V Congreso internacional sobre Mejores Tecnologías Disponibles (MTD) en vertederos, suelos contaminados y gestión de residuos

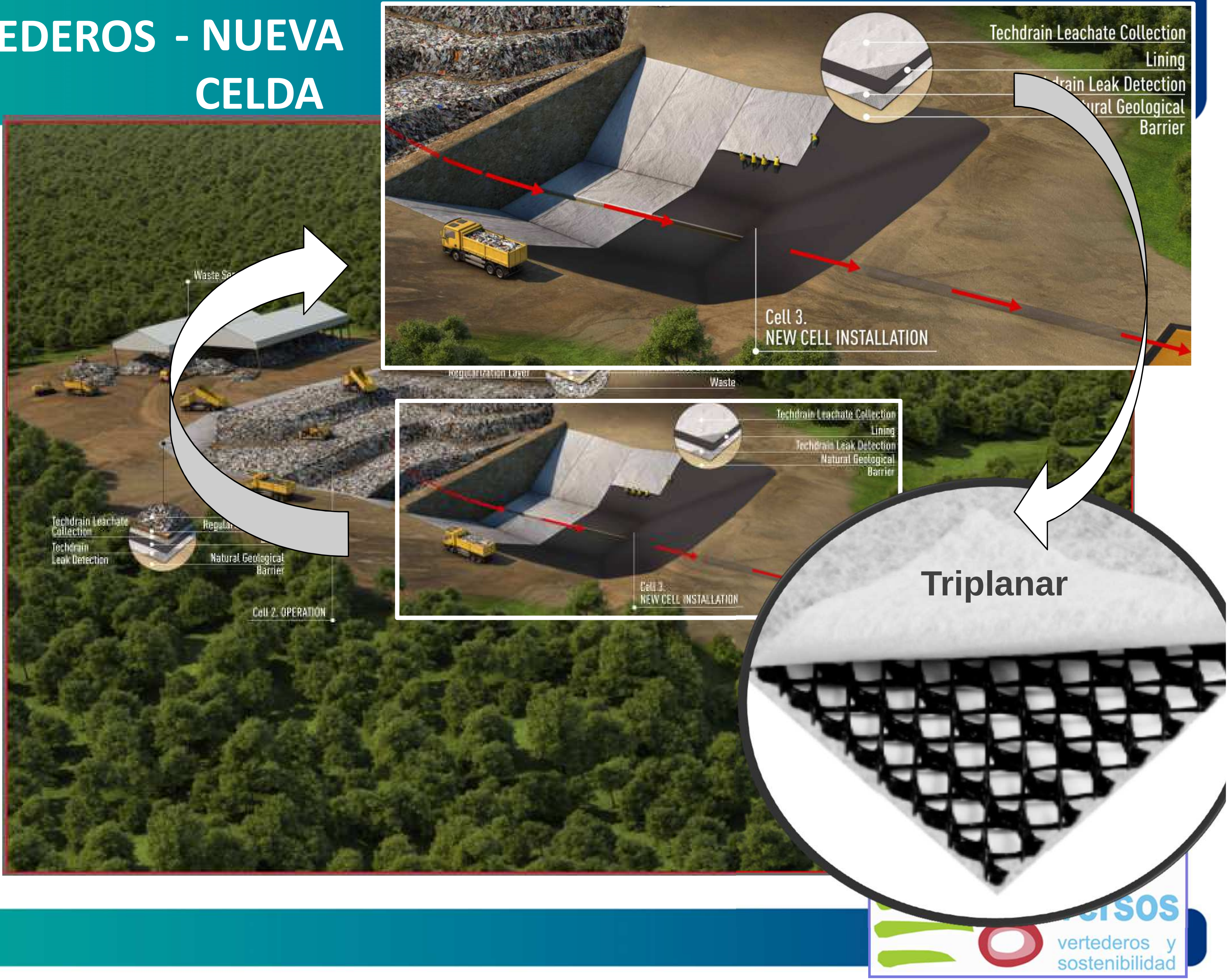
'Nuevos sistemas de drenaje mediante georredes y cálculo de factores de seguridad'

Bilbao
9-10 Noviembre 2016

Jorge Gutiérrez y Oihane Ansa

versos
vertederos y sostenibilidad

VERTEDEROS - NUEVA CELDA



VERTEDEROS - NUEVA CELDA

Vertedero de Iruatxeta (Vizcaya) con geocompuesto drenante PEAD bi-planar.

