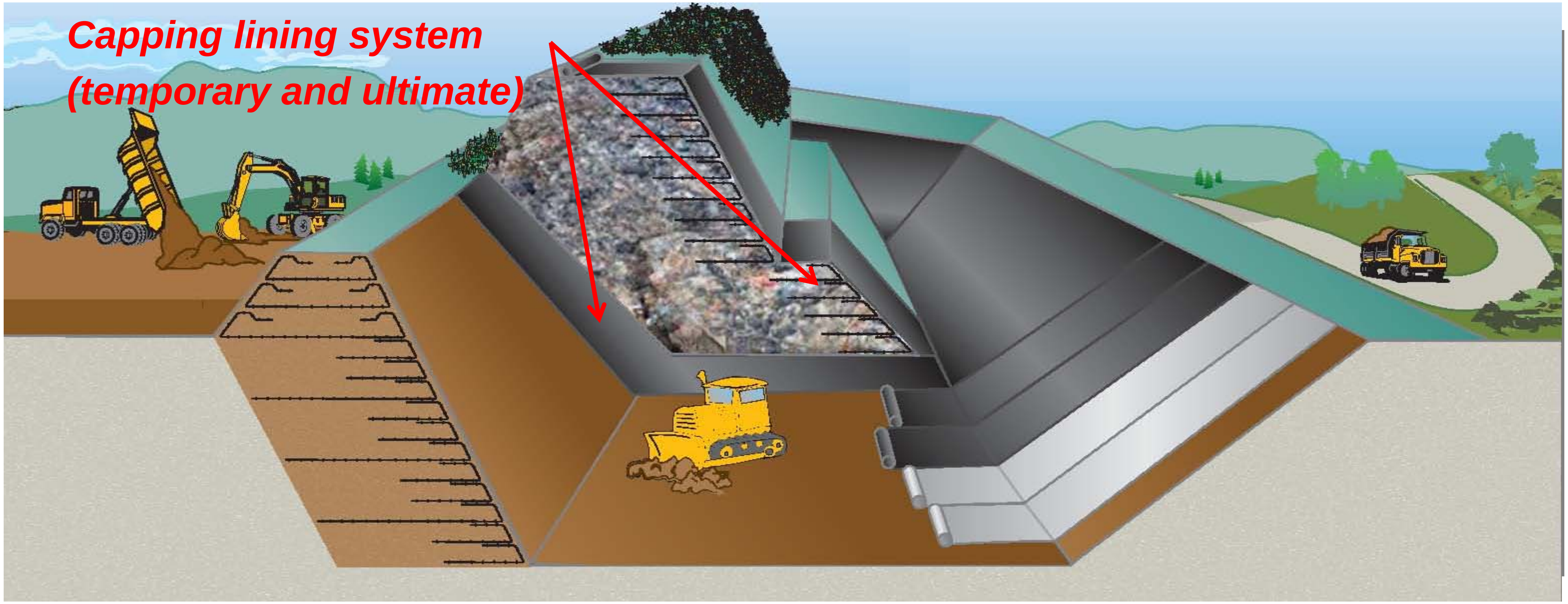
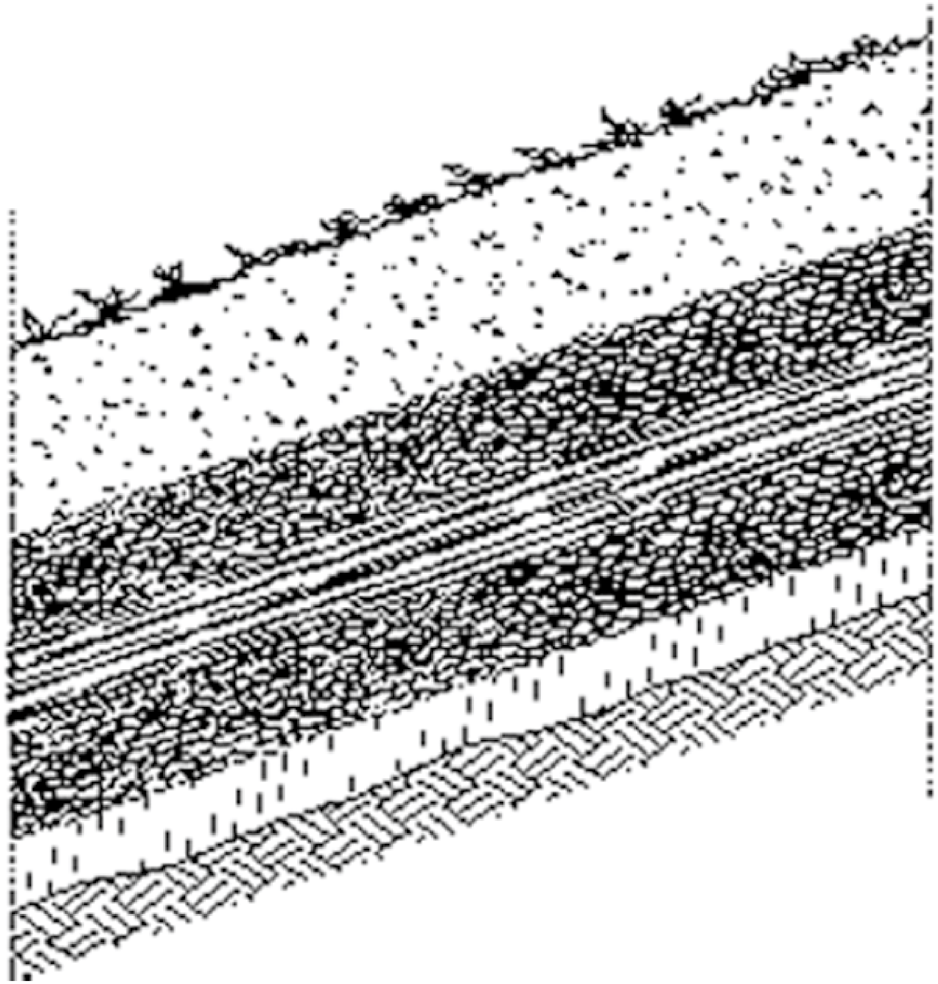
MACCAFERRI
GEOSYNTHETICS



Landfills

The capping solutions

Maccaferri Industrial Group



- The standard solution according to European standards

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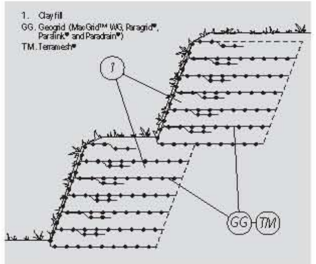
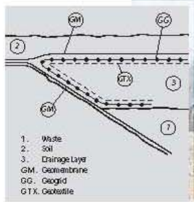
GEOSYNTHETICS

REINFORCEMENT

Foundation support and reinforcement

This includes the consolidation of the base of the landfill or of the waste, in order to provide a stable foundation layer and/of the overall stability of the landfill. This aspect is particularly relevant where a new landfill has to be constructed on a soft surface (e.g. an old landfill, unstable clays soils) or in soils subjected to landslides or when existing facilities need enlarging. Geogrid products such as MacGrid™ WG, Paragrid®, Paradrain®, Paralink® or even Gabions or Terramesh® units can provide, in various combinations, an answer to many problems faced by the designer during initial planning stages or in emergencies or unforseen situations.





WATERPROOFING

Improvement of the site's geological characteristics

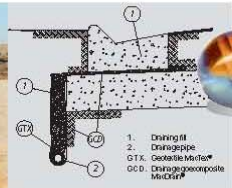
To limit the impact of leachate losses that are ultimately anticipated to take place though any barrier system, the standards allow for either a natural low permeability layer or alternatively a geo-clay-barrier composite chosen from the Macline® GCL family.
This second application is on slopes within the landfill cell where it is necessary to take into consideration the serious difficulties of placing and compacting cohesive soils (typically clay) on such surfaces.

FILTRATION

DRAINAGE

Water drainage and filtration

Leachates arising from rainfall or from phreatic surfaces or water tables adjacent to the landfill must be diverted to avoid pollution by the waste and to avoid possible landfill stability problems or problems with the buoyancy of the barrier. It can be overcome with the use of natural materials or by the use of drainage geocomposites chosen from the large family of the MacDrain® geocomposite products. These provide drainage paths within the cell to reduce water pressure.
In case of conventional drainage trenches, the traditional filtration systems can be conveniently replaced and with greater efficiency by the use of MacTex® the non-woven geotextiles. In special circumstances, when used in contact with the waste MacTex® HF woven geotextiles can be used.



