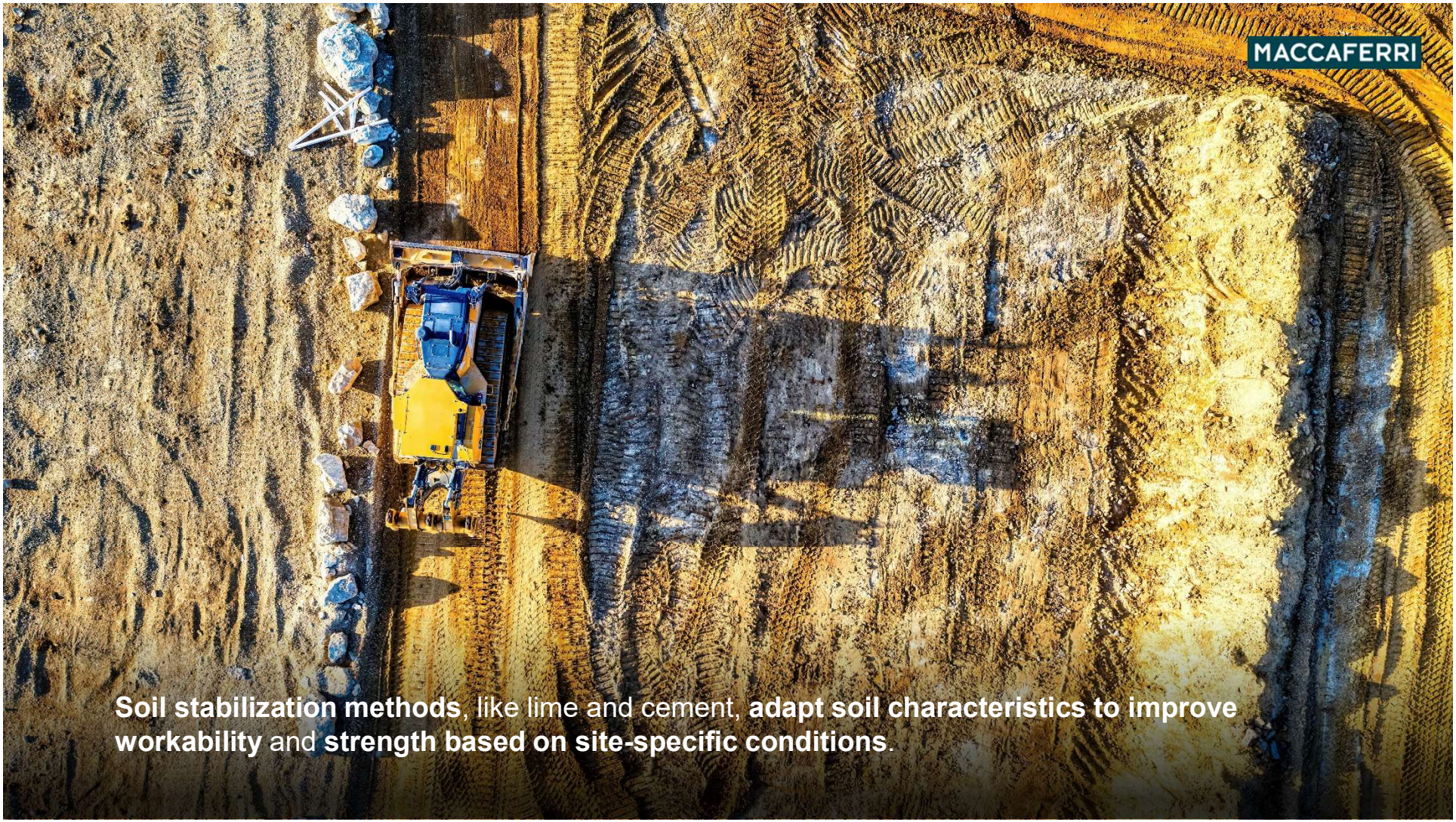


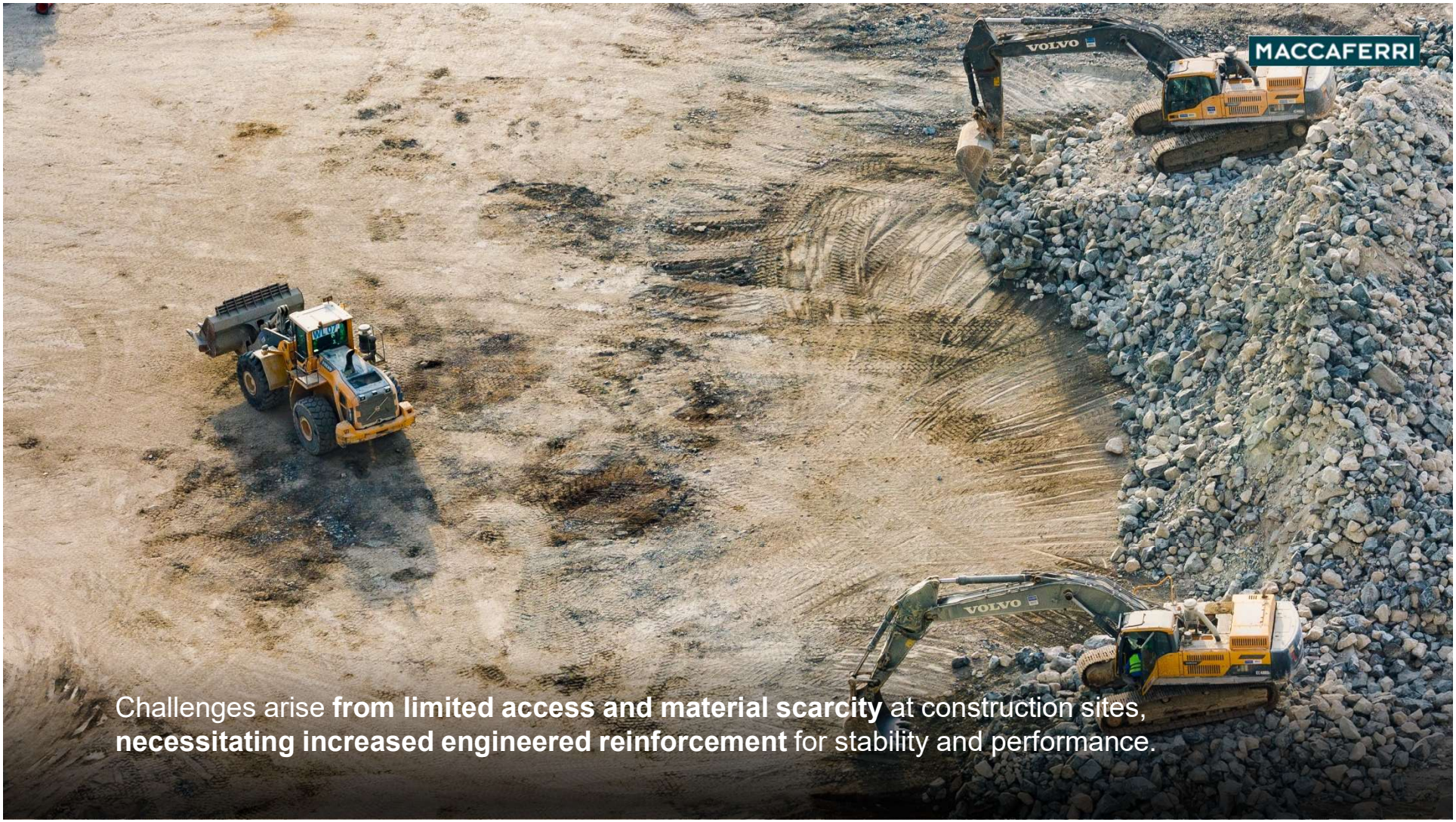
The world today is becoming **increasingly aggressive**, with a trend towards **more hostile environments** exacerbated by human impact on nature.

In response:
Regulatory measures, following standards like ISO 17745, ISO 17746, and EN 10223, classify air environments into C2, C3, and C4 **levels based on aggressiveness**.