Superficie: 80.000 m2

versos
vertederos y sostenibilidad

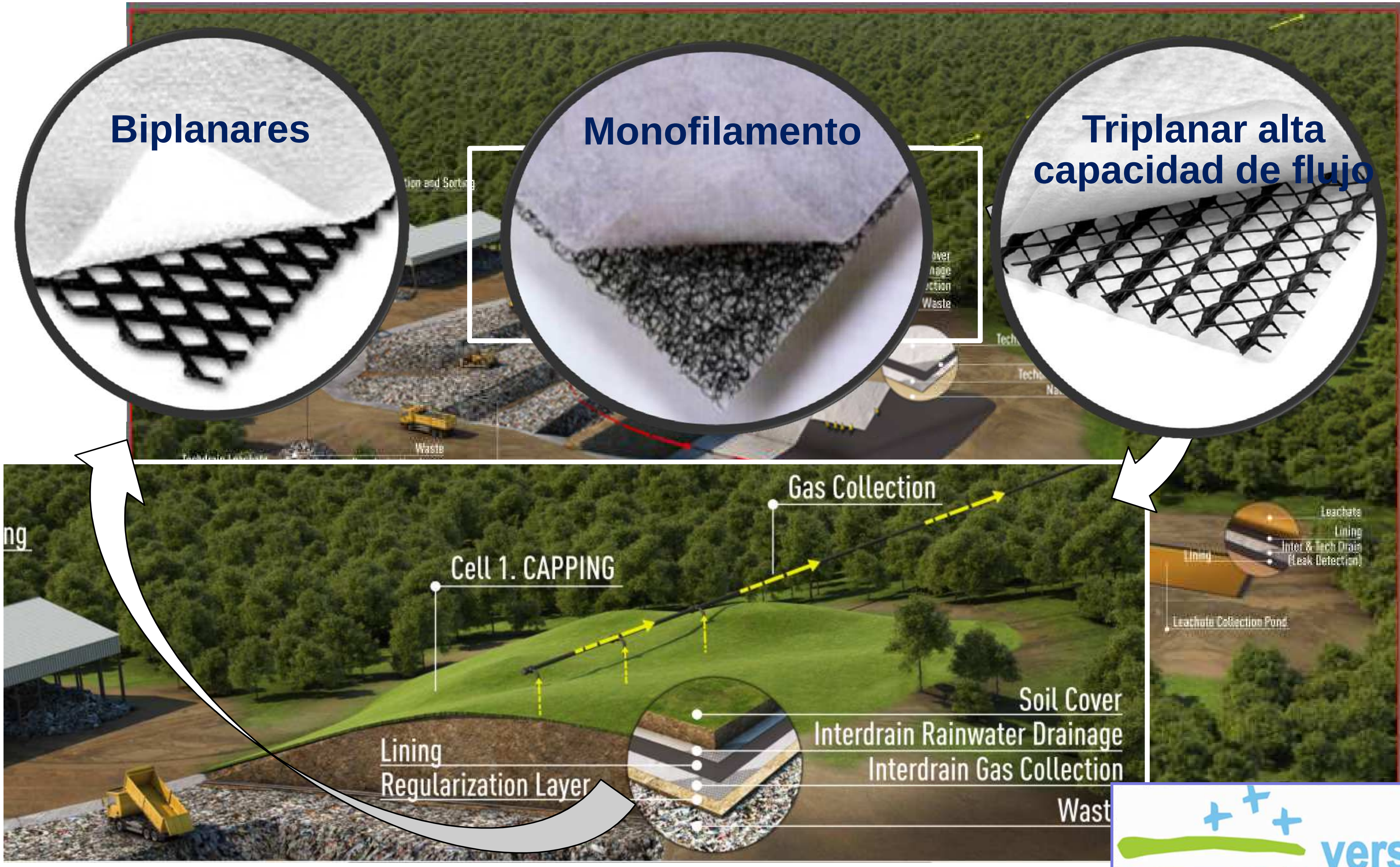
VERTEDEROS - NUEVA CELDA

Vertedero de Meruelo (Cantabria) con geocompuesto drenante PEAD tri-planar.

Superficie: 230.000 m2

versos
vertederos y sostenibilidad

VERTEDEROS - SELLADO / CLAUSURA



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VERTEDEROS - SELLADO / CLAUSURA

Sellado vertedero de escorias y arenas de fundicion de ATUSA

(Salvatierra - Álava) con geocompuesto drenante PEAD tri-planar alta capacidad de flujo.