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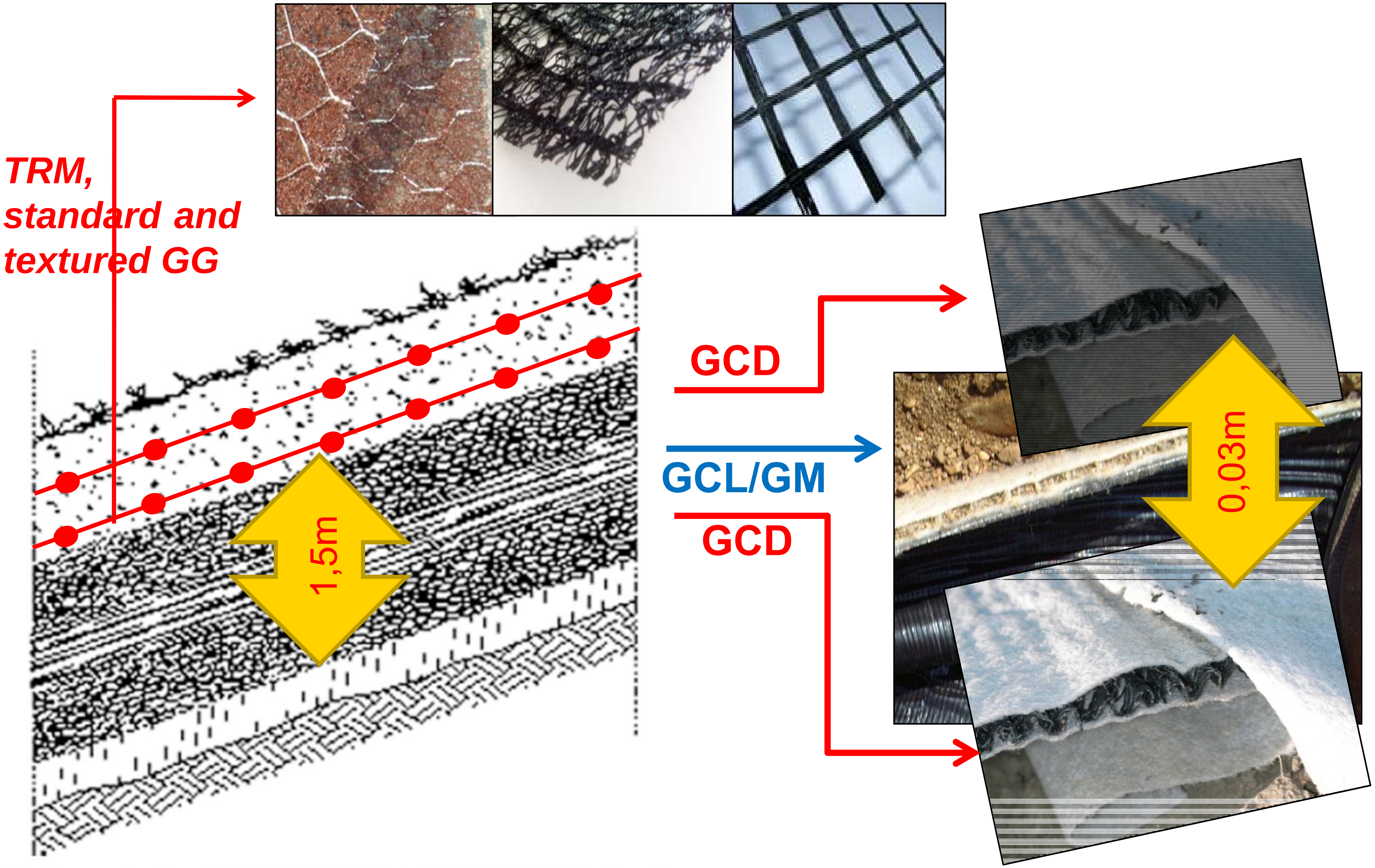
Capping



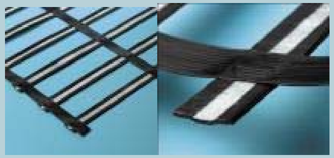
Maccaferri products vs APPLICATION

MACCAFERRI GEOSYNTHETICS

SOIL FOUNDATION GEOTECHNICAL IMPROVEMENT

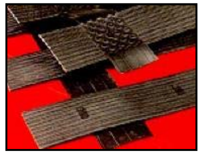
Paragrids, Paralink

SOIL REINFORCED SLOPES WITH CLAY → SOIL REINFORCEMENT APPLICATIONS WITH COHESIVE SOIL OR STANDARD CLAY



BOTTOM LINING

SOIL REINFORCED SLOPES WITH WASTES and CONTAMINATED SOILS



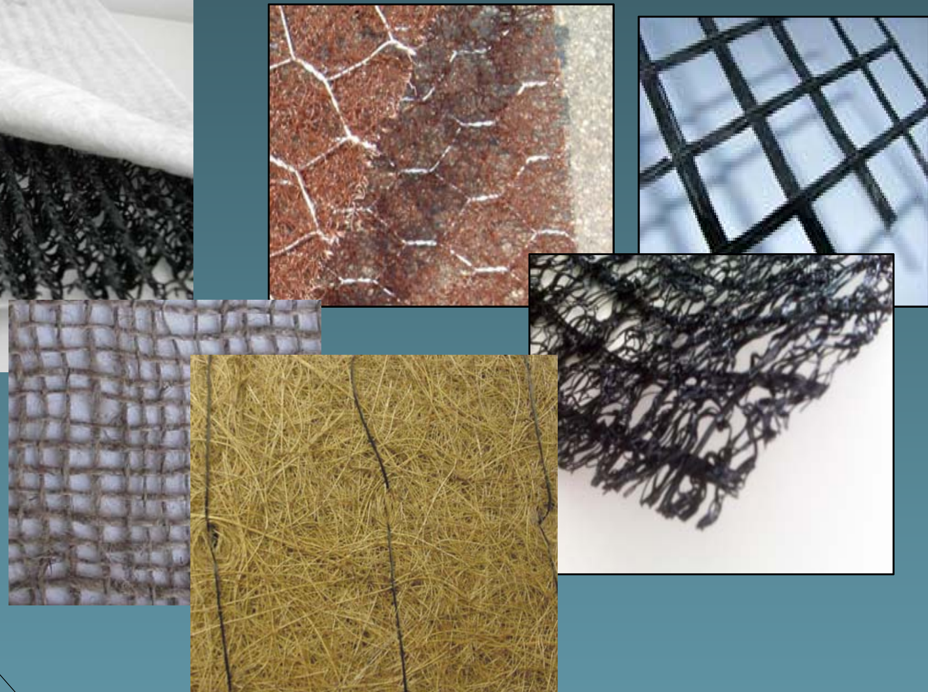
CAPPING SYSTEM

REINFORCED STEEP SLOPE & Capping SYSTEM

→ SOIL REINFORCEMENT APPLICATIONS WITH AGGRESSIVE SOIL: contaminated soils, high ph & similar, wastes

Maccaferri products vs APPLICATION

CAPPING SYSTEM



Erosion control natural blankets

Soil Veneer reinforcement

Drainage Water Rainfall

Waterproofing

Biogas Drainage – if applicable

- Standard geogrids

Textured geogrids

+Turf reinforced mats

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GEOSYNTHETICS

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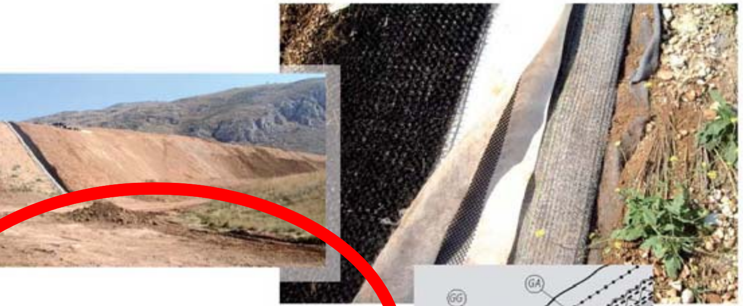
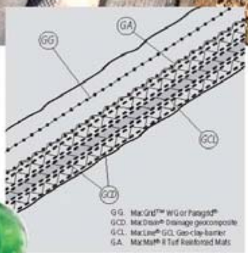
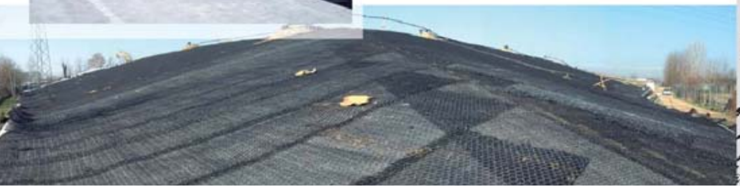
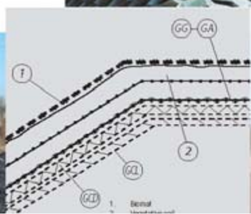




Gas and water run-off collection

The need to collect and ventilate the gas (methane) produced within the landfill, makes it essential to construct a biogas pipe system and chimneys. A gravel layer of 50 cm is the typical solution for a drainage layer suitable either for gas or for rainfall water collection. In this application MacDrain® drainage geocomposites can provide an effic[illegible] alternative to fine gravels or other inert natural materials. E[illegible] a [illegible] layer is the only acceptable solution, [illegible]inforcement layers like Mac[illegible] (in combination with geogrids if required) can be used on the sloped surfaces. For the construction of chimneys, special gabions can provide an easy and efficient method of construction.





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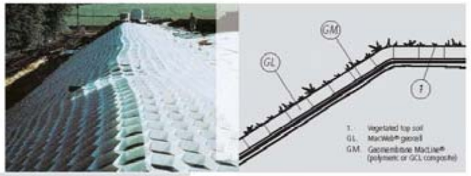
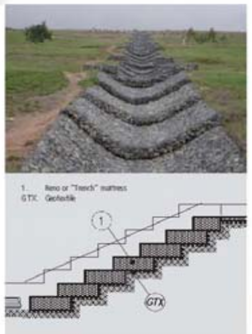
EROSION CONTROL

REINFORCEMENT

Erosion control

This is a problem that arises at the time that a landfill cell has to be closed and capped. After construction of the final impermeable barrier, a skin of vegetative soil has to be applied typically 1 m thick either on flat or sloped surfaces. In this situation there are a number of technical solutions to limit slumping, wash off and surface erosion; MacWeb® geocells, Macmat® R geomats reinforced with double twisted wire mesh or synthetic geogrids, steep soil slopes reinforced with Paragrid® or MacGrid® WG geogrids and Terramesh® units, vegetated Reno mattress revetments or simply the soil bioengineering blankets of the Biomac® range. Each of these materials can offer an appropriate solution to the specific site problem but require specialist input to select and design the right solution.