There's a **growing focus on reducing the environmental footprint** by **minimizing natural resource exploitation.**

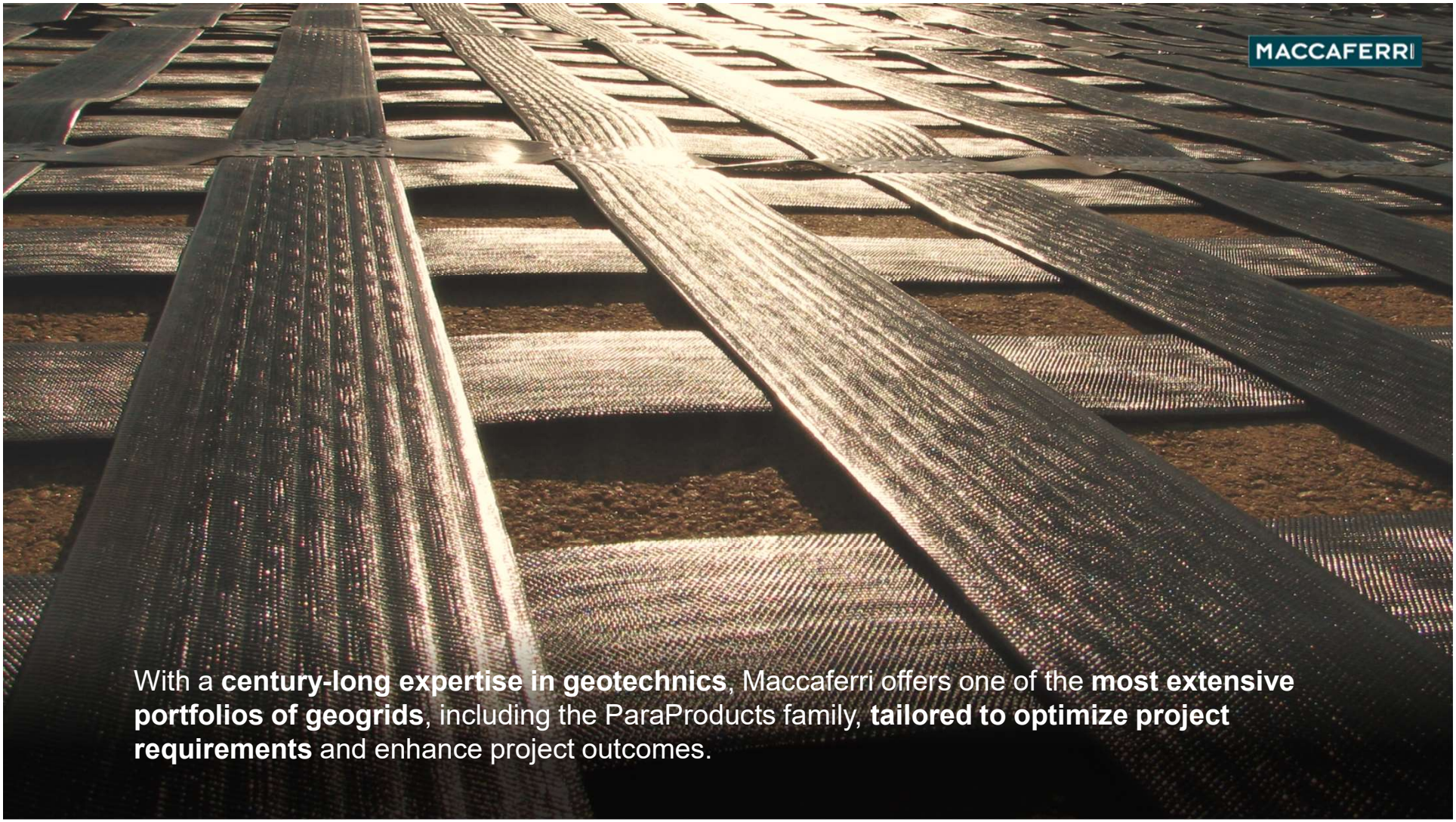


To address resource scarcity, there's a **clear trend to utilize on-site lands**, even if unsuitable for geotechnical purposes, with **chemical stabilization rendering them suitable** (EN14475 - Execution of special geotechnical works - Reinforced fill).


