A sensitive mine closure in Canada – analysis after 15 years of completion using a multi-linear drainage geocomposite for surface water collection

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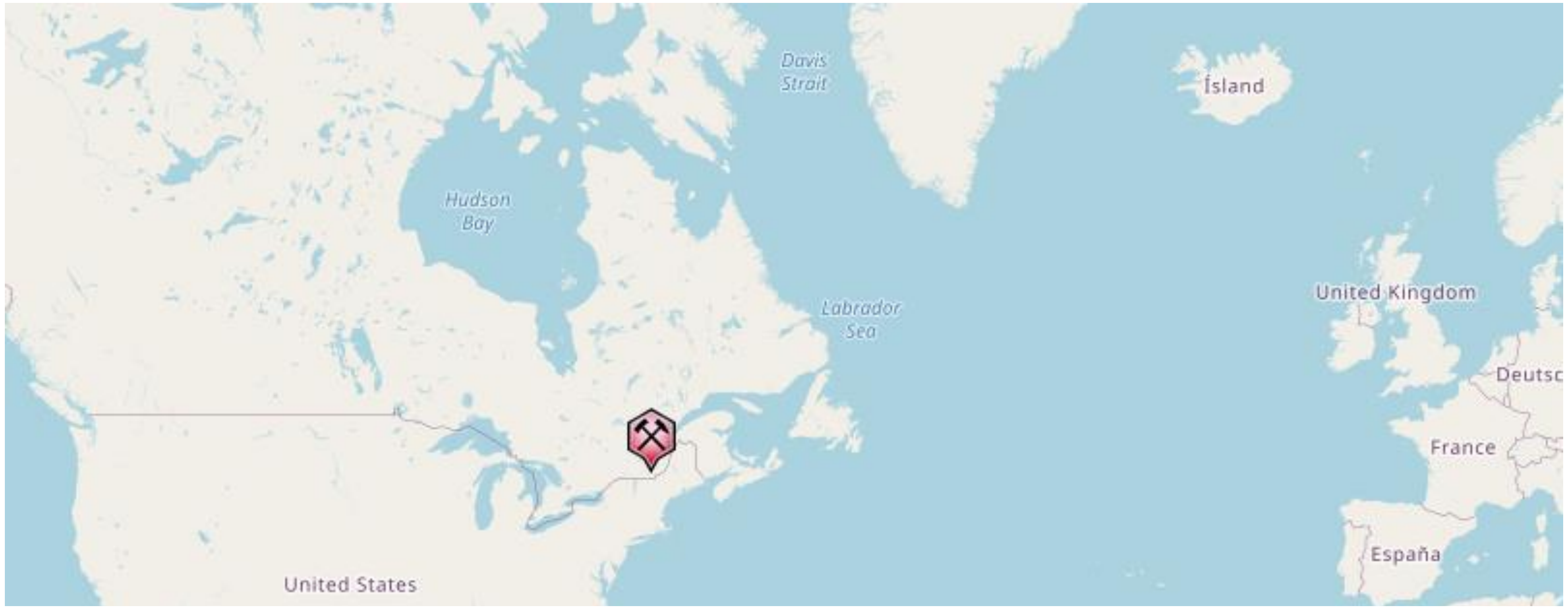
GEOANZ #1 ADVANCES IN GEOSYNTHETICS
7–9 JUNE 2022 | BRISBANE CONVENTION & EXHIBITION CENTRE

- Description of the situation
- Multi-linear drainage geocomposites technology
- Technical approach for run-off drainage (final closure)
- Exhumation and tests after 15 years of use
- Conclusion

The Eustis mine is a mine historically located in the Eastern Townships region (now in the Eastern Townships administrative region) of Quebec, Canada. It was started around 1865 and closed in 1939. **When it closed, it was the last operating mine in the region's mine complex and also the oldest copper mine in Canada as well as the deepest copper mine in Canada.**

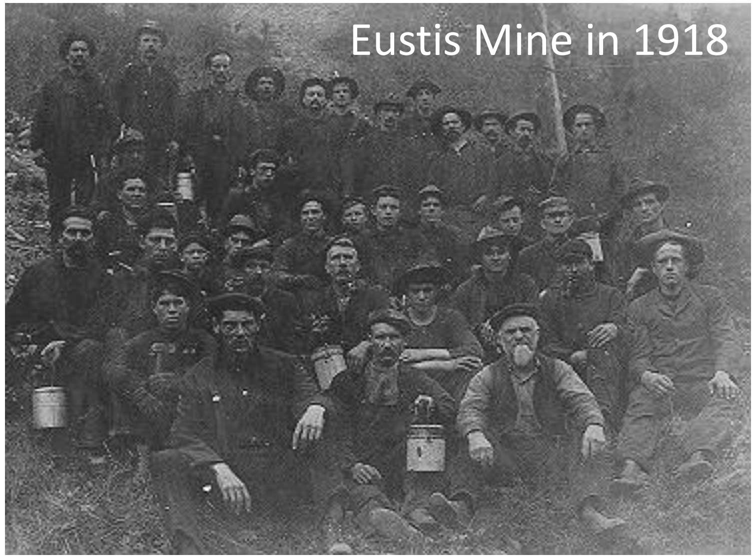

Eustis Mine in 1918

During the American Civil War, copper was in high demand. Several mines appeared in what is now the Eastern Townships: the Capelton, Eustis and Albert mines. Three mining engineers, members of the Orford Nickel and Copper Company, acquired the Eustis mine area around 1863. The initial plan was to create a horizontal access drift about 300 m (1,000 feet) long to intersect the shaft of the Hartford mine, owned by the Canadian Copper and Sulphur Company. The first installations were probably called the Crown Mine, but the name Eustis Mine was later used.



Seulement trois de ces sites seront restaurés dans la province cette année, dont la **mine Eustis pour 3 millions de dollars en deux ans**. « On y va par priorité », a affirmé le ministre Pierre Corbeil.

Cette mine de cuivre a été exploitée pendant des dizaines d'années jusqu'à sa fermeture, en 1939. **Des métaux lourds se répandent toujours dans la rivière Massawipi et rien ne pousse sur la terre acide du site.**



Client : **Ministry of Natural Ressources of CANADA**

Eng : **GSI Environnement**

Installer : **Solmax-Texel**

QA/QC : **Groupe Alphard**

Year of completion : **2007-2009**

Total area restorated : **50 000 m2**

(in 3 sections)