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OSYNTHETICS

propylene mat with waved profile
gitudinal channel shape) of various thickness
various mass:

t
y
p
e

w

ACCAFERRI
OSYNTHETICS

ESTING OF GEOCOMPOSITES ACCORDING TO EN AND ISO:

The following tests are applicable to draining geocomposites:

Short term flow rate test (EN ISO 12958)

Compressive creep test with shear load applied (EN ISO 13432)

ction peel and junction shear tests for geocomposites (EN 13426-2)

Direct shear test (EN ISO 12957-1)

Inclined plane test (EN ISO 12957-2)

Long term protection efficiency test (EN 13719).

MacDrain®

nder **normal compressive creep** loads of **50, 100, 200 and 500 kPa** using both the **Isothermal Method (SIM) and of time-temperature superposition (TTS)** in accordance M D7361-07(2012) and the ISO 25619-1:2008 up to **120 years** design life.

tion, **tests under normal and shear loads erformed to simulate drainage on slopes ngs) with a load of 50kPa.** The flow rate of ocomposites is obtained by applying a set of **tion Factors** which take into account all the mena that may decrease the flow rate over tire design life compared to the short term ate measured in EN ISO 12958:2010 or D4716-08 (2013) tests. With the information ed through performance tests, **Design Data s (DDS) were developed for each ain product providing reduction factors**

DESIGN DATA SHEET

Rev. 03 ; Date: August 2014

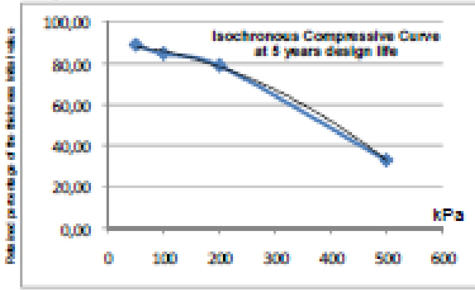
MACDRAIN W 1081-1091-1101®

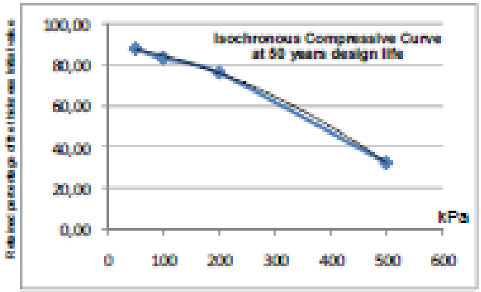
DRAINAGE GEOCOMPOSITES

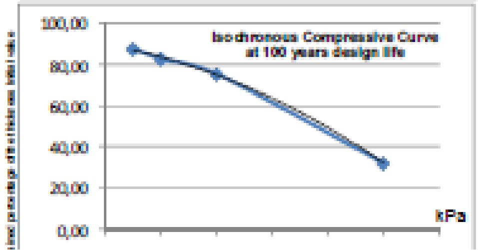
Compressive Creep performances of MacDrain® W (grades 1081-1091-1101)

The **MacDrain® geocomposites** are made of synthetic polymers, hence the compressive creep behavior can significantly affect their long term draining performances due to the variation of thickness at constant loads. The info reported in this DDS are based on tests run under normal compressive loads of 50, 100, 200 & 500 kPa using both the Stepped Isothermal Method (SIM) of time-temperature superposition (TTS) compressive creep tests and conventional isothermal compressive creep tests performed at room temperature. The testing method used were the ASTM D7361-07 (2012), *Accelerated Compressive Creep of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method* and the ISO 25619-1:2008, *Geosynthetics - Determination of Compressive behavior - Part 1: Compressive Creep Properties.*

Isochronous Compressive Creep Curves as variation of the core thickness (as percentage of the initial one) according to different values of the design life at various loads







For all applications, the available flow rate of the geocomposites shall be obtained by applying a set of Reduction Factors which take into account all the phenomena that may decrease the flow rate over the entire design life compared to the short term flow rate measured in EN ISO 12958:2010 or ASTM D4716-08 (2013) tests:

$$Q_a = \frac{Q_L \cdot F_t}{RF_{in} \cdot RF_{cr\text{-}Q} \cdot Rf_{cc} \cdot RF_{bc}}$$

- Q_a ▪ available long term flow rate for the geocomposite;
- Q_L ▪ short term flow rate obtained from laboratory tests;
- RF_{in} ▪ Reduction Factor for the intrusion of filter geotextiles into the draining core;
- $RF_{cr\text{-}Q}$ ▪ Reduction Factor for the compressive creep of the geocomposite;
- RF_{cc} ▪ Reduction Factor for chemical clogging of the draining core
- RF_{bc} ▪ Reduction Factor for biological clogging of the draining core
- F_t ▪ empirical factor to be applied when the test results for Q_L are available for contact conditions different from the project conditions

$RF_{cr\text{-}Q}$	50 kPa	100 kPa	200 kPa	500 kPa
1 year	1,011	1,061	1,118	1,771
5 years	1,016	1,071	1,136	1,894
10 years	1,021	1,080	1,153	1,958
20 years	1,028	1,085	1,161	2,028
50 years	1,031	1,090	1,170	2,148
≥ 100 years	1,036	1,099	1,188	2,242

RF_{in}	values can change according to the type of geotextile used, the applied load and the contacts in testing conditions (R/R, R/S, S/S)		1.0 - 1.5
RF_{cc}	higher values are suggested for water with high content of encrusting materials	For standard water (rain water or "soil water") a unit safety factor is advisable	1.0 - 1.3
RF_{bc}	higher values are suggested for leachate, sewage, biological fluids		1.0 - 1.3

F_t for all MacDrain	Contacts used for flow rate tests		
Contacts in project conditions	Rigid / Rigid	Rigid / Soft	Soft / Soft
Rigid / Rigid	1.0	1.5 - 2.5	2.0 - 4.0

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$$Q_a = \frac{Q_L \cdot F_{lr}}{RF_{in} \cdot RF_{cr\text{-}Q} \cdot Rf_{cc} \cdot RF_{bc}}$$

Q_a = available long term flow rate for the geocomposite;

Q_L = short term flow rate obtained from laboratory tests;

RF_{in} = Reduction Factor for the intrusion of filter geotextiles into the draining core;

$RF_{cr\text{-}Q}$ = Reduction Factor for the compressive creep of the geo-composite;

RF_{cc} = Reduction Factor for chemical clogging of the draining core

RF_{bc} = Reduction Factor for biological clogging of the draining core

F_{lr} = empirical factor to be applied when the test results for Q_L are available for contact conditions different from the project conditions

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OSYNTHETICS

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50 years	1,031	1,090	1,170	2,148
≥ 100 years	1,036	1,099	1,185	2,242

Rigid / Soft	0.5 - 0.7	1.0	1.2 - 2.0
Soft / Soft	0.3 - 0.5	0.4 - 0.6	1.0

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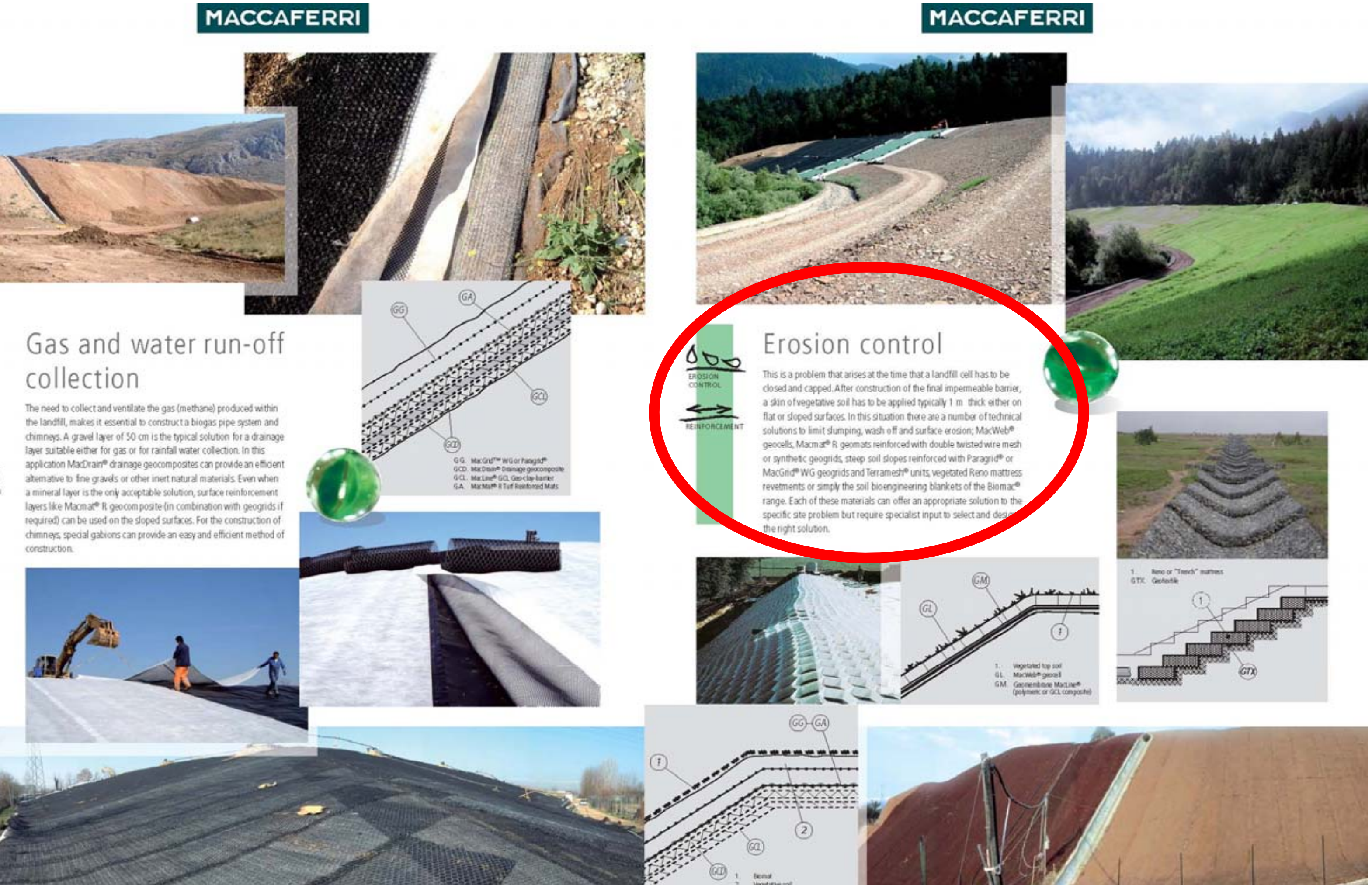
OSYNTHETICS