MACCAFERRI
Soil stabilization methods, like lime and cement, **adapt soil characteristics to improve workability** and **strength based on site-specific conditions**.



Challenges arise **from limited access and material scarcity** at construction sites, **necessitating increased engineered reinforcement** for stability and performance.


MACCAFERRI
With a **century-long expertise in geotechnics**, Maccaferri offers one of the **most extensive portfolios of geogrids**, including the ParaProducts family, **tailored to optimize project requirements** and enhance project outcomes.

PARAPRODUCTS

The hallmark of Maccaferri's geosynthetics excellence

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

CE

NTPEP
AASHTO
NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM

BBA APPROVAL INSPECTION TESTING CERTIFICATION

BIM
CERTIFICATE
19-BI001/2

EPD®
THE INTERNATIONAL EPD® SYSTEM


MACCAFERRI
BBA
APPROVAL
INSPECTION
TESTING
CERTIFICATION

BBA CERTIFICATION: WHAT IT IS

MACCAFERRI

HAPAS

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Vale Mills
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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

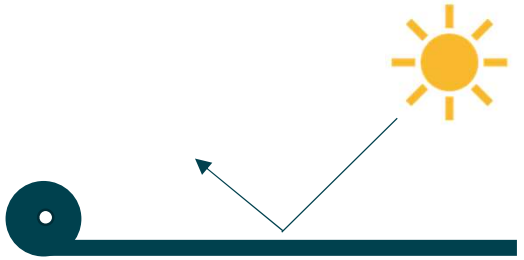
BBA CERTIFICATION: KEY FACTORS ASSESSED

MACCAFERRI

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

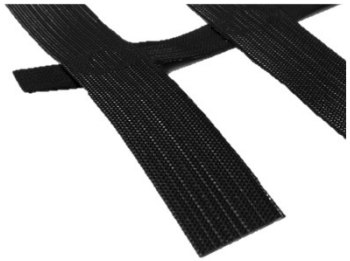
Mechanical properties
The short- and long-term tensile strength and elongation properties of the geocomposites and loss of strength owing to installation damage have been assessed and reduction factors established for use in design.

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.



PARAPRODUCTS PORTFOLIO

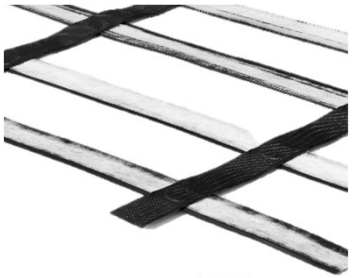
MACCAFERRI



PARAGRID™

PARALINK™

PARAGRID ™ HF



PARADRAIN™

PARAGRID™ W

AVAILABLE STUDIES TODAY

MACCAFERRI

Many publications, such as CUR's "Durability of Geosynthetics," explore the mechanisms of geosynthetics degradation.

CUR
BUILDING & INFRASTRUCTURE

Building with knowledge

Fig. 3.17
PET-strand (8 mm x 0,8 mm) before (below) and after (above) 4 year immersion in saturated lime solution at 50°C (courtesy of Prof. Dr. J. Müller-Rochholz).

243

Durability of Geosynthetics

3.2.2 Accelerated testing

Accelerated tests are performed by immersing the PET products in hot water and measuring the reduction in strength, this being the property of most interest. If the environment is to be neutral careful attention has to be paid to the purity of the water and to constancy of temperature. Alkaline contamination of the water must be avoided at all costs. Further Schroeder (1999, 2000) and Schmidt (1994) tested the PET yarns wrapped around cylinders at constant tension to get very low standard deviations for tensile testing. By this procedure the length of the yarns should stay constant i.e. shrinkage is avoided.

Written by:
J.H. Greenwood
H.F. Schroeder
W. Voskamp

CUR committee C 187

3.2.4 Dry and humid soils

Since the degradation of polyesters requires the presence of water, liquid or vaporous, it has to be assumed that no degradation takes place in totally dry soils. However real dry soil possibly exists not even in deserts, the presence of water vapour is enough to start the hydrolysis process. No studies have taken place on alternative, slower forms of degradation, like oxidation, that might occur too in the complete absence of water, perhaps because such environments are rare.

The rate of degradation in humid or partially saturated soils is assumed to be proportional to the relative humidity, or to the degree of saturation. Thus where liquid water is present the local humidity may approach 100% and the degradation should proceed at the same rate as in water. Where the water content of the soil is 80% of the saturated soil it is assumed that the relative humidity is also 80% and that the rate of degradation is similarly 80% of that in water.

Schröder et al (2000) performed some tests at 75 % humidity at 90 °C and showed that the rate of degradation was 60% of that in water at the same temperature. The assumption that the rate of degradation is proportional to the relative humidity is therefore conservative.

3.2.5 Coatings and sheaths

The primary purpose of a coating or sheath on polyester geosynthetics is to protect the fine fibres from mechanical damage and weathering. It is suggested that the coating will also restrict outer chemical attack in the same way that paints and other polymer coatings protect metal surfaces from corrosion. The access of water vapour is generally not on the long term excluded. By the coating it will be not possible that low molecular hydrolysis

PARAPRODUCTS AVAILABLE STUDIES

Since 1999, Paraproducts has **undergone extensive testing to evaluate the effects of different alkaline environments** on materials previously tested for installation damage, aiming to validate the impact of specific coatings and manufacturing methods.