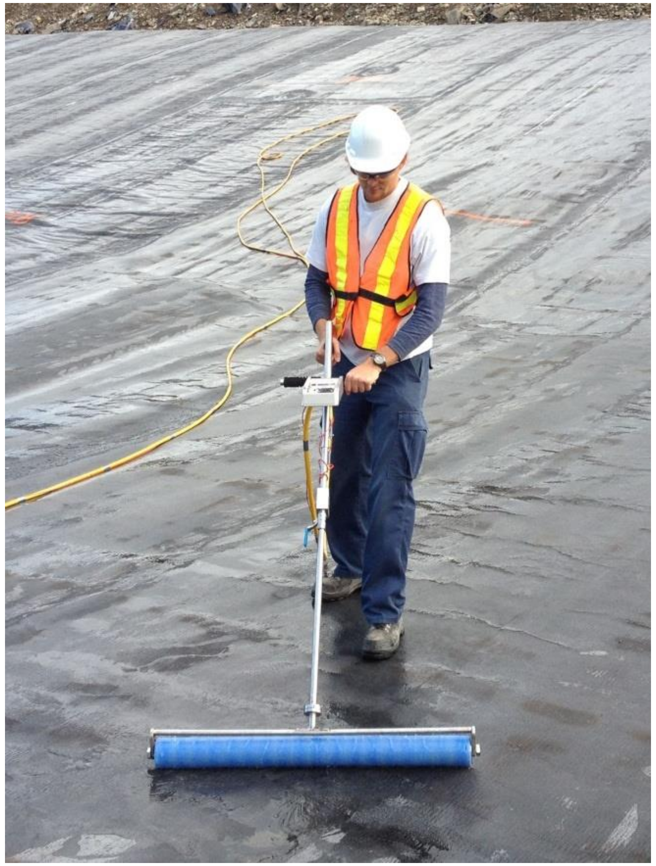
Eustis Mine in 2022

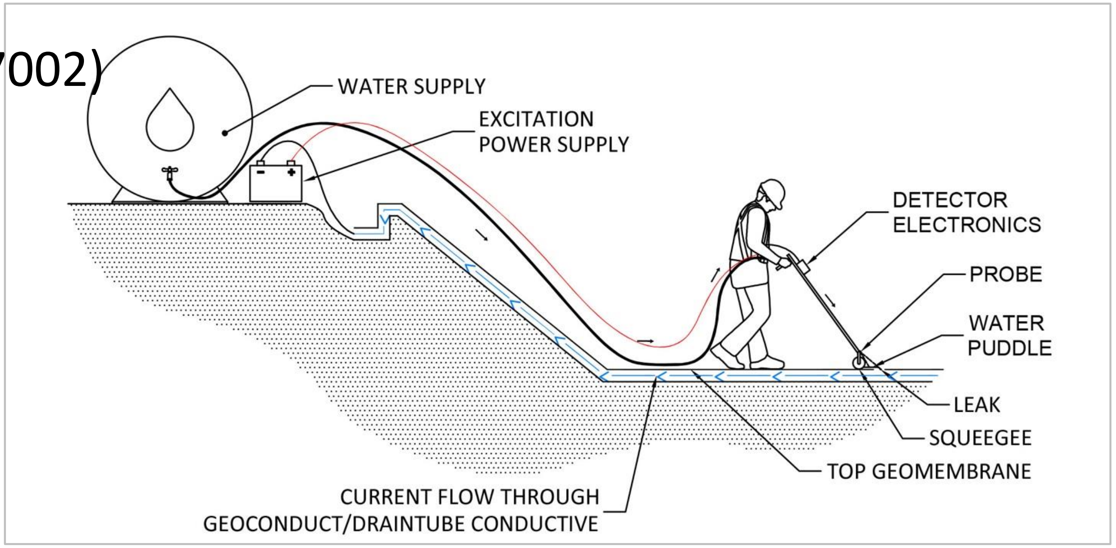
Typical cover design

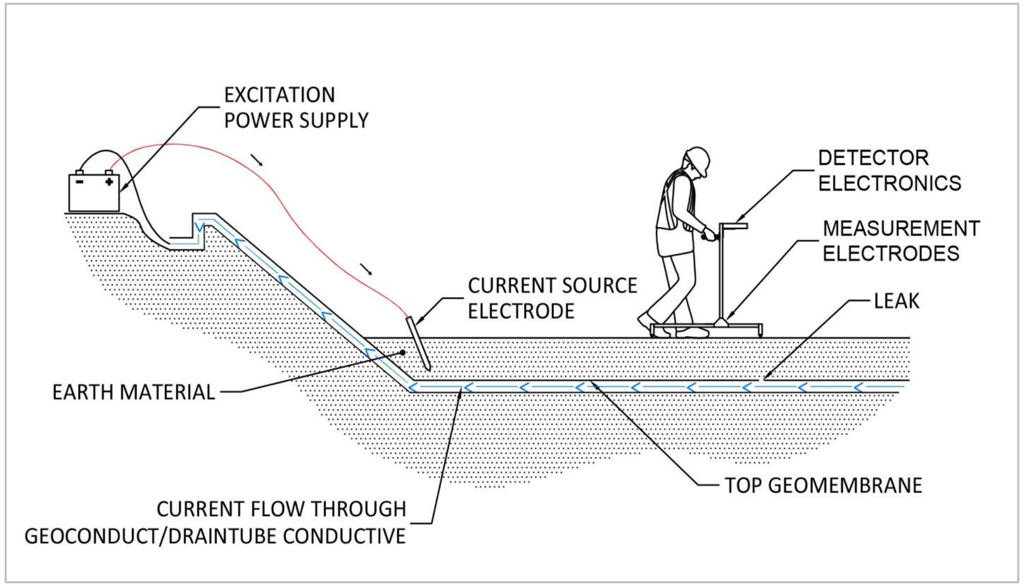
- 50 mm top soil
- 450 mm backfill
- DRAINTUBE 450 FT0.5 D20
- 60 mil Textured HDPE GMB
- Protection gtx
- Reshaped profile

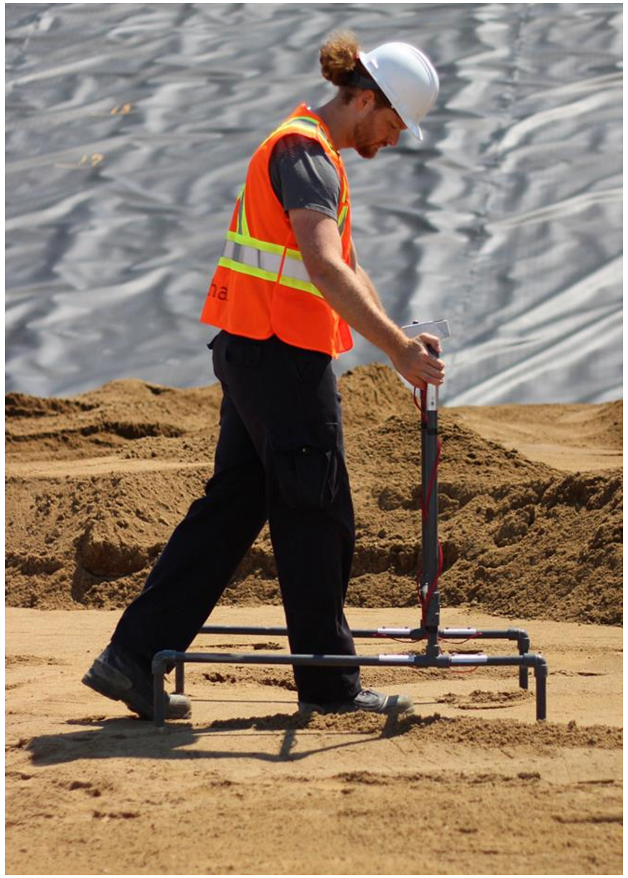
QA/QC Program

Water Lance Method (ASTM D7002)









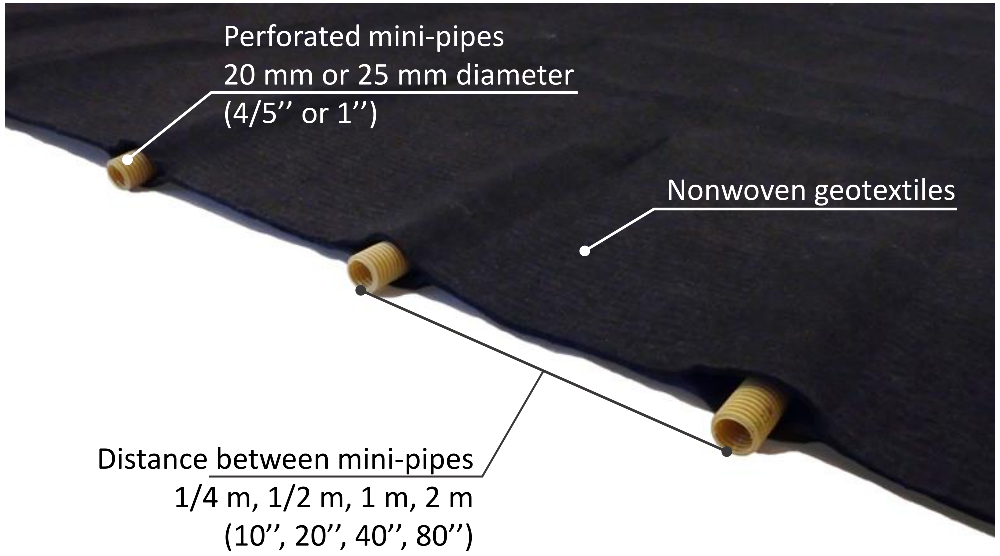
Dipole Method (ASTM D7007)

Multi Linear drainage geocomposite: DRAINTUBE®

Drainage geocomposite with drainage conduits regularly spaced between two geotextiles instead of a geonet core

Drainage conduits:

- Perforated PP mini-pipes,

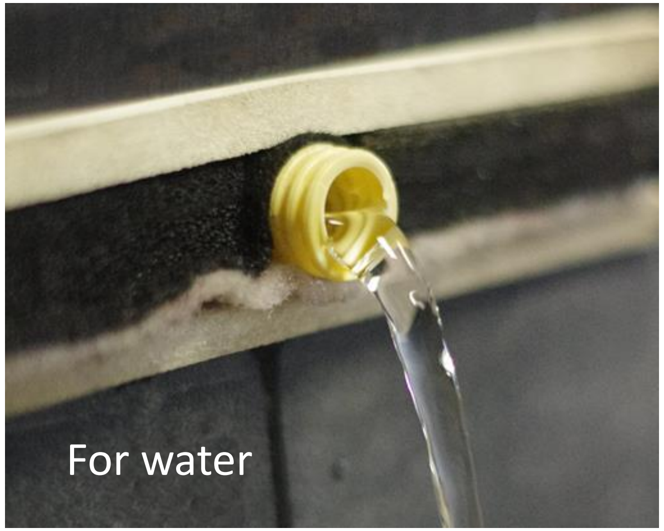


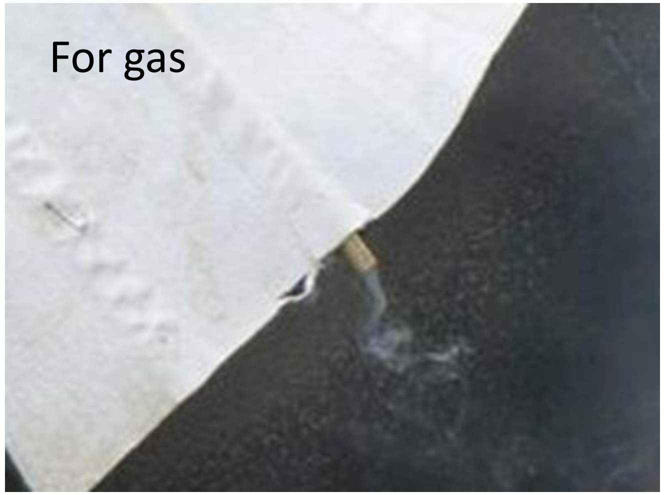
Main characteristics:

- Rolls 3.98 m x 75 m
- Geotextiles layers from 100 g/m2 to 2000 g/m2
- Mini-pipes with high compressive resistance

  Pipe stiffness at 5% deflection (ASTM D2412) > 3 000 kPa

- Transmissivity up to $4x10^{-3}$ m2/s (i=0.1, under 2500 kPa)
- Light and Flexible product
- No creep, No geotextile intrusion
- No peel adhesion issue