Superficie: 40.000 m2

versos
vertederos y sostenibilidad

VERTEDEROS - SELLADO / CLAUSURA

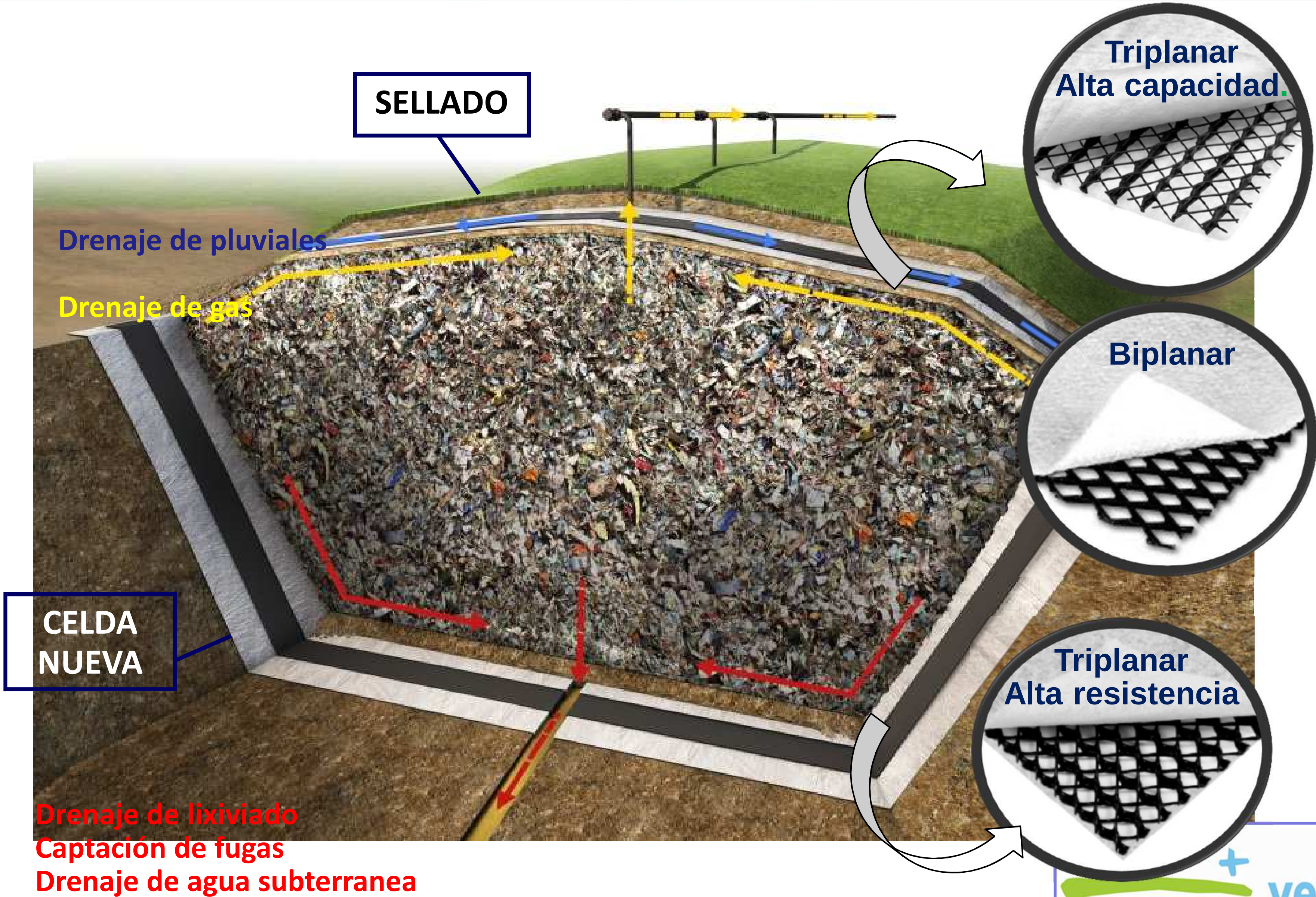
Sellado vertedero de Torrecilla de Valmadrid

(Zaragoza) con geocompuesto drenante PEAD tri-planar alta capacidad de flujo.