Commercial-in-Confidence

COBHAM

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Business Unit:	Cobham Technical Services ERA Technology ECS
Report Title:	Derivation of reduction factors applied to ParaWeb, ParaGrid and ParaLink products for various environments
Author(s):	J Greenwood, C Lechat
Client:	Linear Composites Ltd.
Report Number:	2009-0027
Project Number:	7M0163815
Report Version:	Final Report
Document Control:	Commercial-in-Confidence

Chemical/environmental effects

8.2 The polyethylene sheath used on Paragrid, Paragrid HF and Paradrain Geocomposites acts as a chemical b which, if not broken or damaged, will reduce the risk of chemical attack on the polyester fibres. It should be r the most aggressive fills are usually of fine particle sizes which cause little or no damage to the polyethylene Compaction can reduce the high pH level of a fill. Tests have shown that, 48 hours after the compaction stage level of a soil-lime mix reduces from 12.5 to 11. Where appropriate, site and soil specific testing should be ca to verify the reduction in the pH of the soil.

8.3 The geocomposites are highly resistant to microbial attack.

8.4 To account for environmental conditions, the appropriate reduction factors (RF_{CH}) should be selected from Table 18.

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

2.5.4 Effect of the sheath

Linear Composites provided Cobham with a report dated 1999 presenting data of residual strength measured following installation damage, and then alkaline attack following the installation damage. The immersion in alkaline environment was done at 60ºC over a 6-month duration.

The data presented in their report shows very little strength loss following installation damage (-4% on one sample, and less than -2.2% on other 7 samples), but some scuffing and indentation has been noticed on the specimens. The loss of strength measured is in agreement with the reduction factors RF_{ID} presented in section 2.3.

Following immersion in alkaline solution, some samples that had been exposed at pH 10 to 12 showed very little damage, but at least one sample at pH10 showed an 10.6% loss and one at pH12 showed a 19% loss, which is considered to be significant.

A 32% loss was measured at pH14, but this type of pH is not expected to occur in practice.

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email: mail@linearcomposites.com
website: www.linearcomposites.com

BBA APPROVAL INSPECTION TESTING CERTIFICATION
TECHNICAL APPROVALS FOR CONSTRUCTION

Agrément Certificate
03/4065
Product Sheet 1

LINEAR COMPOSITES SOIL REINFORCEMENT PRODUCTS

PARALINK GEOCOMPOSITES

Test	Standard	Unit	Result
Screening test method for determining the resistance to alkaline liquid	**DIN EN 14030 11.2003**		
Test liquid: saturated $Ca(OH)_2$ suspension*			
residual tensile strength MD		%	97,9
residual strain MD		%	99,4

* pH ≈ 13 (measured with indicator stick of company Macherey-Nagel GmbH & Co. KG (type pH-Fix 0-14) at 20 °C)

NORMATIVE GUIDELINES

The **current normative** applicable to determine the **long-term performances** of geosynthetics is:

ISO TS 20432

Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement

Chapter 9 Weathering, chemical and biological degradation
9.4.1 Causes of chemical degradation
9.4.5. Hydrolysis of polyesters

TECHNICAL SPECIFICATION **ISO/TS 20432**

First edition
2022-12

Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcem

9.4.1 Causes of chemical degradation

The principal causes of chemical degradation of polymeric geosynthetics in the soil are described in ISO/TS 13434. The following is a summary.

The principal cause of degradation of polyester geosynthetics (which consist of polyethylene terephthalate (PET) is by hydrolysis. The rate of hydrolysis is slow at typical soil temperatures but increases rapidly as the temperature is raised. The rate can be less if the polyester is fully coated, but this is discounted since the coating may become damaged by the installation process in the ground. Since PET wicks moisture quite well, any exposure of the fibres due to coating damage could result in hydrolysis at the rate which would occur if the coating was not present. The rate of hydrolysis will be less if the soil is partially instead of fully saturated, but is not zero. Alkaline liquids with pH ≥ 9 can, in addition, erode the surface. Polyester reinforced geosynthetics should not be used in natural or industrially polluted soils where pH > 9 is maintained unless proof of their durability can be provided.

9.4.5.2 Index tests for polyesters

The long-term chemical durability of polyesters in relatively neutral aqueous environments can be tested by one of the following sets of index tests.

— The polyester geosynthetics used for reinforcement, or the yarns from which they are made, should exhibit no more than a 50 % reduction in strength when subjected to EN 12224.

— The CEG measured according to GRI-GG 7 should be less than 30 meq/g, and the number averaged molecular weight, M_n, determined according to GRI-GG 8 should be 25,000 or more. Both criteria should be satisfied.

NOTE A condition of both criteria is that the polyester contains no post-consumer or post-industrial recycled material.

For a geosynthetic that satisfies either recommendation used in saturated soil, estimated values of $f_{R,CH}$ are listed in Table 2. Lower values may be considered when the soil is not saturated and/or if further evidence is provided.

Table 2 — Estimated values of $f_{R,CH}$ for polyesters

pH range	Design lifetime (years)	Service temperature (°C)	$f_{R,CH}$	R_2
4 to 9	25	25	1,0	1,0
		25	1,2	1,0
		25	1,3	1,0
		35	1,4	1,0

NORMATIVE GUIDELINES

MACCAFERRI

The **current normative** applicable to determine the **long term performances** of geosynthetics is:

ISO TS 20432

Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement

Chapter 9 Weathering, chemical and biological degradation
9.4.1 Causes of chemical degradation
9.4.2 Evidence from service experience

9.4.2 Evidence from service experience

The rate of degradation, or evidence for lack of degradation, can be based on results of analysis of specimens of the product exposed to a comparable environment and then exhumed, or of products with a similar physical structure and chemical formulation and including the same additives.