More than **4,000,000 m2 installed in North America** since 2007

More than 300 projects in North America

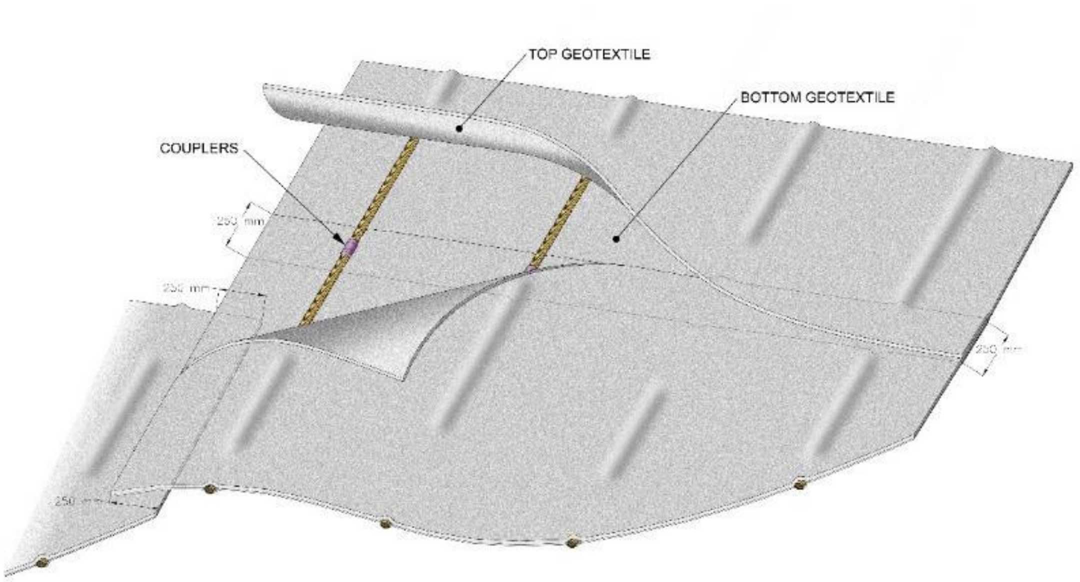
100% conformity for all projects completed in North America

More than **23,000,000 m^2 installed around the world** since 1988

Installation

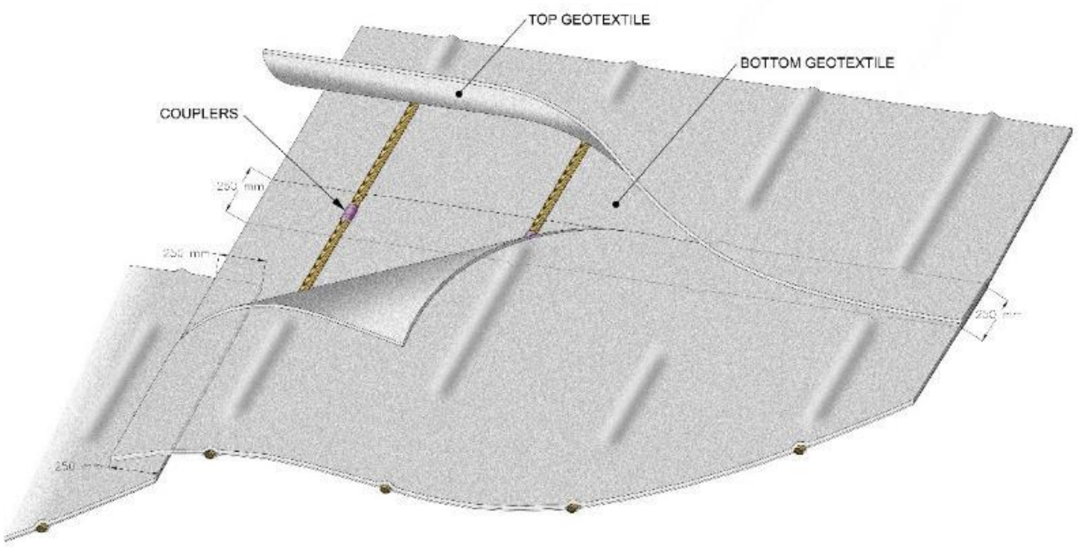
Installation

Welding, Sewing, additional overlap



Installation

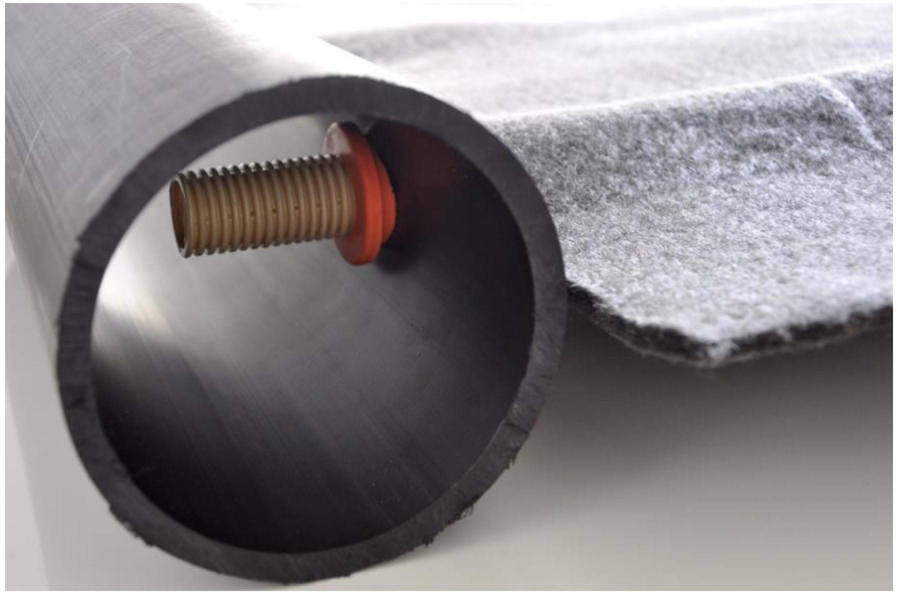
Welding, Sewing, additional overlap



Backfill

Connection to collector trench / ditch

Quick Connect System



DRAINTUBE is a Multi-linear drainage geocomposite as per **ASTM D4439** Standard Terminology for Geosynthetics.

ASTM INTERNATIONAL

INTERNATIONAL

Designation: D4439 – 17

Standard Terminology for Geosynthetics[1]

multi-linear drainage geocomposite, *n*—a manufactured product composed of a series of parallel single drainage conduits regularly spaced across its width sandwiched between two or more geosynthetics.

Geosynthetic Institute
475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
FAX (610) 522-8441

Geosynthetic Institute

GRI Test Method GC15*

Standard Test Method for

"Determining the Flow Rate per Unit Width of Drainage Geocomposites with Discrete High Flow Components"

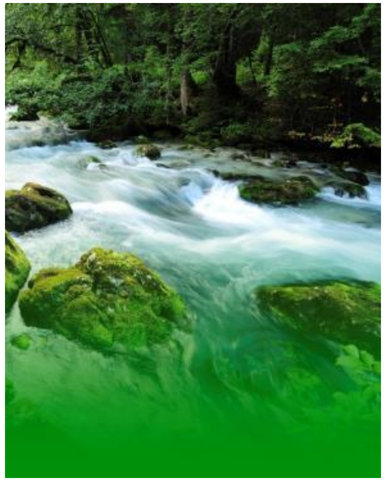
DRAINTUBE geocomposite is also characterized by the Geosynthetic Institute **GRI GC15 standard test method** for Determining the Flow Rate per Unit Width of Drainage Geocomposites with Discrete High Flow Components.