MacDrain W Drainage Composites

Final capping of Gello
ITALY (Pisa), 2011-2013
MacDrain W 1081 drainage geocomposite used as soil gas drainage and as rainfall water drainage in the final capping lining.

ing of Cavenago
ano), 2012
W 1051 drainage
osite used as soil gas



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Gas and water run-off collection

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Erosion control

EROSION CONTROL

REINFORCEMENT

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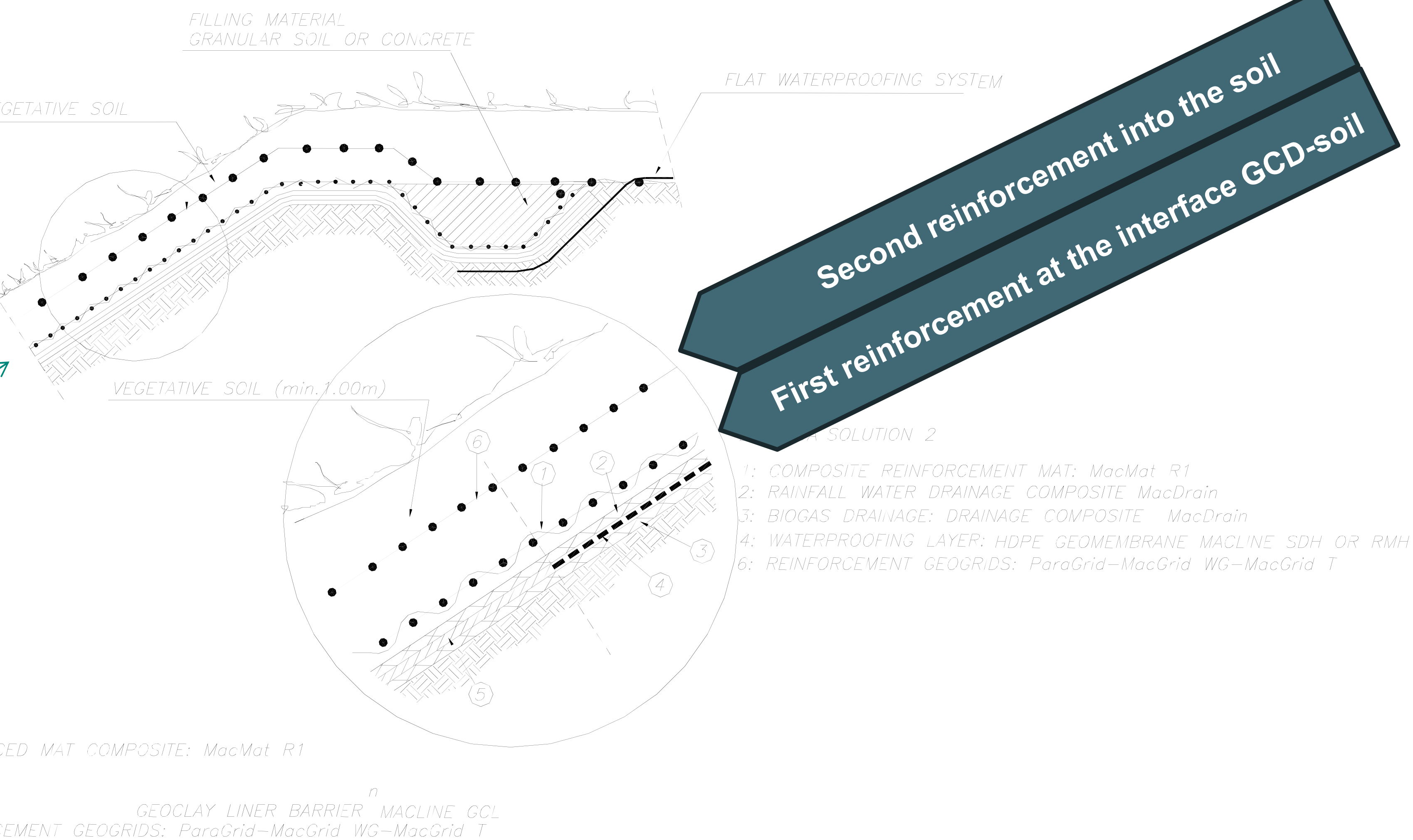
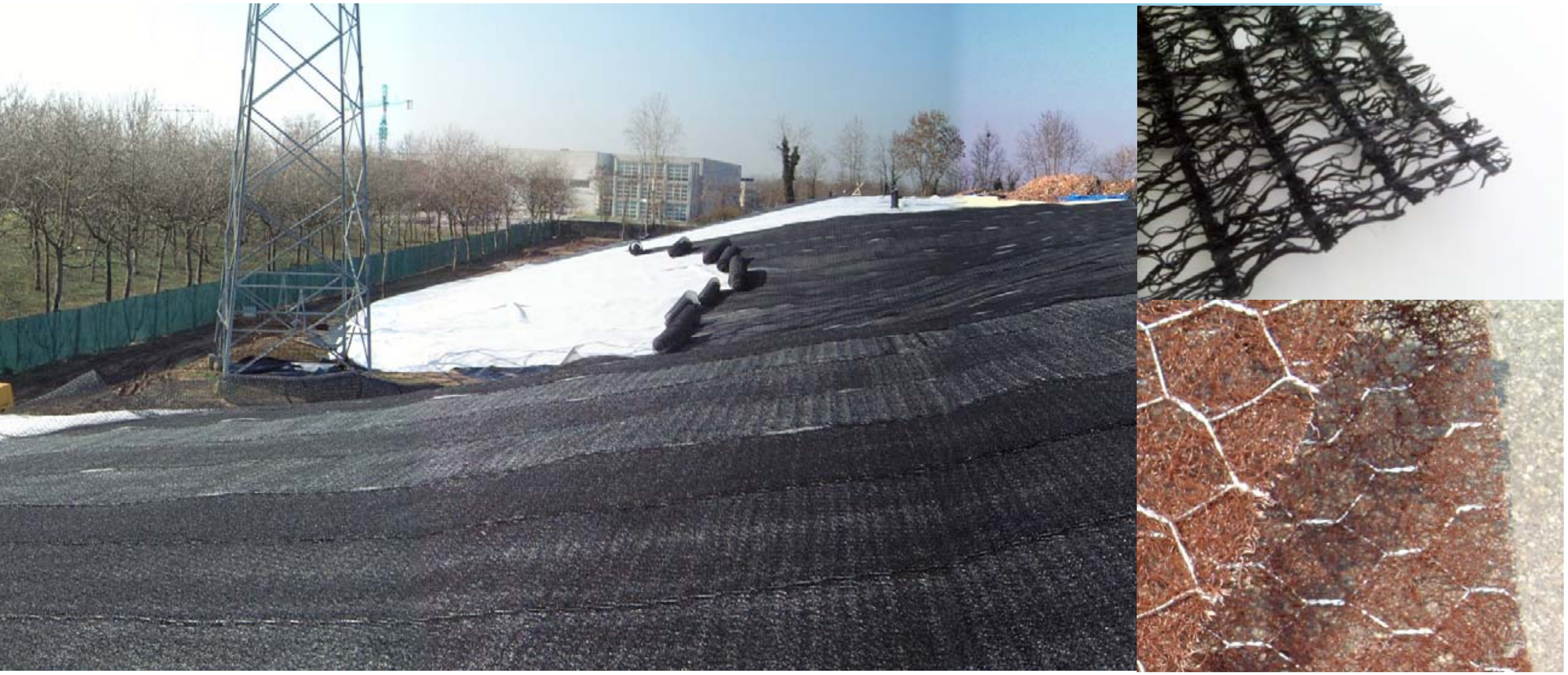
OSYNTHETICS



ACCAFERRI
OSYNTHETICS



most popular reinforcement are turf mats reinforced with a ymeric geogrid or with a metallic reinforcement or textured grids; 3d material are preferred to standard biplanar geogrids e interface with GCD to better contain the soil

MacMat R1 Turf reinforced Mat

Final capping of Chivasso
ITALY (Torino), 2010
MacMat R350 geocomposite used to stabilize the latest lift of vegetative soil having a 3.3 ft thickness on 30°sloped finished surfaces.