The plan of exhumation and testing should be in accordance with ISO 13437. The following additional points should be noted.

— The observation period should be of sufficient length for extrapolation to the full design life to be justified. This justification is particularly important when rapid degradation follows a long incubation period, or when degradation takes place in a series of separate stages (e.g. 9.4.4.3). Service experience of at least 10 years may be necessary for extrapolation to a service life of 50 to 100 years for PET geosynthetics. Longer periods of time may be needed for polyolefins due to the

trength will be observed until the antioxidants are used up.
ce, it is impossible to predict lifetime.

ls are to be made (i.e., the first retrieval is taken right after
ken at some time during the middle of this period, and the
study period).

— Enough specimens for each retrieval should be taken into account for statistical variability in the properties measured. For a more detailed description, see Reference [11].

— The polymer and physical characteristics of the exhumed material should meet the recommendations for "similar" products in 7.9.

An assessment and lifetime prediction should then be made on the basis of this evidence. For a more detailed description of the issues that should be considered when evaluating results from service experience, see References [2], [11] and [12] in the Bibliography.

In the last three years, Maccaferri has embarked on **a field testing journey** to assess the status of its products in twenty-year projects, **further confirming the long-term performance of the ParaProducts family in alkaline environments.**

The entire range of **ParaProducts is certified**; however, with this series of tests, we have further examined **the durability of our solutions** in **highly alkaline environments**, relying on clear evidence, and verified the condition of the products in some of our past projects.

UK TEST CAMPAIGN

The first series of tests was carried out in the UK at **three different sites**. At every site, the geogrid used was **PARAGRID 50/05**, which is made up of strips produced from high tenacity PET tendons encased in a polyethylene coating, assembled into a geogrid shape. The material is **BBA certified material** for soil reinforcement applications, and it's certified with a **characteristic short term tensile strength** (Tch = Mean Average Value at 95% confidence limit) **equal to 50kN/m**

The local soil underwent a soil mix treatment to enhance its original properties and to enable its use as a construction material for soil reinforcement applications. After the treatment, the **soil's pH reached a value of approximately 12.**

PARAGRID

UK TEST CAMPAIGN

MACCAFERRI

1 Moodiesburn, Glasgow – UK

Installation Date: 2020
Project Original pH: 11.1 – 11.9
ParaGrid Grade: 50/05
Investigation: 3 trial pits will be investigated

UK TEST CAMPAIGN

MACCAFERRI

UK TEST CAMPAIGN

2 Lyoncross, Barrhead, Glasgow - UK

Installation Date: 2018
Project Original pH: 11 – 13 (Cement and lime blend - Tests were repeated after cement addition and results showed pH = 12.0 and 12.1)
ParaGrid Grade: 50/05

UK TEST CAMPAIGN

MACCAFERRI

UK TEST CAMPAIGN

3 Napier Park, Luton - UK

Installation Date: 2019
Project Original pH: 10.9 – 12.1 (PH was 10.9 initially. Tests were repeated after cement addition and results showed pH = 12.0 and 12.1)
ParaGrid Grade: 50/05

UK TEST CAMPAIGN

MACCAFERRI

UK TEST CAMPAIGN - STANDARDS

The geogrid exhumation and soil collection was done under the **supervision of a BBA officer**. The samples of geogrids and soils were delivered to **accredited independent laboratories** to **verify their current characteristics**.

Tensile Tests

Luton

certificate 10-24921B

Glasgow, Moodiesnburn

certificate 10-24761

Glasgow, Barrhead

certificate 10-24921

The tensile tests were executed – according to EN ISO 10319

PH soil Tests

Luton

certificate 23-10908

Glasgow, Moodiesnburn

certificate 22-22650

Glasgow, Barrhead

certificate 22-24856

UK TEST CAMPAIGN - RESULTS

The results showed:

- **During the exhumation**, the pH level was found to be **reduced** in two instances, yet it still **exceeded the value of 9**. In one case, it remained comparably high and did not diminish from the initial measurement.

- The geogrids were **minimally affected**, and **their residual strength consistently surpassed 96% of the certified characteristic** strength. The material exceeded the certified specifications and **did not exhibit any issues related to durability**.

Site	ParaGrid type	Characteristic Tensile Strength (T_{char})	Fill type	Binder type	Binder Quantity	pH at time of installation	Average pH at time of exhumation	Expected Tensile strength at time of exhumation	Average measured Tensile strength / Tchar	Time of burial
Moodiesburn, Glasgow	PG 50/05	50 kN/m	Lime-stabilised till clay	Lime	-	11.1-11.9	9.5 (9.2-9.8)	37 kN/m	> 100%	24 months
Barrhead, Glasgow	PG 50/05	50 kN/m	Lime-stabilised till clay	Lime	-	11.0-12.0*	9.1 (8.4-10)	34 kN/m	98%	60 months
Napier Park, Luton	PG 50/05	50 kN/m	Cement-stabilised chalk	Cement	2%	11.0-12.0*	11.7 (10.9-12.0)	35 kN/m	96%	41 months

ITALY TEST CAMPAIGN

The second series of tests took place in **Forlì, Italy**.
On-site, the employed solutions included **ParaLink™ 550** for basal reinforcement over piles, TerraMesh™ Green with **ParaGrid™ 150** for primary reinforcement, and the MacRes™ Wall System with ParaWeb™.

The project involved the construction of **a 530-meter-long embankment** and a **320-meter-long viaduct** over predominantly cohesive alluvial soil, characterized by compressible sandy silt and clay, interspersed with sand and gravel layers. The soil stabilization was achieved using 2% lime.