MOST COMMON APPLICATIONS

BUILDINGS & SPORTS

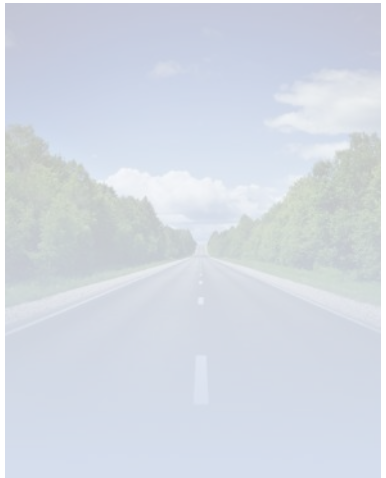
CIVIL

MINING & ENERGY



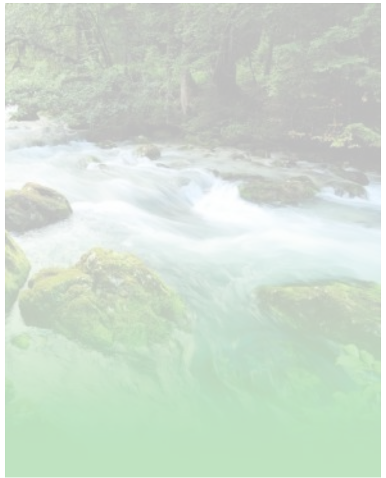
ENVIRONMENTAL

BUILDINGS & SPORTS



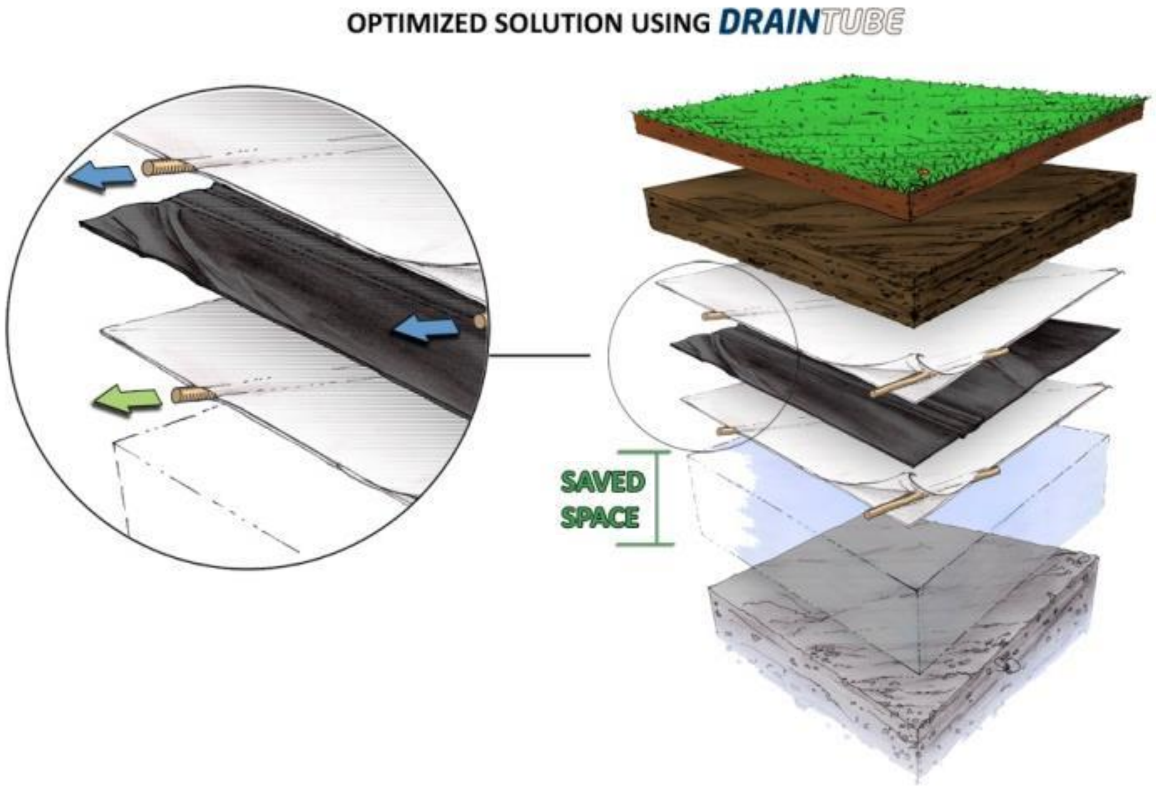
CIVIL

MINING & ENERGY



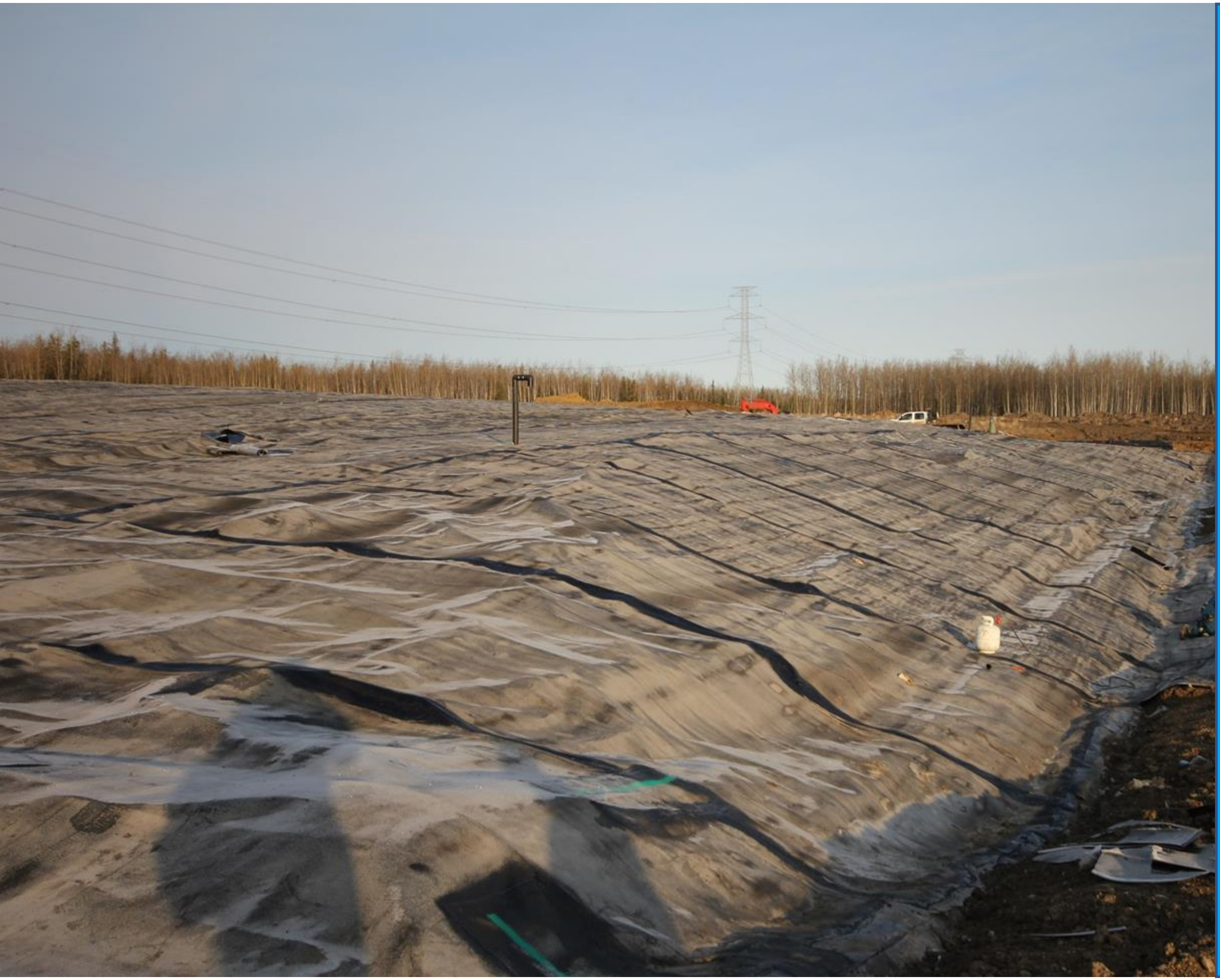
ENVIRONMENTAL

Run-off drainage / Gas venting on final covers



Case Study : HSPP, BC – 2014 / 15

Gibraltar Mines, BC – 2010



McKay River - Suncor, AB – 2013

Central Manitoba Mines, MB – 2011

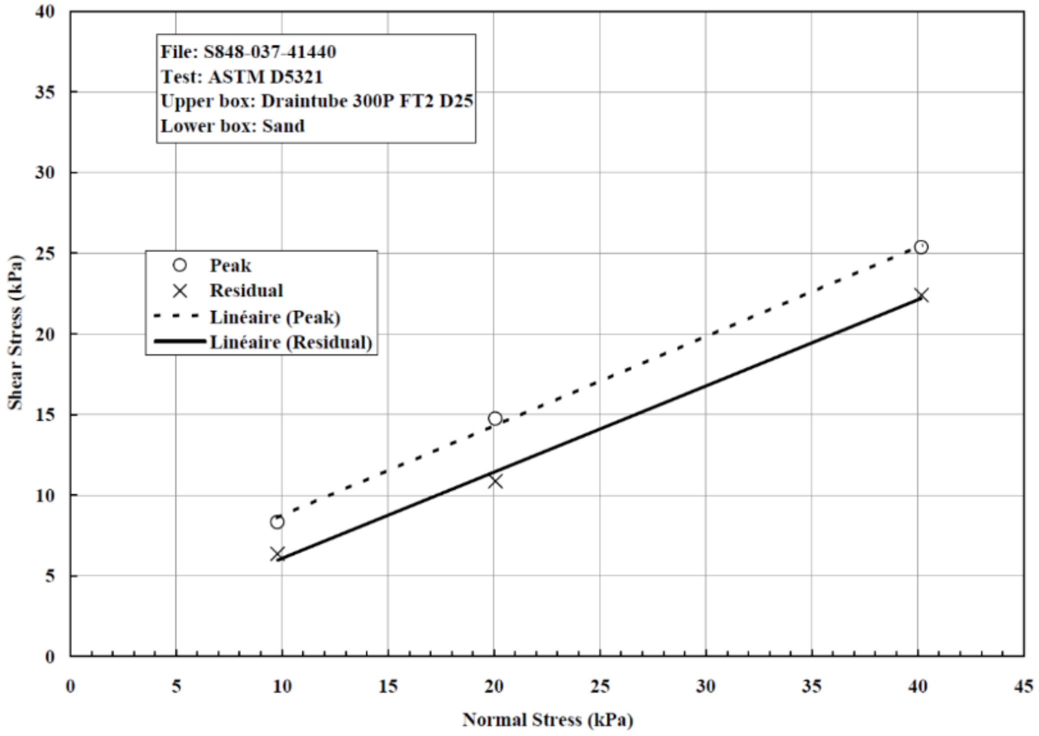
Case Study : Eustis Mine, Qc – 2008 - 2010

Technical point :

Slope Stability

Technical point :

Interface Draintube / Sand



Material Tested	Typical Friction Angle (°) with DRAINTUBE®
Interface Sand/ Granular Soil	Directly related to the internal friction angle of the soil.
Textured Geomembrane	28-30
Bituminous Geomembrane	36
Gripnet Geomembrane	35
Geosynthetic Clay Liner	23
Low-permeability soil	Directly related to the internal friction angle of the soil.