Superficie: 500.000 m2

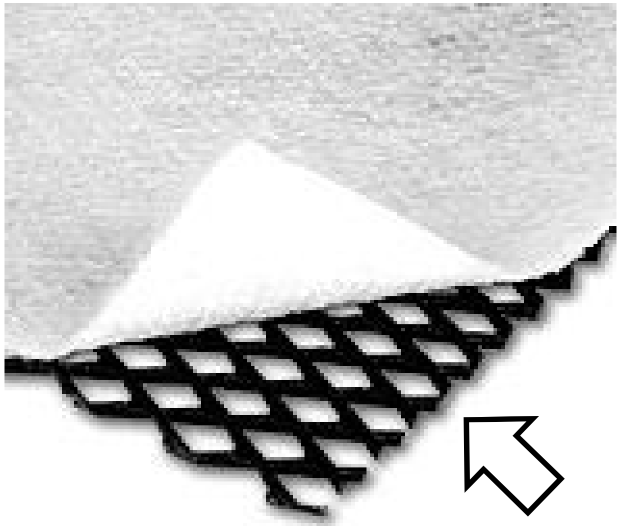
versos vertederos y sostenibilidad

VERTEDEROS – PRODUCTOS DE DRENAJE

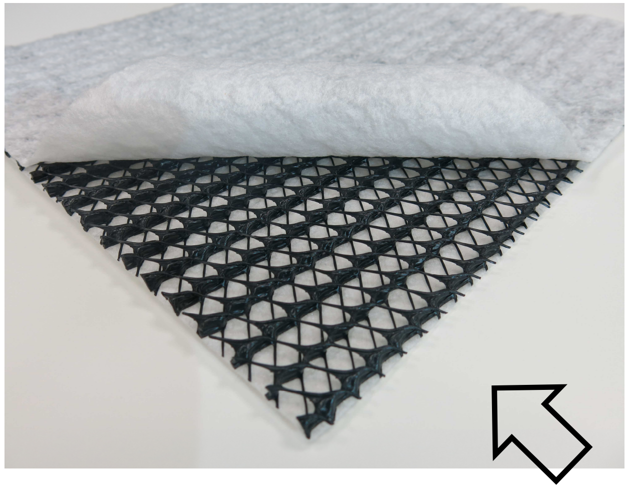


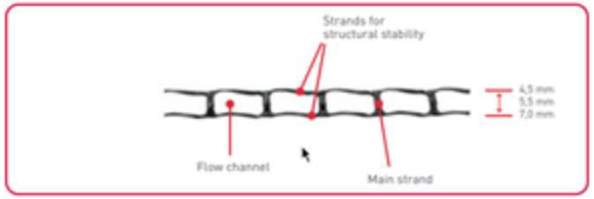
VERTEDEROS – PRODUCTOS DE DRENAJE (georredes)

BIPLANAR

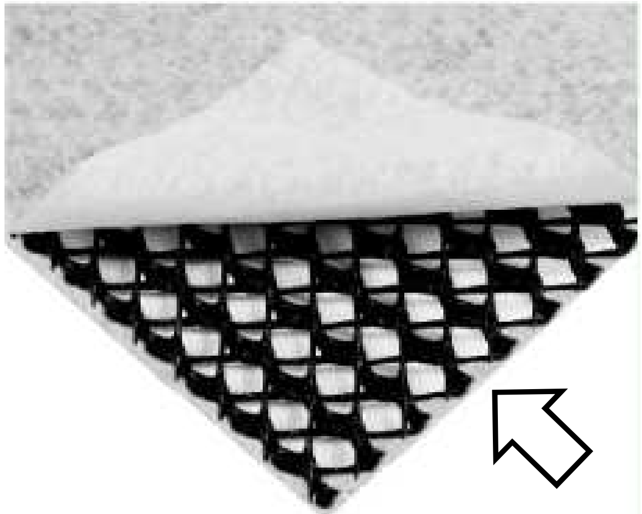


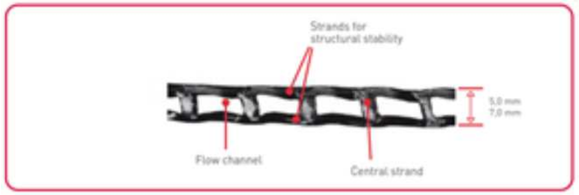
TRIPLANAR ALTA CAPACIDAD DE FLUJO





TRIPLANAR ALTA RESISTENCIA





FACTORES REDUCTORES

- *Geotextiles y geomallas para separación y refuerzo.*
- *Geotextiles para filtración y drenaje.*
- *Geocompuestos de drenaje.*

FACTORES REDUCTORES

Geotextiles y geomallas para separación y refuerzo.

$$T_{allow} = T_{ult}\left[\frac{1}{RF_{ID} \times RF_{CR} \times RF_{CBD} \times RF_{SM}}\right] \qquad \textit{(EQ 1)}$$

- FR_{ID} : Factor Reductor debido daños durante la instalación.
- FR_{CR} : Factor Reductor por fluencia.
- FR_{CBD}: Factor Reductor por degradación química y biológica.
- FR_{SM}: Factor Reductor costuras / uniones (si procede).
- T_{allow} Resistencia de diseño.
- T_{ult}: Resistencia test.

versos vertederos y sostenibilidad

FACTORES REDUCTORES

Geotextiles y geomallas para separación y refuerzo.

$$T_{allow} = T_{ult}\left[\frac{1}{RF_{ID} \times RF_{CR} \times RF_{CBD} \times RF_{SM}}\right] \quad \textit{(EQ 1)}$$