Final capping of Gavorrano
ITALY (Grosseto), 2001
MacMat R1 8127GN geocomposite used to stabilize 2 ft of vegetative soil on 35° sloped finished surfaces.

MacGrid Geogrids

Final capping of Montecalvo in Foglia
ITALY (Pesaro & Urbino), 2010
MacGrid T200 geocomposite used (13,900yd^2) to stabilize the latest lift of vegetative soil having a 3.3 ft thickness on 30°sloped finished surfaces.

MacGrid Geogrids

Final capping of Avlona Landfill
GREECE – Avlona/Malakasa, Attica (TS), 2011
MacGrid T55 geocomposite used ($49{,}000 yd^2$) to stabilize the latest lift of vegetative soil having a 1 ft thickness on 25°-35°sloped finished surfaces.

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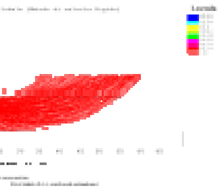
OSYNTHETICS

SOFTWARE

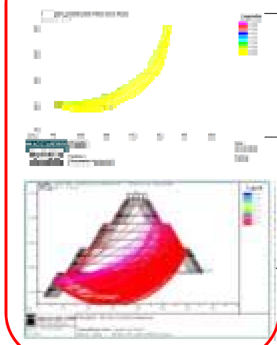


al embankment stability use:
ARS

SOIL REINFORCEMENT APPLICATIONS

VERTICAL & SLOPED APPLICATIONS

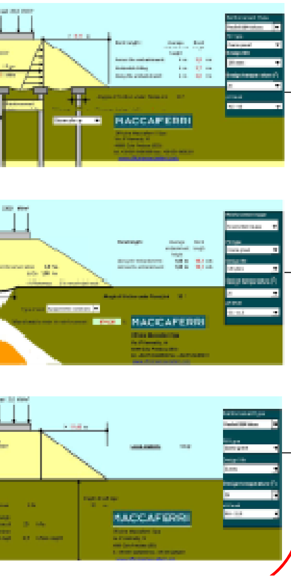
MACSTARS



- Steep & shallow slopes
- Slopes with cohesive soils
- Hybrid structures

FLAT APPLICATIONS

MACBARS

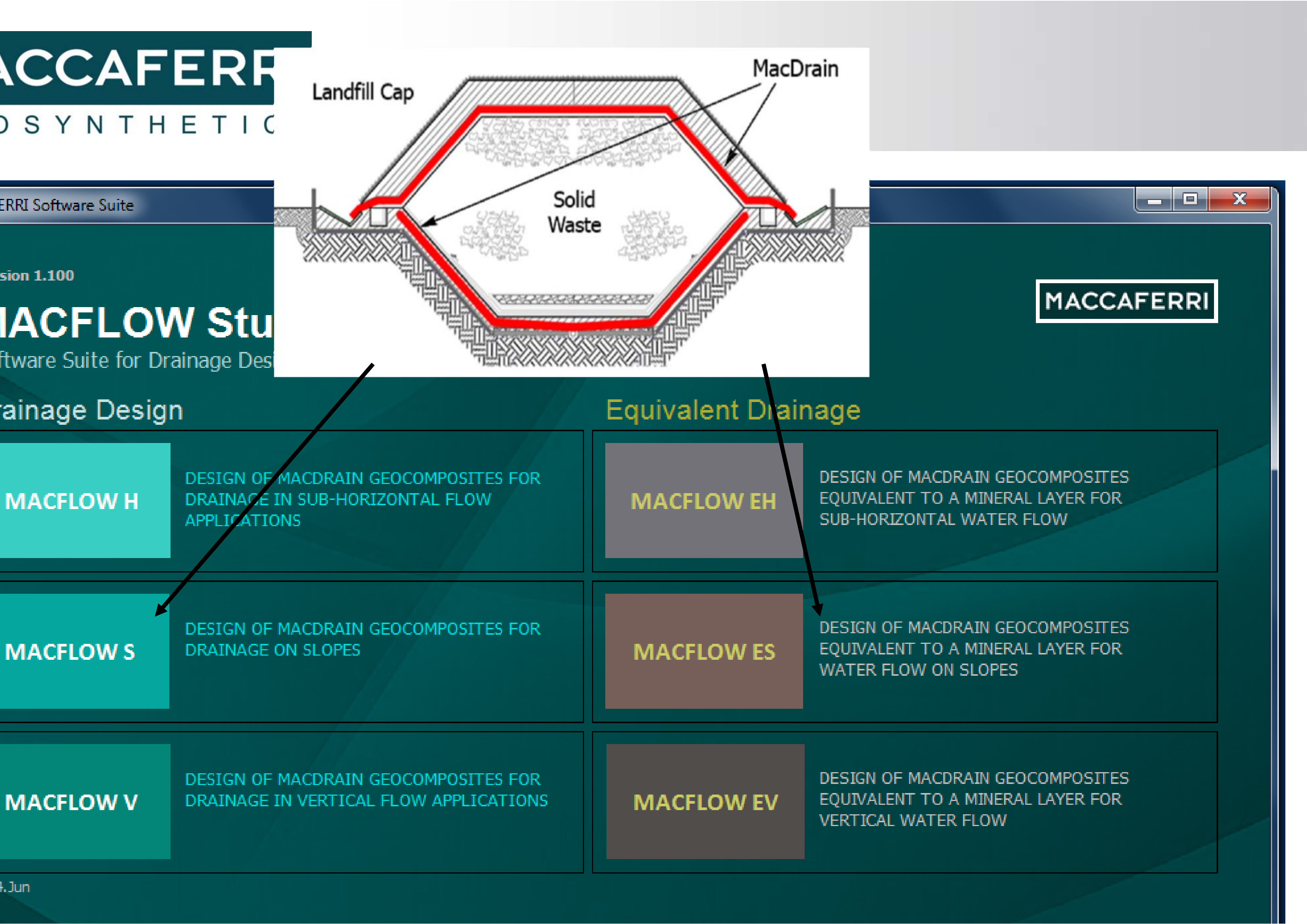


- Piled Embankments
- Sink Holes
- Embankments on soft soil

MACFLOW

- Drainage Applications

ENSPAMac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O S Y N T H E T I C
ERRI Software Suite
sion 1.100
ACFLOW Stu
ftware Suite for Drainage Desi
MACCAFERRI
Landfill Cap
MacDrain
Solid
Waste
ainage Design
Equivalent Drainage
MACFLOW H
DESIGN OF MACDRAIN GEOCOMPOSITES FOR DRAINAGE IN SUB-HORIZONTAL FLOW APPLICATIONS
MACFLOW EH
DESIGN OF MACDRAIN GEOCOMPOSITES EQUIVALENT TO A MINERAL LAYER FOR SUB-HORIZONTAL WATER FLOW
MACFLOW S
DESIGN OF MACDRAIN GEOCOMPOSITES FOR DRAINAGE ON SLOPES
MACFLOW ES
DESIGN OF MACDRAIN GEOCOMPOSITES EQUIVALENT TO A MINERAL LAYER FOR WATER FLOW ON SLOPES
MACFLOW V
DESIGN OF MACDRAIN GEOCOMPOSITES FOR DRAINAGE IN VERTICAL FLOW APPLICATIONS
MACFLOW EV
DESIGN OF MACDRAIN GEOCOMPOSITES EQUIVALENT TO A MINERAL LAYER FOR VERTICAL WATER FLOW
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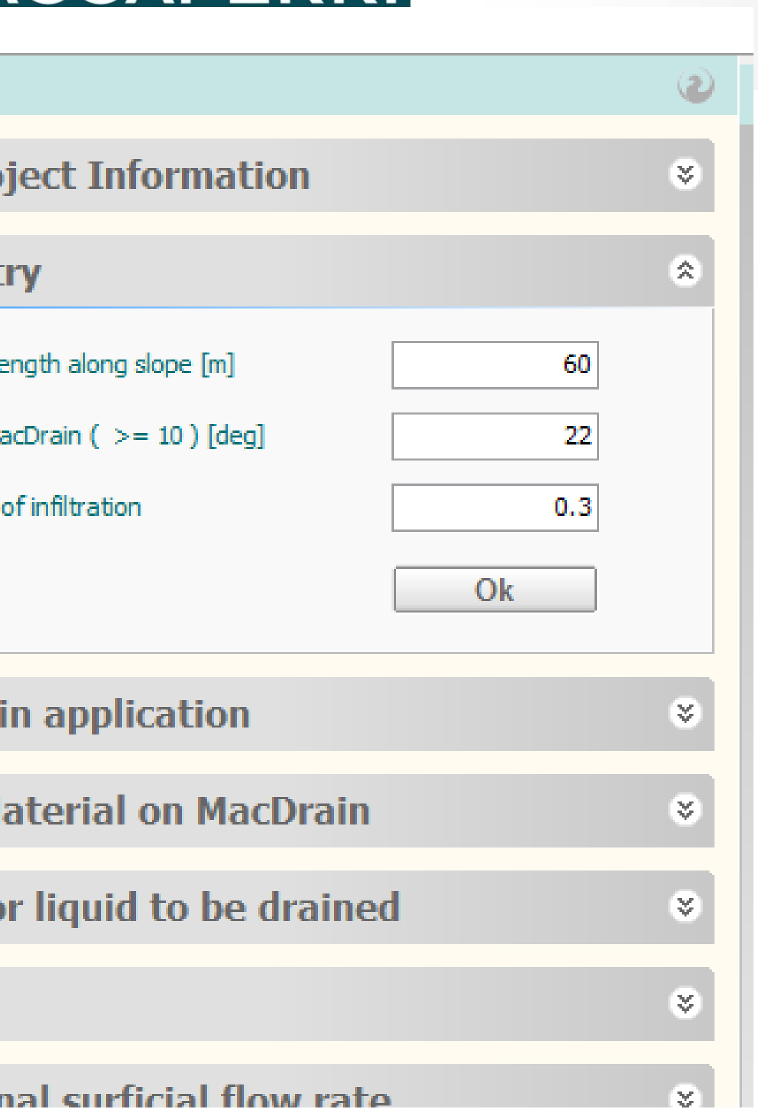
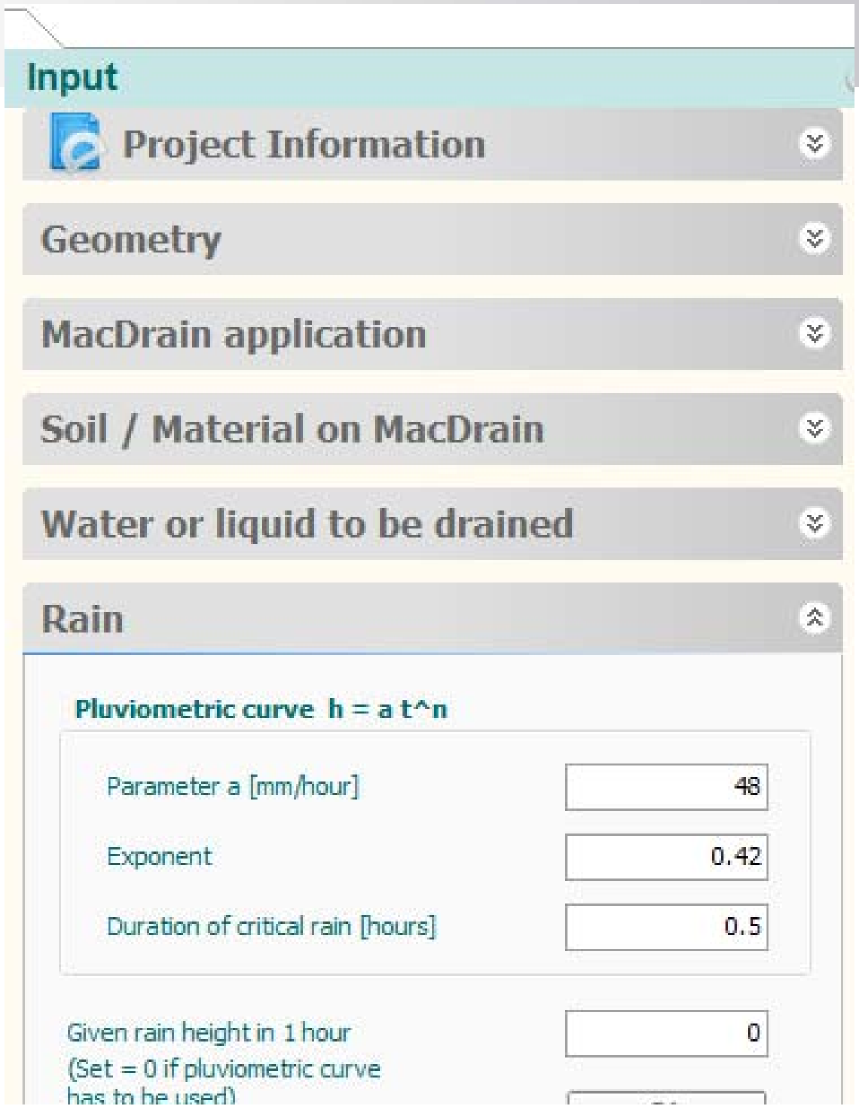


ject Information
try
ength along slope [m]
60
acDrain (>= 10) [deg]
22
of infiltration
0.3
Ok
in application
aterial on MacDrain
r liquid to be drained



Input
Project Information
Geometry
MacDrain application
Soil / Material on MacDrain
Water or liquid to be drained
Rain
Pluviometric curve h = a t^n
Parameter a [mm/hour]
48
Exponent
0.42
Duration of critical rain [hours]
0.5
Given rain height in 1 hour
0
(Set = 0 if pluviometric curve

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ign Calculation

erence water temperature [ºC]	20.00
erence dynamic viscosity	1.005
gn dynamic viscosity	1.142
rection for liquid temperature and viscosity	0.880