Résidual friction angles from 18° to 36° (function of the material in contact)

No peel adhesion issue

Technical point :

Reduction factors for transmissivity

Technical point :

GSI White Paper #4 (Koerner)

Reduction Factors (RFs) Used in Geosynthetic Design

$$Q_{allow} = \frac{Q_{ult}}{RF_{in} \, . RFcr \, . RFcc \, . RFbc}$$

q_{allow} = allowable (or design) flow rate or transmissivity,

q_{ult} = ultimate (or as-manufactured) flow rate or transmissivity,

RF_{IN} = reduction factor for intrusion of geotextiles or geomembranes into the core of drainage product,

RF_{CR} = reduction factor for creep of the drainage core or covering geosynthetics,

RF_{CC} = reduction factor for chemical clogging of drainage core, and

RF_{BC} = reduction factor for biological clogging of drainage core.

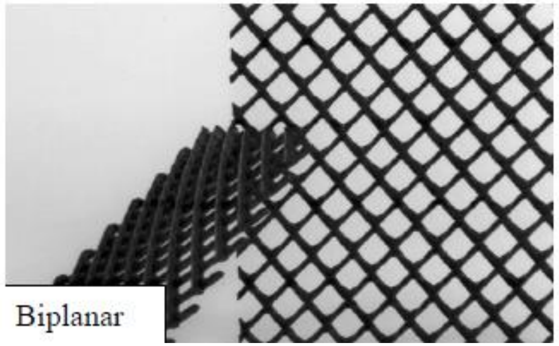
Technical point :

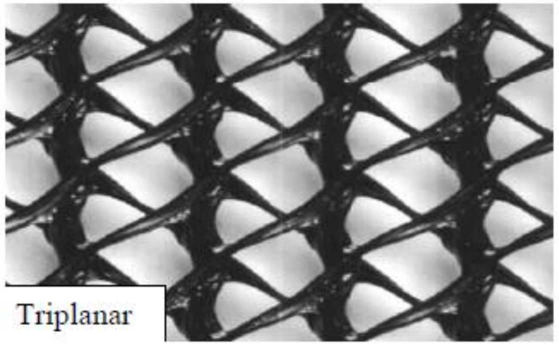
Reduction factor for creep and geotextile intrusion

Function of the shape of the drainage core

For geonet drainage core

Reduction of the drainage capacity under load





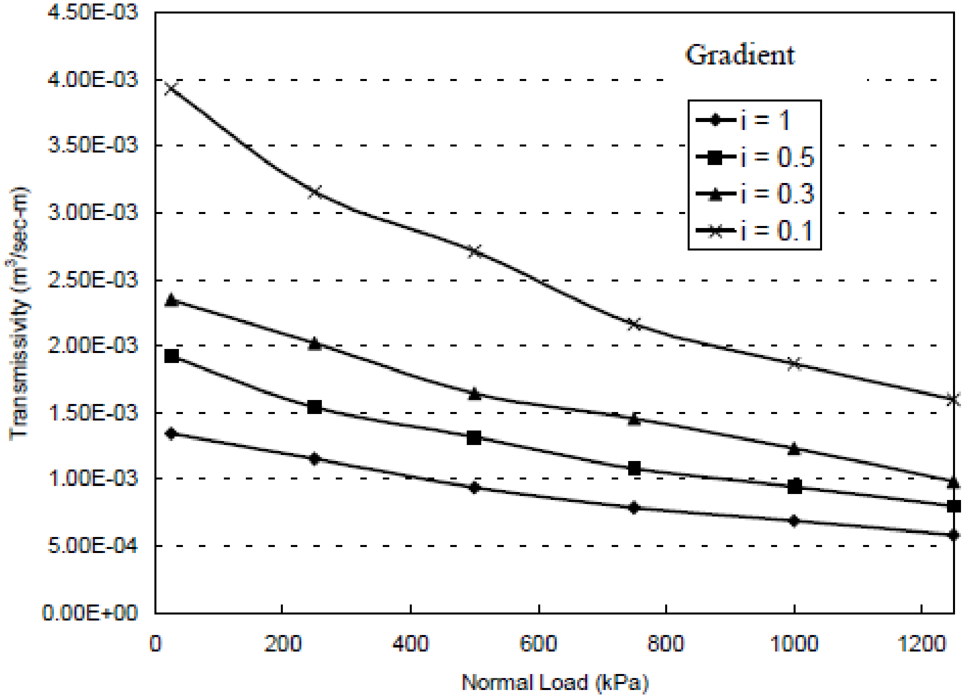


Figure 2.3 Transmissivity data vs. normal loads for a triplanar geonet laminated with a 270g/m² nonwoven on each side with soil as a top boundary and aluminum plate lower boundary (ASTM D4716).

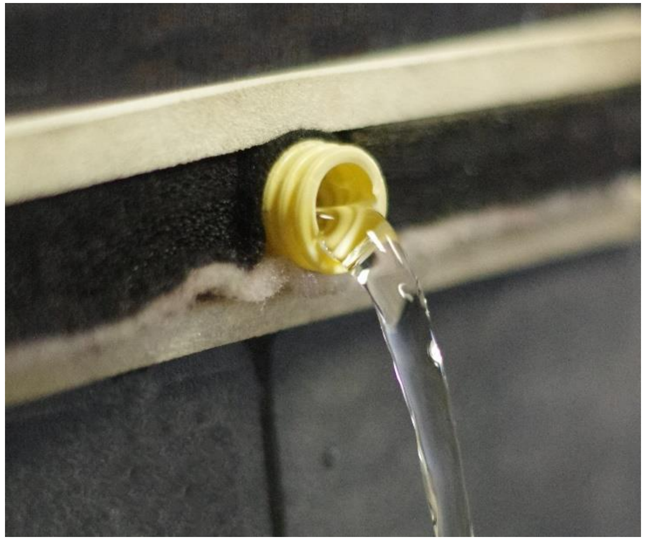
Technical point :

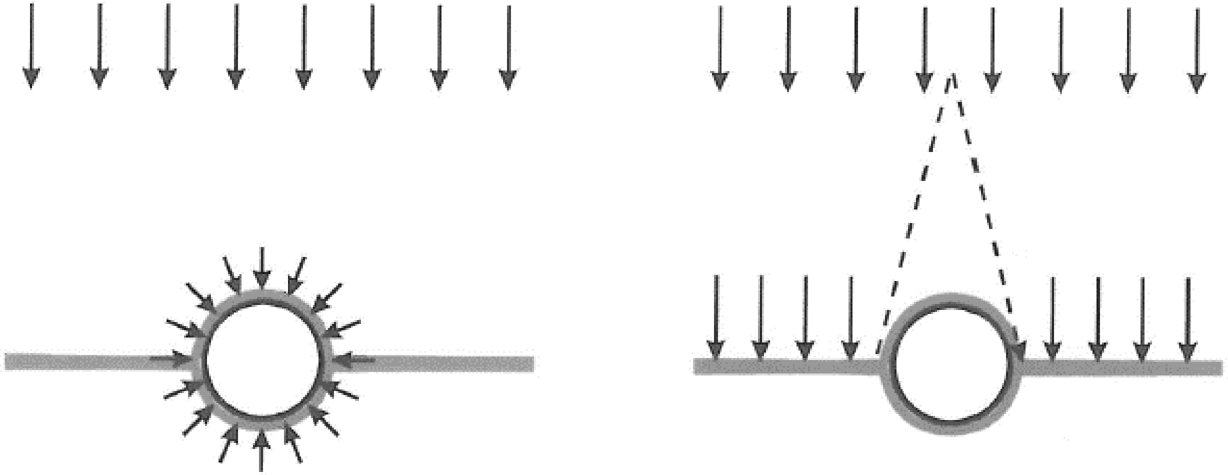
Reduction factor for creep and geotextile intrusion

Function of the shape of the drainage core

For DRAINTUBE

Arching effect when confined in soil





Technical point :