Area	Range of Reduction Factors		
	Installation Damage	Creep*	Chemical/Biological Degradation**
Separation	1.1 to 2.5	1.5 to 2.5	1.0 to 1.5
Cushioning	1.1 to 2.0	1.2 to 1.5	1.0 to 2.0
Unpaved roads	1.1 to 2.0	1.5 to 2.5	1.0 to 1.5
Walls	1.1 to 2.0	2.0 to 4.0	1.0 to 1.5
Embankments	1.1 to 2.0	2.0 to 3.5	1.0 to 1.5
Bearing and foundations	1.1 to 2.0	2.0 to 4.0	1.0 to 1.5
Slope stabilization	1.1 to 1.5	2.0 to 3.0	1.0 to 1.5
Pavement overlays	1.1 to 1.5	1.0 to 2.0	1.0 to 1.5
Railroads	1.5 to 3.0	1.0 to 1.5	1.5 to 2.0
Flexible forms	1.1 to 1.5	1.5 to 3.0	1.0 to 1.5
Silt fences	1.1 to 1.5	1.5 to 2.5	1.0 to 1.5

FACTORES REDUCTORES

Geotextiles para filtración y drenaje.

$$q_{allow} = q_{ult}\left[\frac{1}{RF_{SCB} \times RF_{CR} \times RF_{IN} \times RF_{CC} \times RF_{BC}}\right] \qquad \textit{(EQ 2)}$$

- FR_{SCB} :	Factor Reductor por colmatación y cegamiento.
- FR_{CR}:	Factor Reductor por efecto de la fluencia.
- FR_{IN} :	Factor Reductor debido a intrusion de partículas circundantes.
- FR_{CC}:	Factor Reductor por colmatación o precipitación química.
- FR_{BC}:	Factor Reductor por colmatación de elementos biológicos.
- q_{allow}	Capacidad hidráulica de diseño.
- q_{ult}:	Test transmisividad.

FACTORES REDUCTORES

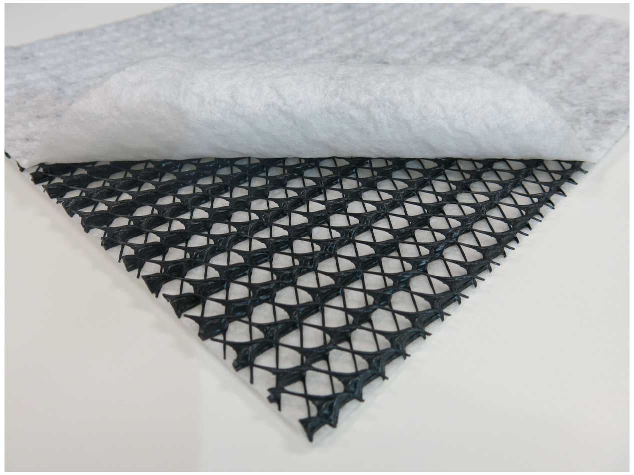
Geotextiles para filtración y drenaje.

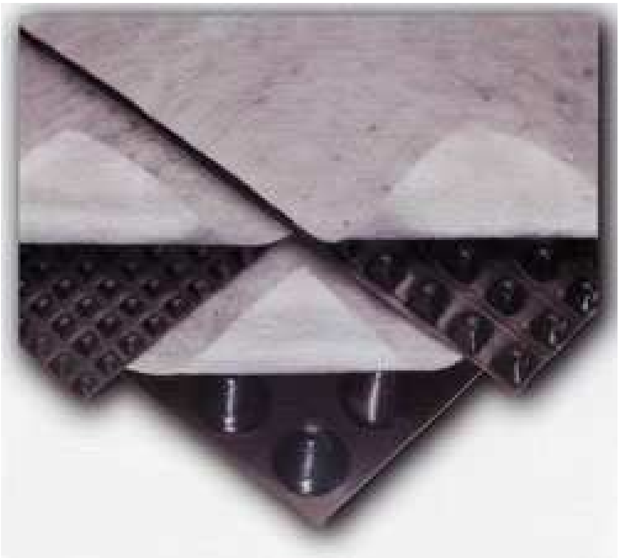
$$q_{allow} = q_{ult}\left[\frac{1}{RF_{SCB} \times RF_{CR} \times RF_{IN} \times RF_{CC} \times RF_{BC}}\right]$$

(EQ 2)