PARAGRID **PARALINK**

ITALY TEST CAMPAIGN

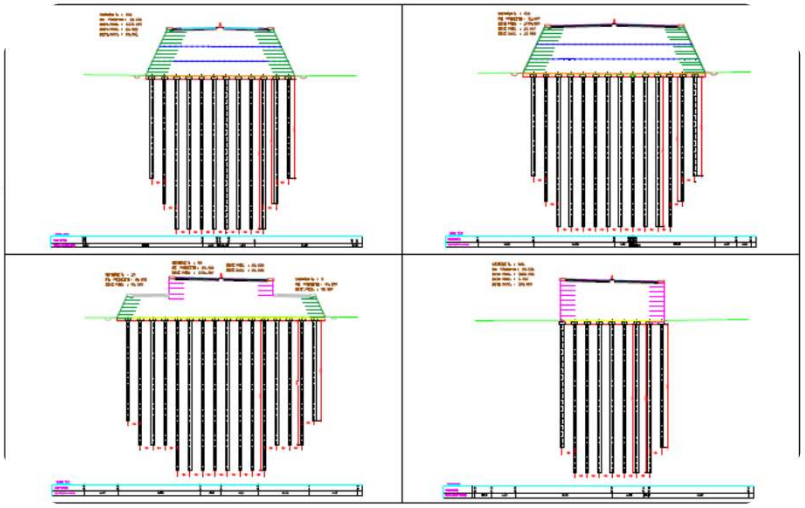
MACCAFERRI

4 Tangenziale di Forlì, Dipartimento Anas – Italy

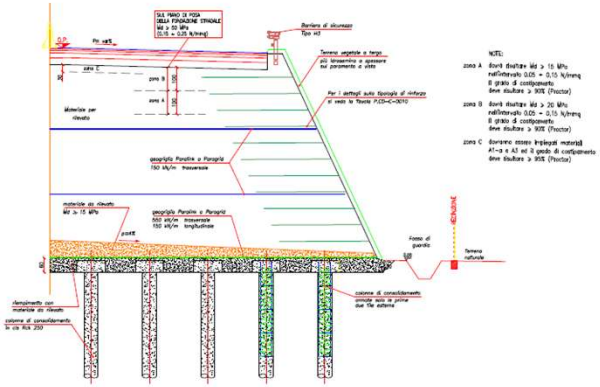
Installation Date: 2005-2008
Project Original pH: 11 – 12

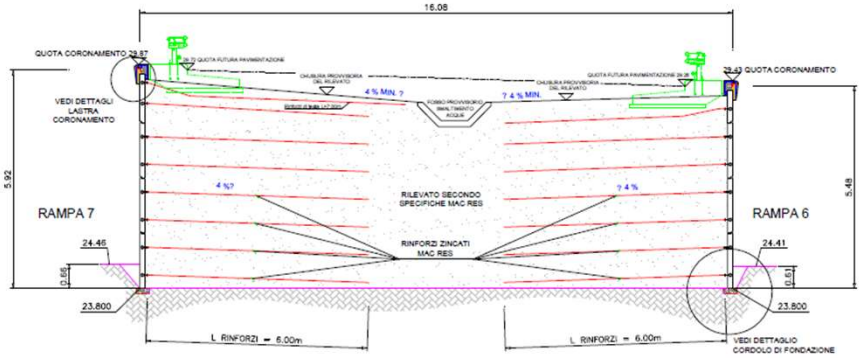
ITALY TEST CAMPAIGN

MACCAFERRI



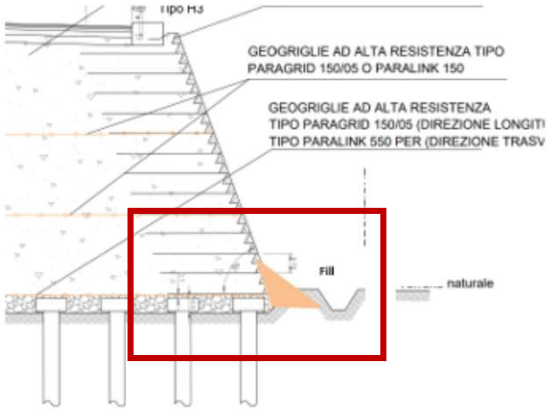
ITALY TEST CAMPAIGN

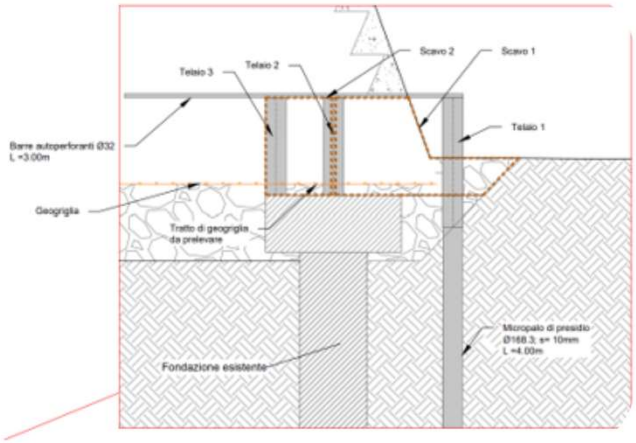




ITALY TEST CAMPAIGN - EXCAVATION SUPPORT

To **gather samples** from the embankments, it was essential to devise a **steel support structure** for the excavated cavity. This design was crafted by E&G S.r.l., an Italian engineering company, and **received approval from the Italian Road Authority (ANAS)**. The following figures demonstrate the method by which **safe excavation** was accomplished, employing self-drilling steel bars for temporary support of the tunnel ceiling and steel frames as ribs for the cavity.





ITALY TEST CAMPAIGN - EXHUMATION OF THE GEOGRIDS

From the "cave," both the geogrid samples **ParaLink™ 550** and **ParaGrid™ 150** and **the soil** were collected.