mum pressure on MacDrain [kPa]	17.00
raulic gradient	0.375

mum solution is MacDrain W Range.
cific MacDrain selected is:

Design Calculation

Rain height for design duration [mm]	35.88
Rain intensity for design duration [mm/h]	71.75
Input flow in MacDrain [l/s/m]	0.359
Design input flow for MacDrain	0.466

Drain	Contact	QL	Qa	Safety Factor	Result
051	R/R	0.66	0.545	1.17	OK
061	R/R	0.985	0.814	1.748	OK
071	R/R	1.021	0.844	1.811	OK
081	R/R	1.374	1.136	2.437	OK

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O S Y N T H E T I C S

OIL COVERS DESIGN

MACCAFERRI
AFRICA

ENTIFICATION

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INFORMATION

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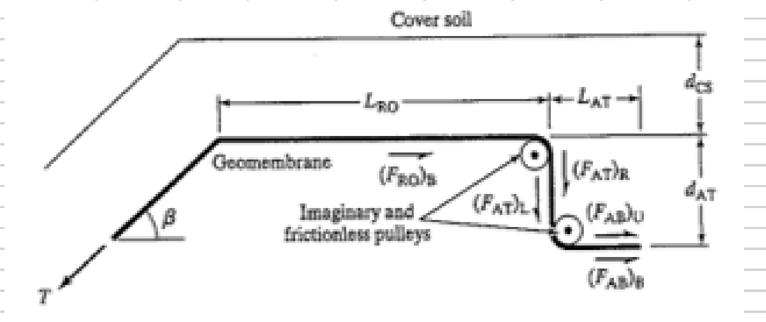
ith Geosynthetics - 5th edition - Robert M Koerner 3.2.7 pag 300-303

- is covered with soil, a stability calculation should be made to assess the potential for the soil on the barrier layer. Four situations come to mind: landfill liners with leachate r gravel above them until such time that the solid waste acts as a passive resistance e impoundment liners where the cover soil is placed over the geomembrane to shield it ight, heat degradation, and equipment damage; landfill covers that have topsoil and aced over the geomembrane; and general slopes and embankments containing sion control materials being covered with a layer of soil. In all cases the soil layer is .3 to 1.0 m), hence the sliding stability of such a veneer of cover soil is the issue.

ENSPAMac

ANCHOR TRENCH DESIGN

MACCAFERRI
AFRICA



Ref. Geotechnical Aspects of landfill design and construction - X. Qian, R.M. Koerner, D.H. Gray - par. 4.

DESIGN INFORMATION

SYMBOL	VALUE	UNIT	DESCRIPTION
β	22	°	side slope angle
d_{cs}	0.3	m	thickness covering soil
γ_{soil}	19	kn/m³	weight of soil
d_{at}	1	m	trench depth
L_{RO}	1	m	length of geosynthetic runout
L_{AT}	2	m	length of geosynthetic inside the trench
ϕ_{soil}	30	°	trench soil friction angle
δ_C	22	°	friction angle between the geosynthetics and the underlying soil
δ_F	18	°	friction angle between the geosynthetic and the backfill soil
Tult	110	kN/m	Ultimate tensile strength of the geosynthetic
RF	2		Reduction factor (RF=RF$_{cr}$xRF$_{id}$xRF$_{cbd}$xFS)
Tall	55.00	kN/m	Allowable tensile strength

RESULTS

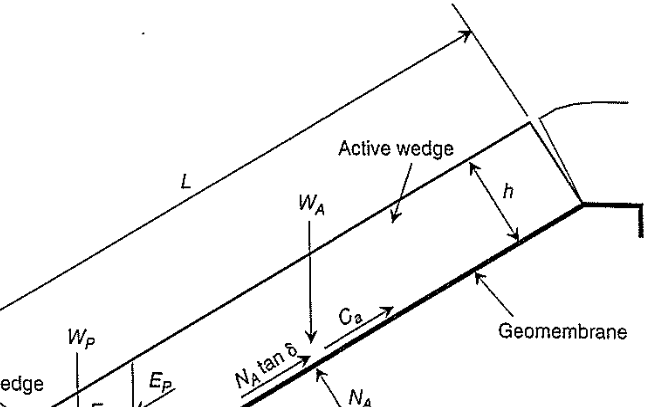
DESIGN INFORMATION

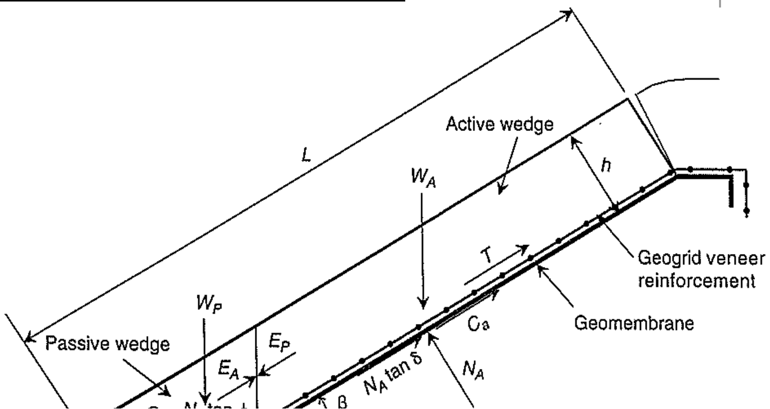
SYMBOL	VALUE	UNIT	DESCRIPTION
γ	19	kN/m³	unit weight of cover soil
ϕ	22	deg	friction angle of the cover soil
c	0	kpa	cohesion of the cover soil
h	0.3	m	thickness of the cover soil
β	22	°	soil slope angle
L	50	m	length of the slope
ca	0		adhesion between cover soil of the active wedge and geomembrane
δ	22	°	interface friction angle between cover soil and geomembrane