Application	Range of Reduction Factors				
	Soil Clogging and Blinding*	Creep Reduction of Voids	Intrusion in Voids	Chemical Clogging**	Biological Clogging***
Retaining wall filters	2.0 to 4.0	1.5 to 2.0	1.0 to 1.2	1.0 to 1.2	1.0 to 1.3
Underdrain filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.2 to 1.5	2.0 to 4.0***
Erosion control filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.0 to 1.2	2.0 to 4.0
Landfill filters	2.0 to 10	1.5 to 2.0	1.0 to 1.2	1.2 to 1.5	2.0 to 5.0***
Gravity drainage	2.0 to 4.0	2.0 to 3.0	1.0 to 1.2	1.2 to 1.5	1.2 to 1.5
Pressure drainage	2.0 to 3.0	2.0 to 3.0	1.0 to 1.2	1.1 to 1.3	1.1 to 1.3

FACTORES REDUCTORES





versos
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FACTORES REDUCTORES

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FAX (610) 522-8441

GRI GEI GII GSI GAI GCI

Original: April 17, 2001
Rev. 1: January 9, 2013-Editorial

GRI Standard GC8[*]

Standard Guide for

Determination of the Allowable Flow Rate of a Drainage Geocomposite

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or other specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

GRI Standard GC8

1. Scope

1.1 This guide presents a methodology for determining the allowable flow rate of a candidate drainage geocomposite. The resulting value can be used directly in a hydraulics-related design to arrive at a site-specific factor of safety.

1.2 The procedure is to first determine the candidate drainage composite's flow rate for 100-hours under site-specific conditions, and then modify this value by means of creep reduction and clogging reduction factors.

1.3 For aggressive liquids, a "go-no go" chemical resistance procedure is suggested. This is a product-specific verification test for both drainage core and geotextile covering.

1.4 The type of drainage geocomposites under consideration necessarily consists of a drainage core whose purpose it is to convey liquid within its manufactured plane. The drainage core can be a geonet, 3-D mesh, built-up columns, single or double cuspations, etc.

1.5 The drainage core usually consists of a geotextile on its upper and/or lower surface. In some cases, the drainage core is used by itself. The guide addresses all of these variations.

1.6 The guide is also applicable to thick nonwoven geotextiles when they are utilized for their drainage capability.

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

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GC8 - 1 of 11 Rev. 1: 1/9/13

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GRI GEI GII GSI GAI GCI

GSI White Paper #4
Reduction Factors (RFs) Used in Geosynthetic Design

GSI

Part I - Separation and Reinforcement Applications Using Geotextiles and Geogrids

Part II - Filtration and Drainage Applications Using Geotextiles

Part III - Drainage Applications Using Geonets, Geocomposites and Geospacers

by

Robert M. Koerner, Ph.D., P.E., NAE
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February 3, 2005
Revision #1, March 1, 2007

ISO

ISO/TC XXX Business Plan
Date: 02/11/2016
Version: Draft #X
Page: 1

ISO/TC 221 Business Plan template
Drafting Instructions – Introductory Information

Main objective of a TC Business Plan
The main objective of a Business Plan (BP) of a technical committee is to provide a concise and up-to-date overview in a user-friendly format for interested stakeholders from within and outside the committee of important business, technological, environmental and social trends in the field addressed by the work of the ISO committee. The BP shall provide an analysis of these trends as well as an explanation of the linkages between them and the priority areas in the standards development work of the committee.

The BP of a TC covers the activities of any subcommittees under the TC. Each active TC is required to prepare and maintain its own BP.

The types of stakeholders of a committee addressed by a BP are

- the management layer of organizations and companies making a contribution to standardization
- standards developers and standards developing organizations
- regulators
- users of standards
- the interested public.

ISO 221

The BP contains information which needs to be keyed into this BP template as indicated in the relevant **Drafting Instructions**. Other information (e.g. regarding the work programme and project target dates, the list of published standards, the committee structure etc.) is included dynamically via hyperlinks from the BP template to committee-specific information available from ISO's main website *ISO Online*. The target dates of the following project stages will be accessible:

- Technical enquiry (DIS) [stage 40.00]
- Approval (FDIS) [stage 50.00]
- Publication [stage 60.60]

To ensure that the information accessible through the BPs is current and therefore reliable, it is of utmost importance that the ISO committees provide up-to-date information to the ISO Central Secretariat on their work programme, the target dates of their projects and the structure of the committees.

Committees can include in their BP in addition to the hyperlinks pointing to sections on *ISO Online* hyperlinks to own databases with more detailed project information.

BPs of newly established TCs
Newly established technical committees are required to prepare a BP within 18 months after their provisional establishment, in parallel with their standards development work. The BP of a new TC will be reviewed and approved by the Technical Management Board (TMB).