Reduction factor for creep and geotextile intrusion

Function of the shape of the drainage core

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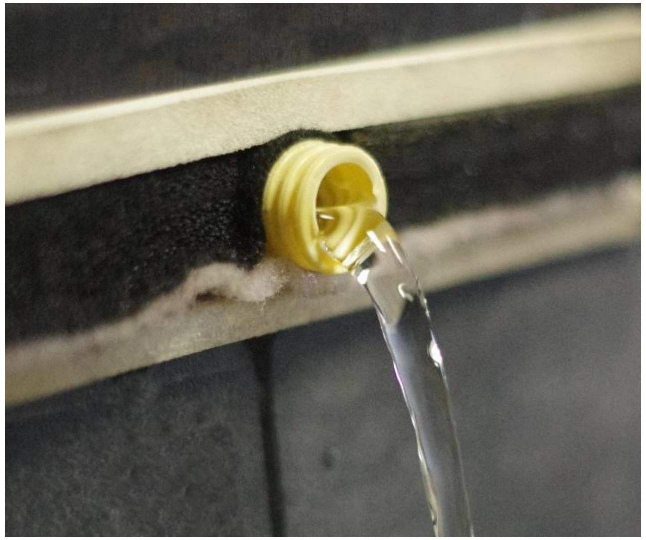
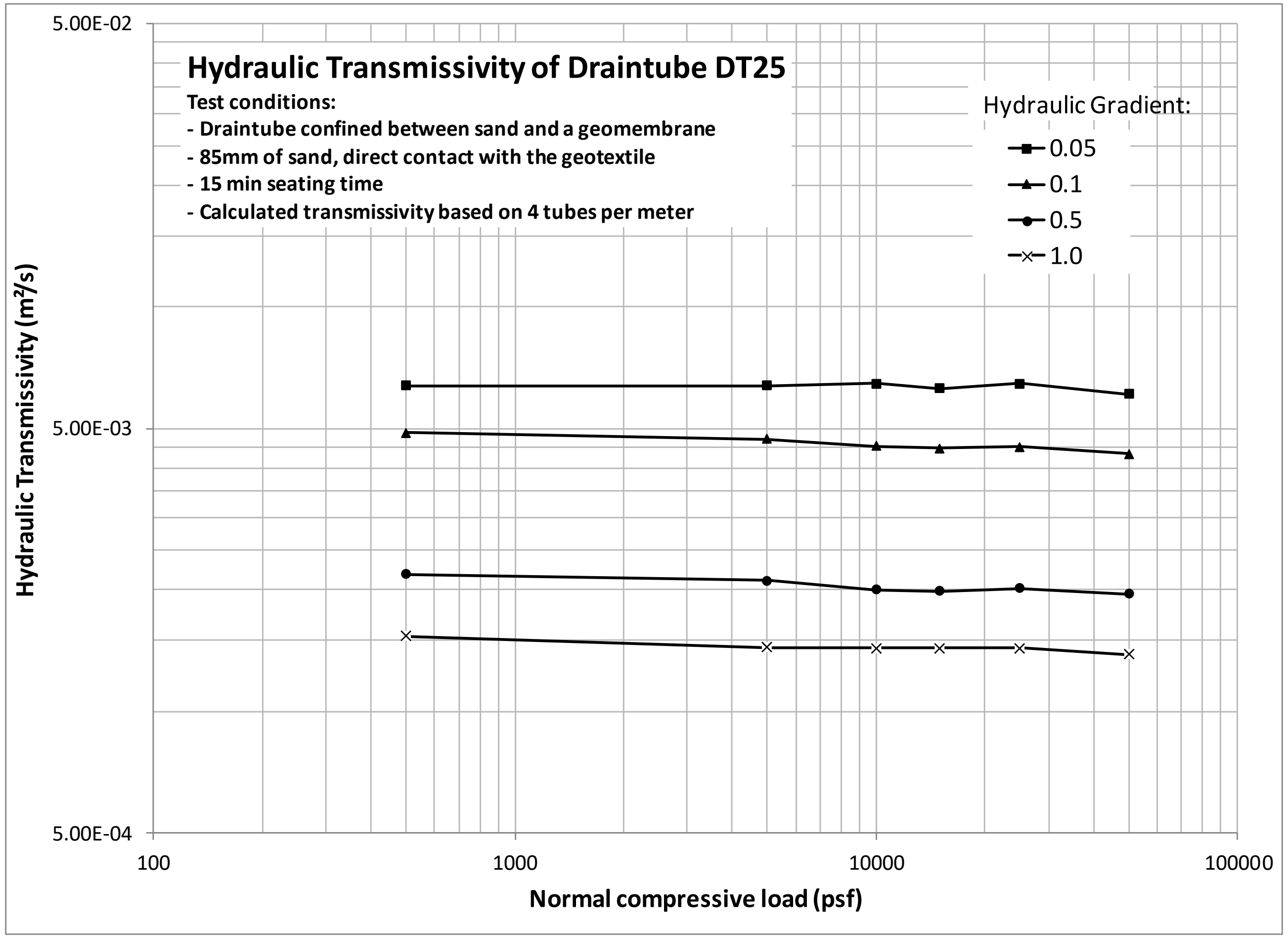




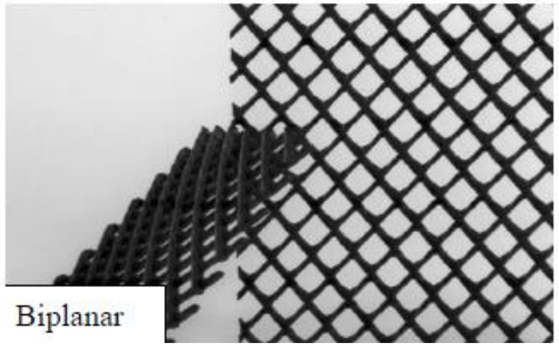
Technical point :

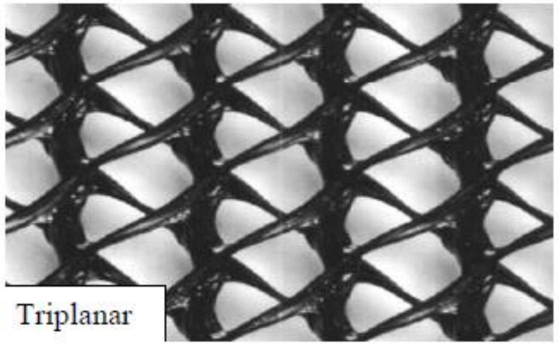
Reduction factor for creep and geotextile intrusion

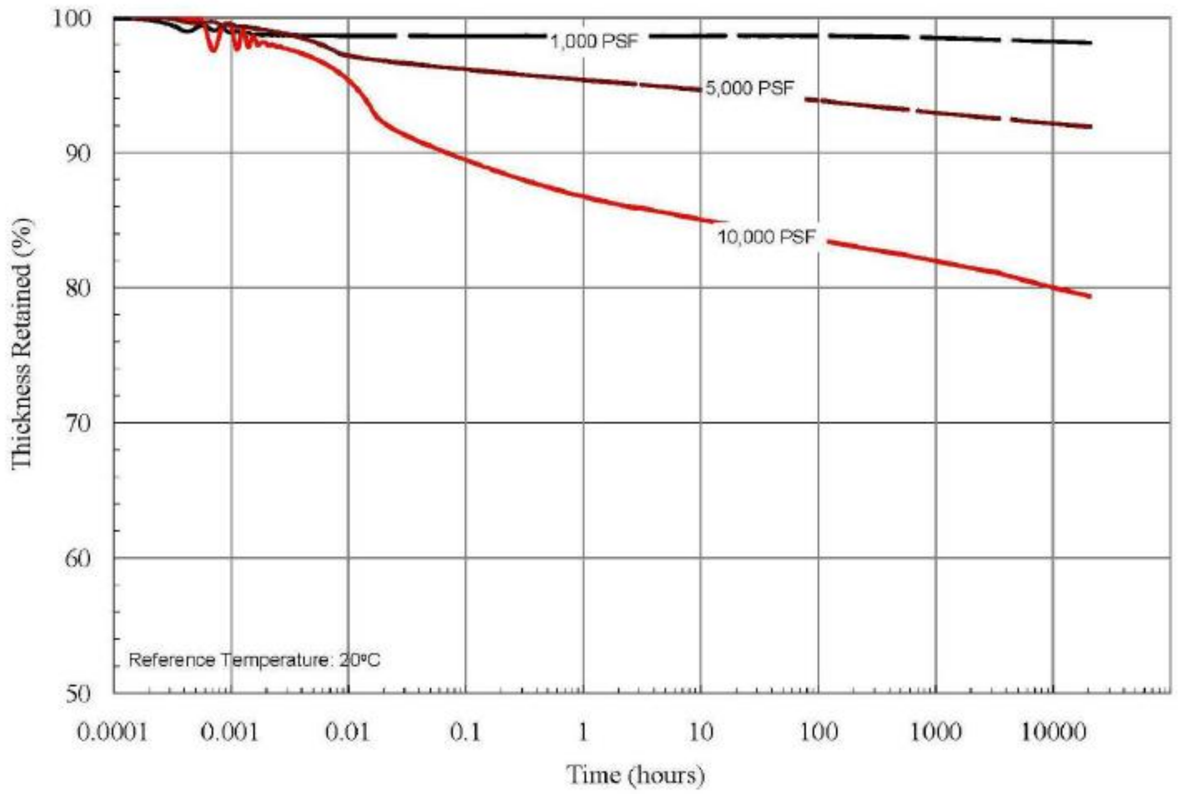
Function of the shape of the drainage core

For geonet drainage core

Reduction of the drainage capacity over time







Creep Curves for a 250 mil geonet

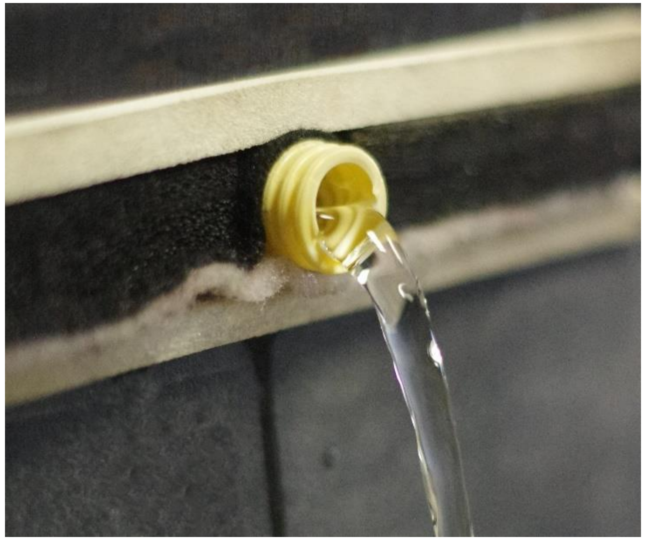
Technical point :