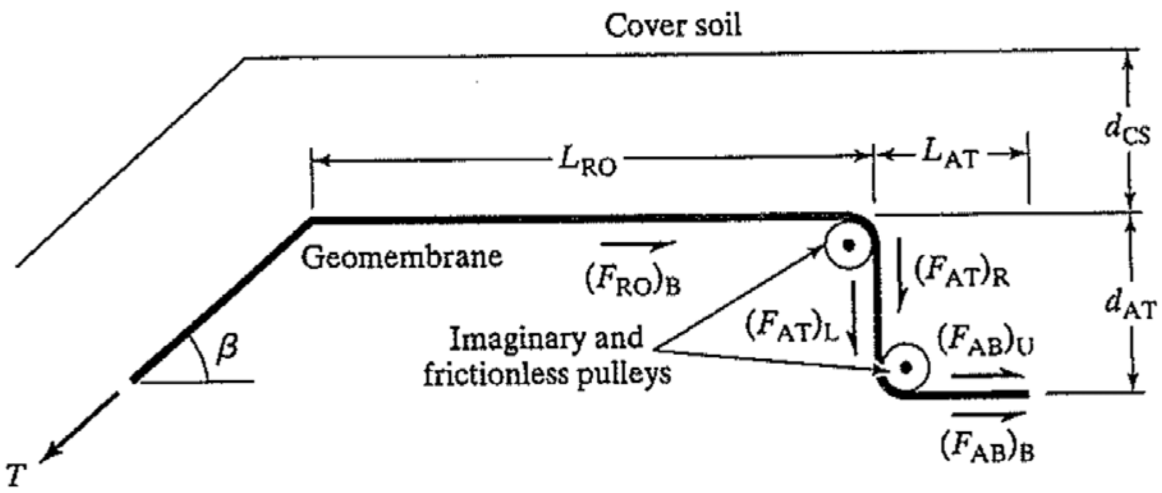
WITHOUT REINFORCEMENT

SYMBOL	VALUE	UNIT	DESCRIPTION
Wa	280.8	kN/m³	total weight of the active wedge
Na	260.3	kN	effective force normal to the failure plane of the active wedge
Ca	0.0	kN	adhesive force between cover soil and gsy
Wp	2.5	kN/m³	total weight of the passive wedge
C	0.0	kN	cohesive force along the failure plane of the passive wedge
a	36.5		n/a
b	-42.9		n/a
c	6.0		n/a

$FoS_{unreinf}$	**1.01**







DESIGN INFORMATION			
SYMBOL	VALUE	UNIT	DESCRIPTION
β	22	°	side slope angle
d_{cs}	0.3	m	thickness covering soil
γ_{soil}	19	kn/m^3	weight of soil
d_{at}	1	m	trench depth
L_{R0}	1	m	length of geosynthetic runout
L_{AT}	2	m	length of geosynthetic inside the trench
ϕ_{soil}	30	°	trench soil friction angle
δ_C	22	°	friction angle between the geosynthetics and the underlying soil
δ_F	18	°	friction angle between the geosynthetic and the backfill soil

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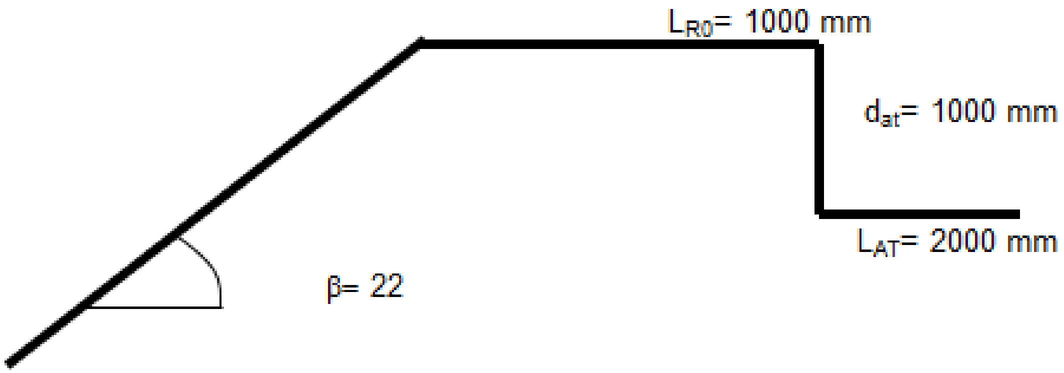
RESULTS			
SYMBOL	VALUE	UNIT	DESCRIPTION
$(F_{R0})_B$	8.55	KN/m	friction force beneath runout geosynthetics
$(F_{AT})_R$	2.47	KN/m	friction force between the right side of the geosynthetic and the side wall of anchor trench
$(F_{AT})_L$	3.07	KN/m	friction force between the left side of the geosynthetic and the side wall of anchor trench
$(F_{AB})_B$	9.98	KN/m	friction force between the right side of the geosynthetics and the underlying soil at the botton of anchor trench
$(F_{AB})_U$	8.03	KN/m	friction force between the right side of the geosynthetics and the overlying soil at the botton of anchor trench
T_{MAX}	36.61	KN/m	geosynthetic tensile force developed by the anchor trench
T_D	25.95	KN/m	geosynthetic design tensile force

FoS (T_{MAX}/T_D)	**1.41**



THE FIRST CAPPING IN ITALY OF A MINING LANDFILL

The Rigoloccio mine, located in Gavorrano (GR) in Tuscany

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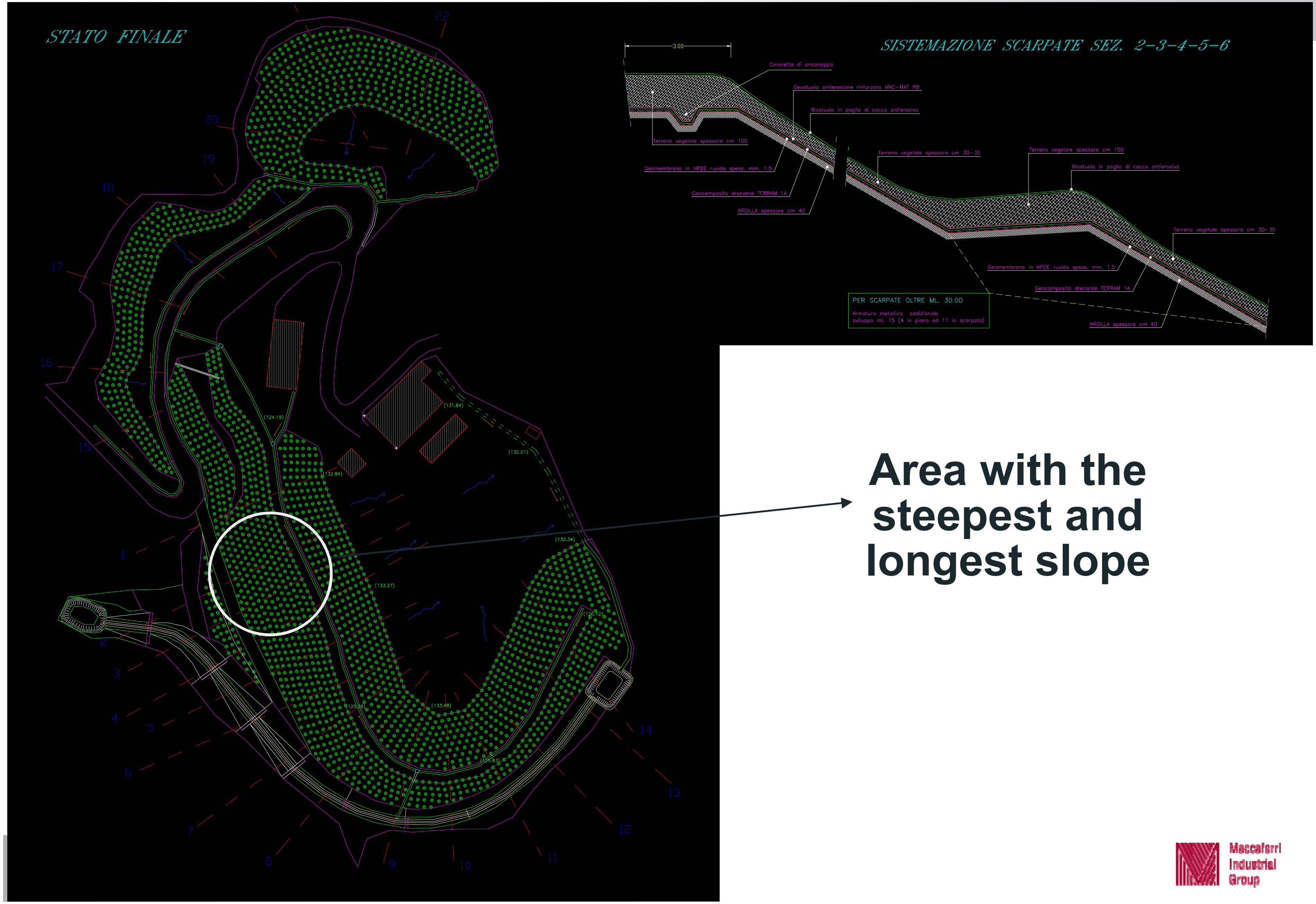