Maintenance of existing BPs
The BP of a technical committee shall be reviewed by the TC at each plenary meeting and preferably once per year. The review may result in the reconfirmation or the revision of a BP. An approval is not required by the TMB.

versos
vertederos y sostenibilidad

FACTORES REDUCTORES

$$q_{Largo-plazo} = \frac{q_{test}}{FR_{in} \cdot FR_{cc} \cdot FR_{bc} \cdot FR_{cr}}$$

- FR_{in} : Factor Reductor debido a cargas durante instalación, deformación elástica y la intrusión del geotextil en la georred.
- FR_{cc}: Factor Reductor por colmatación química y/o precipitación de elementos químicos en el núcleo drenante.
- FR_{bc}: Factor Reductor por colmatación de elementos biológicos en el núcleo drenante.
- FR_{cr}: Factor Reductor por efecto de la fluencia.

- $q_{Largo-plazo}$: Capacidad hidráulica a largo plazo (100 años).

- q_{test}: Test transmisividad (UNE EN ISO 12958).

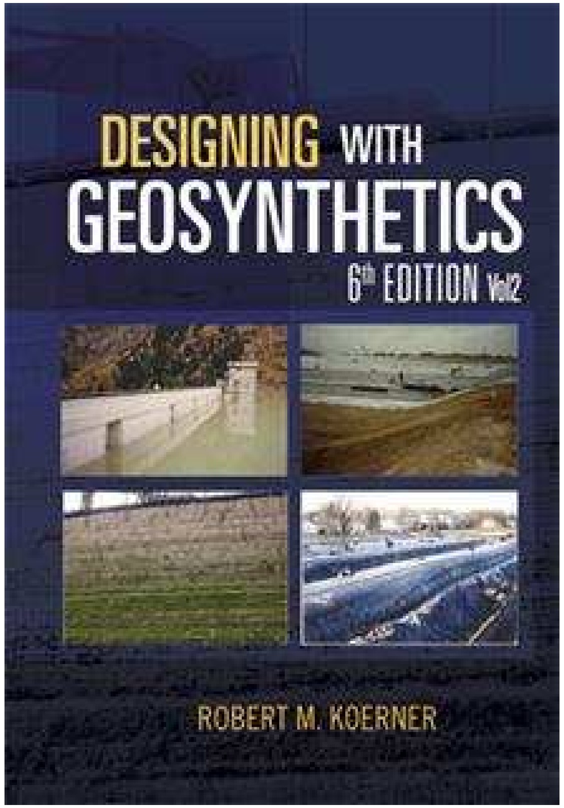
versos vertederos y sostenibilidad

FACTORES REDUCTORES

$$q_{Largo-plazo} = \frac{q_{test}}{RF_{in} \cdot RF_{cc} \cdot RF_{bc} \cdot RF_{cr}}$$

Factores Reductores recomendados:

Aplicación	FRin	FRcc	FRbc
Drenaje agua infiltrada para sellado de vertederos.	1,3 – 1,5	1,0 – 1,2	1,5 – 2,0
Drenaje secundario para lixiviados (vertederos).	1,5 – 2,0	1,5 – 2,0	1,5 – 2,0
Drenaje principal para lixiviados (vertederos).	1,5 – 2,0	1,5 – 2,0	1,5 – 2,0



Koerner (2012)

"Designing with Geosynthetics" 6th Edition, Prentice Hall, New Jersey.

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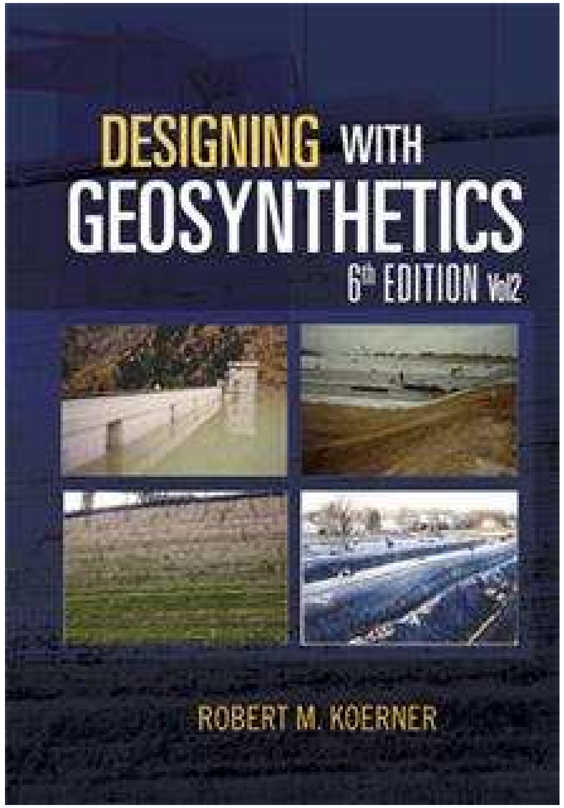
FACTORES REDUCTORES

$$q_{Largo-plazo} = \frac{q_{test}}{RF_{in} \cdot RF_{cc} \cdot RF_{bc} \cdot RF_{cr}}$$