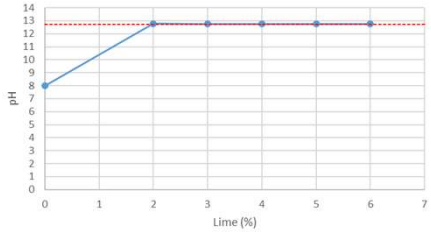
ITALY TEST CAMPAIGN – SAMPLING OF THE SOIL

Soil sampling was carried out at various locations at the back of the excavation to assess the current condition and pH levels of the area where geogrids were installed.

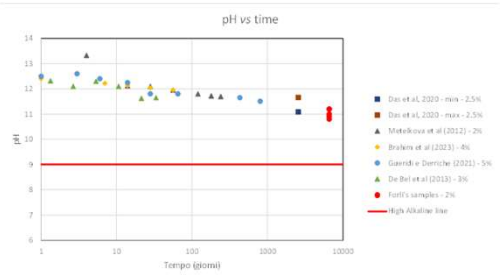
ITALY TEST CAMPAIGN - THE RESULTS

In the laboratory, pH tests were conducted **according to UNI EN ISO 10390:2022 standards** on both the natural soil and samples of lime-stabilized soil**. ICL was performed on natural soil to verify the amount of lime for effective stabilization**. The ICL test followed the methodology outlined in the Eades and Grim (1996) standard, in **compliance with ASTM No. D 6276 – 99 and EN ISO 10390:2022.**

To achieve the target pH of 12.74, an addition of 2% lime is required, as per design specifications.



Plot of pH vs time from pertinent literature



Time elapsed from installation		Samples (Rilevato Forli)				
Time						
years	days	1	2	3	4	5
18	6570	11,0	10,9	11,2	10,8	11,2

These pH findings resulted from the samples are **consistent with relevant literature** that illustrates the **behavior of pH over time**, as shown in the figure.

ITALY TEST CAMPAIGN - THE RESULTS

The reinforcement geogrids were delivered to the jobsite by Linear Composites Ltd, the UK-based manufacturer of **ParaGrid™ 150/05** and **ParaLink™ 550** geogrids. These materials are **BBA certified reinforcements**, with ParaGrid™ holding certificate BBA16H249 and ParaLink™ certificate BBA4065/03 and are **produced in accordance with a certified Quality Control Plan (QCP).** Tensile tests conducted by **BTTG**, a UKAS accredited laboratory also based in the UK, on samples excavated from the jobsite as per EN ISO 10319, reported the following values:

Paragrid type	Characteristic Tensile Strength (T_{char})	Expected Tensile strength at time of exhumation	Average measured Tensile strength / Characteristic Tensile Strength
Paragrid 150/5 sample 1	150 kN/m	102 kN/m	99%
Paragrid 150/5 sample 2	150 kN/m		> 100%
Paralink 550 sample 3	550 kN/m	373 kN/m	> 100%
Paralink 550 sample 4	550 kN/m		> 100%

RECAP

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PARAPRODUCTS materials (ParaGrid™, ParaLink™, PARAWEB, PARADRAIN) have been **exhumed form severeal jobsites** based in UK and in Italy **where soil mix technologies were used to improve the soil performances**;

Either the soil pH and the current mechanical properties of the geogrids have been **tested by accredited laboratories under the BBA office survelliance**;

The soil pH – originally set at 12 – was **reduced in two of the 4 jobsites** to values between 9 and 10 but in two jobsites (one of the two more than 18 years aged) it was still in the range of 11.5-12

The reinforcement materials **exhumed and tested** – even if damaged – **had a residual tensile strength much higher than expected** with **retained strength > 95%** of the certified characteristic value (minimum average at 95% confidence limit)

CONCLUSIONS AND FURTHER STEPS

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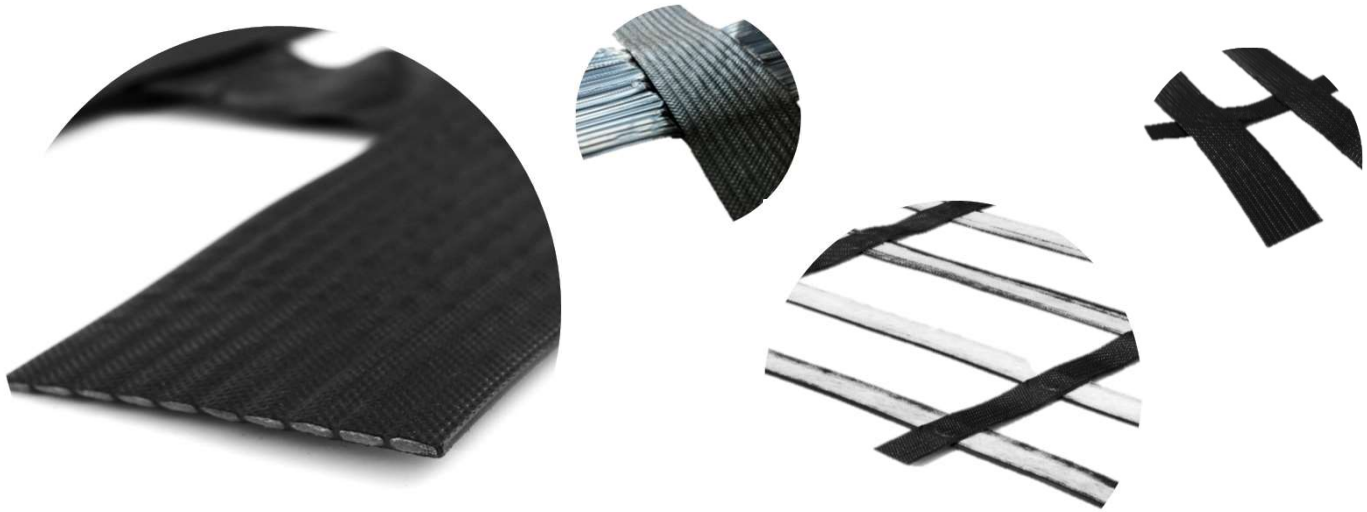
- In **highly alkaline environments**, hydrolysis significantly impacts PET geogrids, rendering **not all PET reinforcements suitable**. Nevertheless, with **specific coating structure**, **thickness**, and **appropriate manufacturing technology**, significant protection can be afforded to the yarn, thereby **minimizing the diffusion of alkaline liquor through the reinforcement area.**