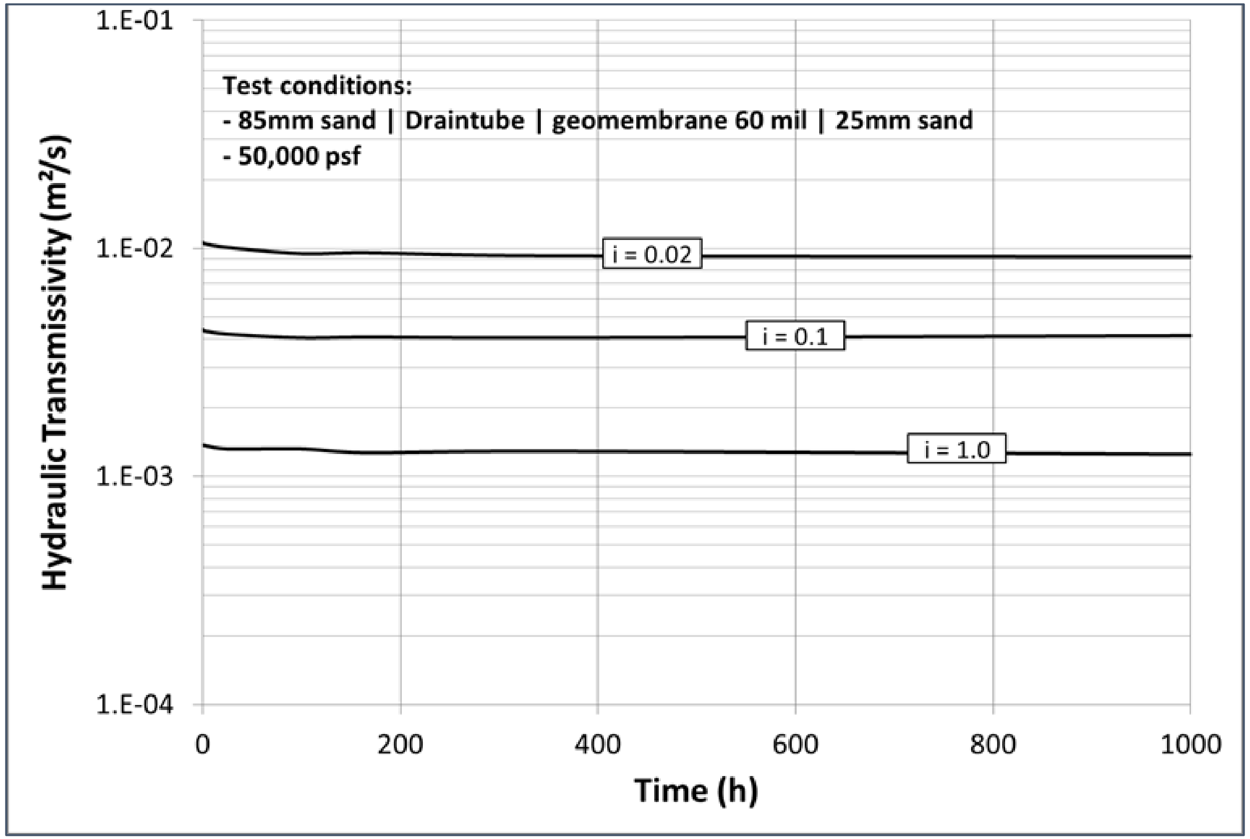
Reduction factor for creep and geotextile intrusion

Function of the shape of the drainage core

For DRAINTUBE

Arching effect when confined in soil





<u>Published related reference</u>

Assessment of the Resistance of Drain Tubes planar drainage geocomposites to high compressive loads
Eric Blond (SAGEOS) and Pascal Saunier (AFITEX-Texel), ***ICG 2010***

Designation: D7931 – 17

Standard Guide for Specifying Drainage Geocomposites[1]

8. Reduction Factor of Creep

8.1 Depending on the site-specific situation and applied stresses, the drainage core of the geocomposite might creep which leads to a reduction of its in-plan flow capacity. The creep phenomenon is core dependent. Some products, like multilinear drainage geocomposites, may not be sensitive to creep when confined into a soil matrix because of their core structures.

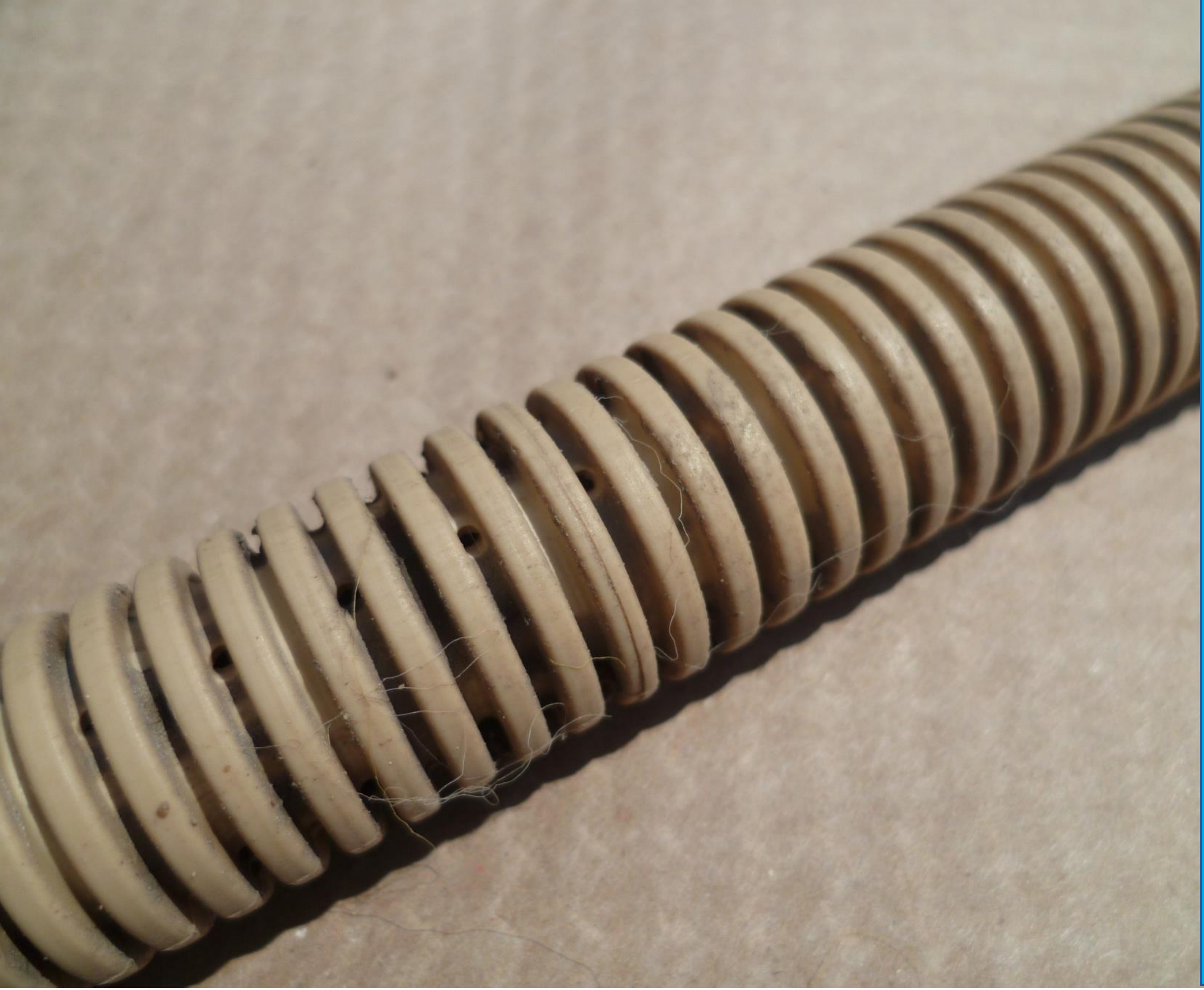
After 15 years of use :

- Complete loss of functions ?
- Still efficient properties ?
- Overall behaviour of the product

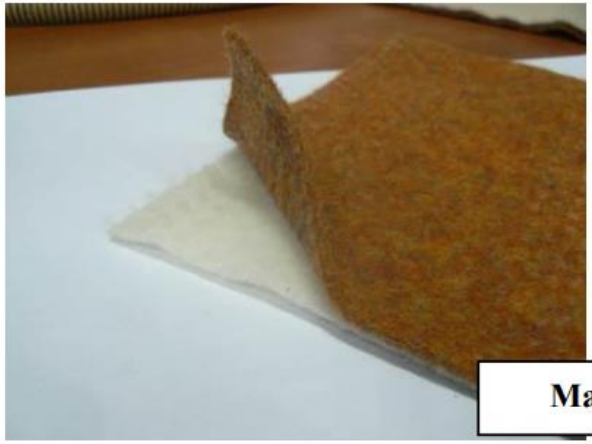
After 15 years of use :

After 15 years of use :

After 15 years of use :