Area with the steepest and longest slope

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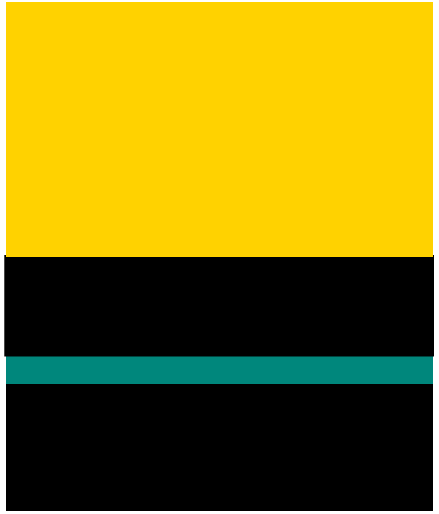
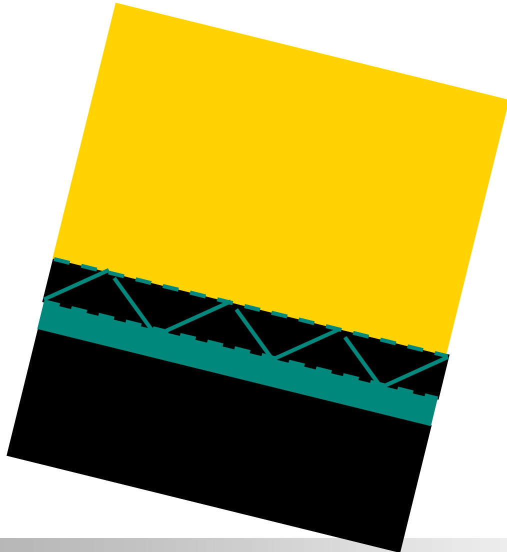
Original solution:



Flat areas

- 0,50 m of vegetative soil;
- drainage layer of 0,15 m thk;
- smooth hdpe membrane (2 mm thk);
- 0,40 m of clay;
- waste.



Sloped areas

- **0,50 m** of vegetative soil;
- drainage composite (two geotextiles + net);
- textured hdpe membrane (2 mm thick);
- **0,40** m of clay;
- waste.

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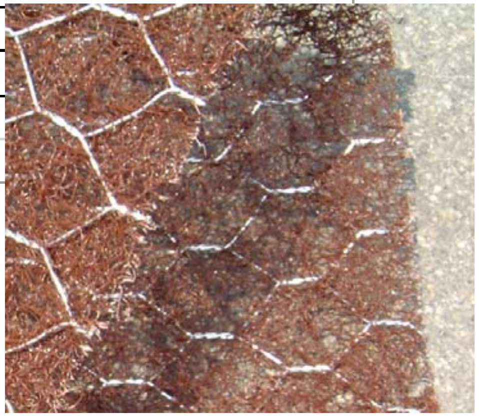
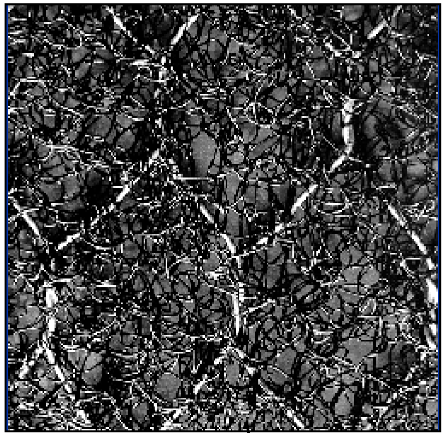
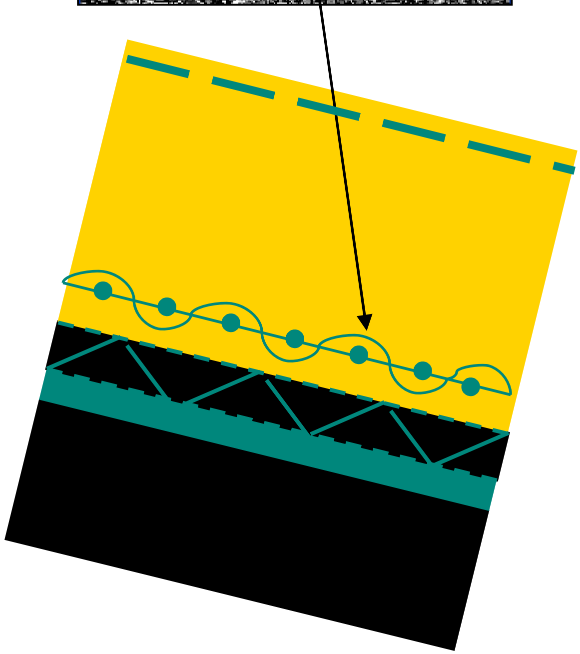
DESIGN INFORMATION			
SYMBOL	VALUE	UNIT	DESCRIPTION
γ	19	kN/m^3	unit weight of cover soil
ϕ	30	deg	friction angle of the cover soil
c	0	kpa	cohesion of the cover soil
h	0.3	m	thickness of the cover soil
β	30	°	soil slope angle
L	20	m	length of the slope
ca	0		adhesion between cover soil of the active wedge and geomembrane
δ	10	°	interface friction angle between cover soil and geomembrane

WITH REINFORCEMENT				
SYMBOL	VALUE	UNIT	DESCRIPTION	
Tuts	94	kN/m	Ultimate tensile strengh of the geosynthetic	
RF	2		Reduction factor (RF=RFcrxRFidxRFenvxFS)	
Tall	47.00	kN/m	Allowable tensile strength	
δ_{Reinf}	8.00	°	interface friction angle between cover reinforcement and underlying gsy	
a	3.70		n/a	
b	-7.66		n/a	
c	1.95		n/a	
			FoS_{reinf}	1.77







In the sloped area solution was modified due to evident soil veneer stability problems during construction:

- Biomat blanket;
- **0,30** m of vegetative soil;
- TRM geocomposite to stabilize soil
- drainage composite (two geotextiles + net);
- textured hdpe membrane (2 mm thick);
- 0,40 m of clay;
- wastes.

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500 m2 on a total of 18.000 m2 job failed after heavy rainfall

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Results of the back-analysis and on site investigations:

•The layer of vegetative soil was **30-40% thicker** than the one designed;

• **Friction angle reduced** below the design value (set to **12º**) occurred during the time due to heavy rains.

• Presumably an **increase in the soil weight** due to the cohesive component occurred.

•Failure of the mat occurred **predominantly at the end of the additional reinforcement** confirming that collapse was due to a **lack of mechanical strength** and, in few other sections, at different points along the slope. A back-analysis at the point of rupture confirmed the initial expectation. More difficult was to understand how failures occurred in the middle of the mat (probably due to poor connection).

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DESIGN INFORMATION			
SYMBOL	VALUE	UNIT	DESCRIPTION
γ	19	kN/m^3	unit weight of cover soil
ϕ	12	deg	friction angle of the cover soil
c	0	kpa	cohesion of the cover soil
h	0.4	m	thickness of the cover soil
β	30	°	soil slope angle
L	20	m	length of the slope
ca	0		adhesion between cover soil of the active wedge and geomembrane
δ	10	°	interface friction angle between cover soil and geomembrane

WITH REINFORCEMENT			
SYMBOL	VALUE	UNIT	DESCRIPTION
Tuts	94	kN/m	Ultimate tensile strengh of the geosynthetic
RF	2		Reduction factor (RF=RFcrxRFidxRFenvxFS)
Tall	47.00	kN/m	Allowable tensile strength
δ_{Reinf}	8.00	°	interface friction angle between cover reinforcement and underlying gsy
a	11.43		n/a
b	-9.51		n/a
c	0.95		n/a
		FoS_{reinf}	0.72

0.83 only altering h

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What did we learn?

• the textured membrane in this case was ineffective and not capable to stabilise the soil; a smooth membrane could be used instead, reducing the costs;

• the interaction factors between the different geosynthetics are a key point; these values can vary in fact very much depending on the different situations;

• Thickness and “quality” of the soil placed on the reinforced mat are relevant issues:

- The thickness (especially when small) is difficult to manage and it is likely to overload the geosynthetic;

- The weight and also the quality of the soil are not homogenous and the characteristics are often different from those assumed. Changing the soil weight and/or quality can also increase the loads.

Conclusions:

- the design of an erosion system, like in this case, is **a real structural project** and the input data must be consistent with the real situation;

- the use of a textured membrane can be insufficient and ineffective, case to case;

- the reinforcement strength must be appropriate in the short-long term conditions in any operating situation (dry/wet);

- soil characteristics are important;

- installation operations are easy, but the design instructions must be strictly followed (thickness layer!).

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- Maccaferri provides a **range of products** used **in Capping Systems**:
  - **Paragrids and Paralinks** for soil reinforcement with geogrids;
  - **MacDrain** for Drainage Geocomposites;
  - **MacMat-R** for soil erosion and reinforcement.

- Maccaferri provides **3 levels of service**:
  - **Level 1**: Supply of products;
  - **Level 2**: Design and Supply;
  - **Level 3**: Quality Management Systems, Training, Site Assistance, PI on Design.

- Maccaferri provides **design software and design service**:
  - **MacStars W** for soil reinforced structures;
  - **MacFlow** for drainage design;
  - **ENSPAMac** for veneer soil cover design and anchor design

- Maccaferri provides informative **design data sheets** relevant to Capping:
  - MacDrain with RFcr for long term analysis allowing reduction in costs.

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Engineering a better solution

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THANK YOU

Any questions?