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- For **structures designed to last 120 years**, meticulous attention to **material quality and reliable certification of system or reinforcement performance is crucial**. This includes **assessments** of **tensile strength, deformation, reduction factors, pullout resistance, and other factors**. It's imperative to rely on internationally recognized **third-party certificates to ensure the validity of material tests** and the accreditation of laboratories to applicable standards.

BBA APPROVAL INSPECTION TESTING CERTIFICATION
CERTIFICATE 16/H249

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- Maccaferri has crafted an **extensive array of geogrids and geostrips** specifically designed for **extreme environments, ensuring superior engineering and enduring performance**.

MACCAFERRI GEOGRIDS

MACCAFERRI

PARALINK™

for Basal Reinforcement applications (300-1600kN/m)

PARAGRID ™ HF

for Paramesh solutions & Basal reinforcement (100-250kN/m)

PARADRAIN™

for cohesive-marginal soils (50-200kN/m)

PARAGRID™

for standard Soil Reinforcement applications in aggressive soils

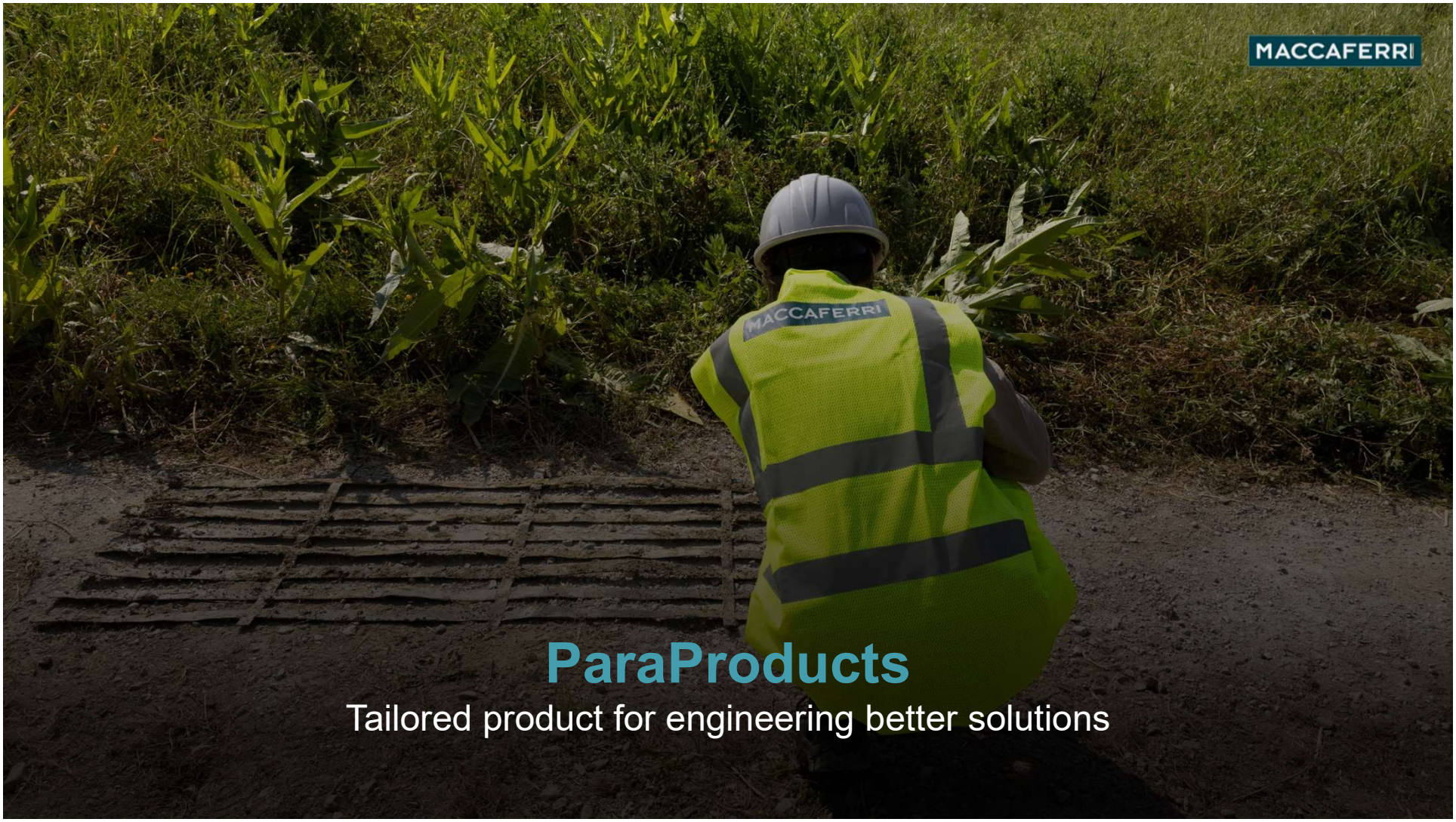
PARAGRID™ W NEW

for Segmental Walls & Standard Reinforcement in NON-aggressive soils

Materials suitable for use

in aggressive soils with ph<11 for 120years design life

in standard soils with 4<ph<9 for 120y design life



ParaProducts

Tailored product for engineering better solutions

Q&A

Do you have questions?
Type them in the chat box!

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Thank you

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