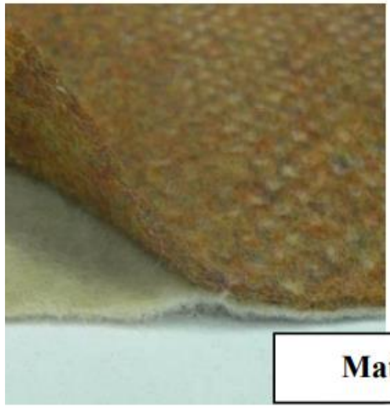

Original product from a stored sample

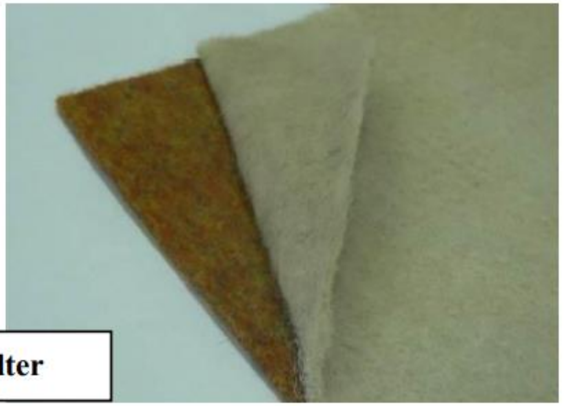


Mat + Filter

Mini-pipe
ϕ 20 mm

Exhumed product after 10 years





Mat + Filter

Mini-pipe
ϕ 20 mm

IDENTIFICATION

Mass per area
NF EN ISO 9864

Weigth measure of several samples of 400 cm²

Balance de précision

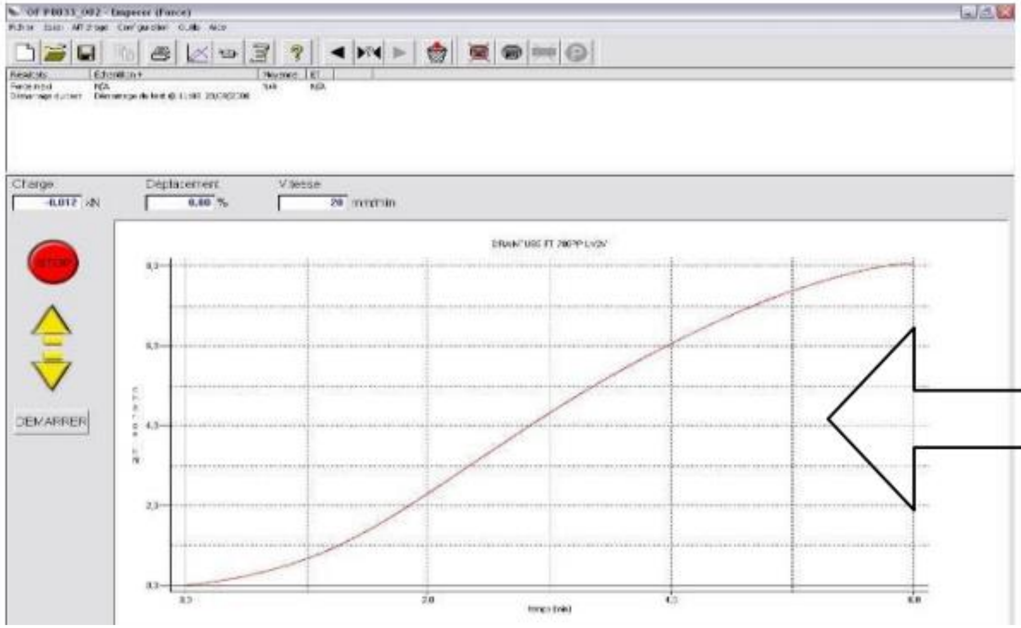
Thickness
NF EN ISO 9863-1

Measurement of the thicknesss with:
- a presser foot
- a constraint setting cylinder
- a thick Compare

Comparateur d'épaisseur

Tear strength and ellongation at break
NF EN ISO 10319

Tests on several samples
- width: 200 mm
- length: 250 mm



Traction apparatus

RESULTS

Original sample

CONTROLS	VNAP	PRV 95		AVERAGE
		Mini	Maxi	
Identification				
Mass per area in g/m²	450	405	495	**430,00**
Thickness/mm under 2 kPa	5,10	4,08	6,12	**4,28**
Thickness/mm under 20 kPa	3,90	3,12	4,68	**3,89**
Tear strenght				
Machine direction in kN/m	12	10,44	NR	**23,90**
XMachine direction in kN/m	12	10,44	NR	**28,05**
Ellongation at break				
Machine direction in %	110	77,00	143	**113,00**
XMachine direction in %	110	77,00	143	**83,33**

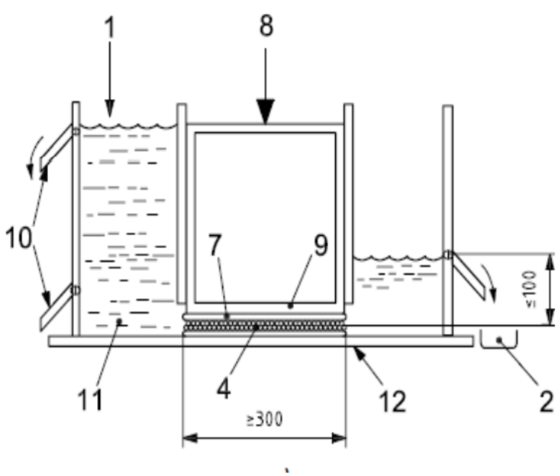
10 years old sample

AVERAGE	
845,00	soil/dust presence
4,31	
3,82	
22,00	7.94% loss in machine direction (tear)
24,00	14.43% loss in xmachine direction (tear)
77,56	31% loss in machine direction (elongation)
77,00	7.22% loss in xmachine direction (elongation)

→ Safety factor at design stage of 2.00

In plan flow rate
NF EN ISO 12958

Schema:



Legend

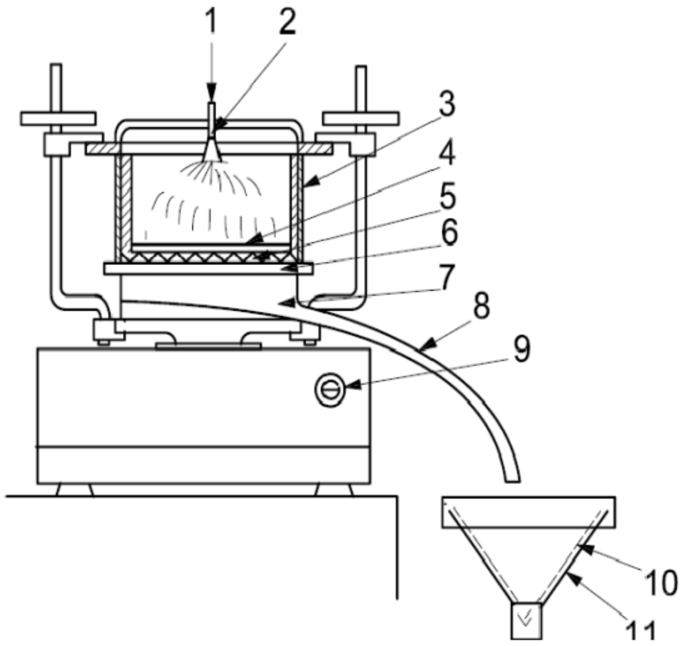
1 water inlet
2 Water collector
3 manometers
4 test tube
5 membrane
6 pressure cell
7 foam
8 charge
9 laod plate
10 gradients
11 Water tanks
12 Base

Measurement of transmissivité with:

- a Transmissivimeter apparatus
- un chronometer
- un weight recipient

Filtration opening size of the filter
ISO12956:2010

Schema:



Legend

1 water inlet
2 pulverization
3 dispositif de serrage
4 granular material
5 test tube
6 support net
7 tank
8 connection tube
9 amplitude regulation
10 filter papier
11 collection system

RESULTS

Original sample

10 years old sample

Applied constraints (kPa)	Hydr. Grad. i	Flow (1) (l/min)	Flow (2) (l/min)	Flow (3) (l/min)	Aver. Flow (l/min)	T (°C)	In plan Flow rate (m^2/s)
20	1	7.25	7.10	7.30	7.21	18	$6.3\ 10^{-4}$
100	1	6.01	5.87	5.80	5.89	18	$5.2\ 10^{-4}$

10 years old sample:

$5.31.10^{-4}$ 15% loss at 20 kPa

$4.76.10^{-4}$ 9% loss at 20 kPa

AFITEX
L'intelligence des sols

Results:

Measured Opening Filtration Size : O_f = 80 mm

Conclusion:

The Filtration Opening size is the one that has been initially specified in 2004 with DRAINTUBE 450 FT.

Champhol, 2014 Septembre 4th
Responsable laboratoire
Jamal CHAMINI

RF$_{cc}$ at design stage of 1.40

Filtration Opening Size (microns)	10 years old sample
80	80

General Conclusions:

After the in situ exhumation and the related laboratory testings:

- A visual inspection of Draintube FT after 10 years of usage does not show any aspect of modification of the filter, nor trace of soils into the mini-pipes

Laboratory testings lead to the following results:

Mas per area:	2004 Value:	430 g/m²	
	2014 Value:	845 g/m²	
Thickness under 20 kPa:	2004 Value:	3.89 mm	
	2014 Value:	3.82 mm	
Tear Strength (MD.):	2004 Value:	23.9 kN/m	
	2014 Value:	22 kN/m	
Ellongation at break:	2004 Value:	113 %	
	2014 Value:	77.6 %	
In plan flow rate:	2004 Value:	20 kPa	$6.3 .10^{-4}$ m²/s
		100 kPa	$5.2 .10^{-4}$ m²/s
	2014 Value:	20 kPa	$5.31 .10^{-4}$ m²/s
		100 kPa	$4.76 .10^{-4}$ m²/s
Filtration Opening Size:	2004 Value:	80 µm	
	2014 Value:	80 µm	

After 15 years of use :

- All properties still in the specification / design criterias
- No visual slope instability
- Great vegetation
- In 5 years for the 20th anniversary ?

After 15 years of use :

2007

2010

2022

Thank you for your attention

afitex·Texel
GEOSYNTHETICS

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