Factores Reductores recomendados:

Aplicación	RFcr*
Drenaje agua infiltrada para sellado de vertederos.	1,1 – 1,4
Drenaje secundario para lixiviados (vertederos).	1,4 – 2,0
Drenaje principal para lixiviados (vertederos).	1,4 – 2,0

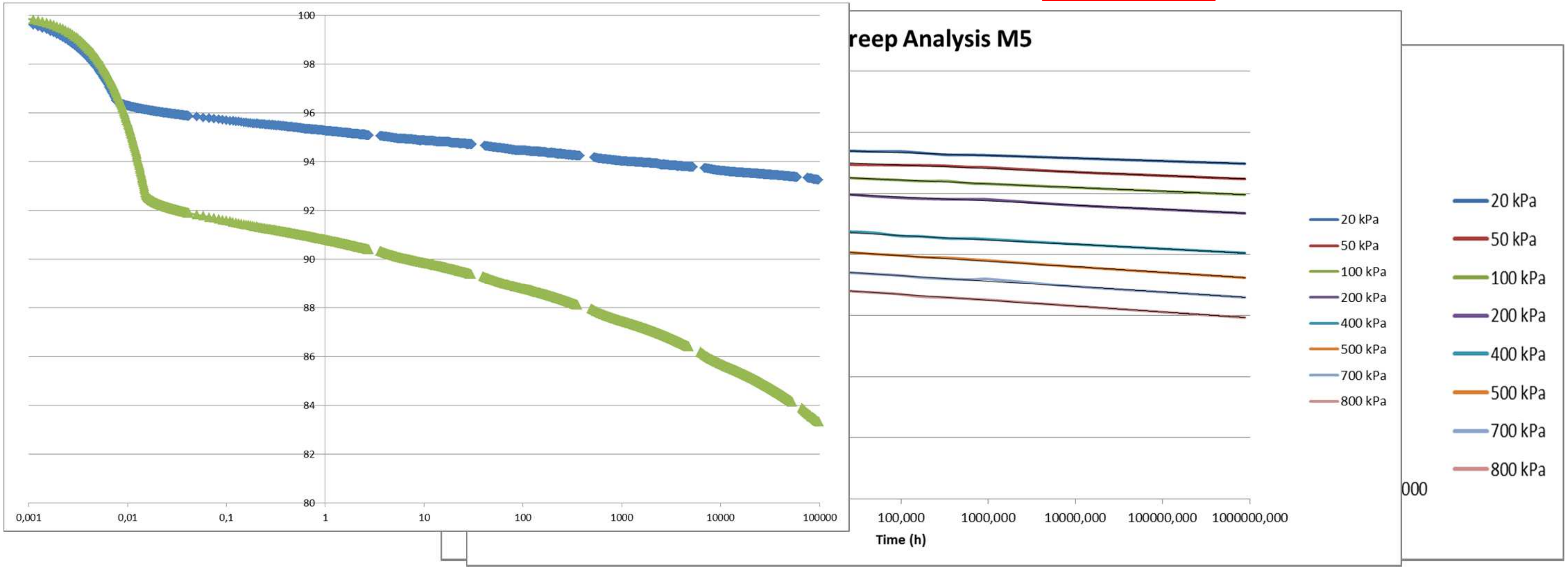


Koerner (2012) “Designing with Geosynthetics” 6th Edition, Prentice Hall, New Jersey.

versos vertederos y sostenibilidad

FACTORES REDUCTORES

$$q_{Largo-plazo} = \frac{q_{test}}{RF_{in} \cdot RF_{cc} \cdot RF_{bc} \cdot RF_{cr}}$$



$$RF_{cr} = 1{,}1 - 1{,}4$$

→ ***Georredes***

Accelerated Compressive Creep via SIM (ASTM D7361)

FACTORES REDUCTORES

Triplanar alta capacidad de flujo

Pressure (kPa)	$t_{original}$ (cm)	100hrs reduction	t_{co} (cm)	1.000.000hrs reduction	t_{cr} (cm)	m (g/cm^2)	r (g/cm^3)		$n_{original}$	RFcr
20	0,56	97,00%	0,543	95,68%	0,536	0,048	0,95		0,91	1,05
50	0,56	94,50%	0,529	92,85%	0,520	0,048	0,95		0,91	1,06
100	0,56	91,80%	0,514	89,83%	0,503	0,048	0,95		0,91	1,08

$$RF_{CR} = \left[\frac{(t_{CO}/t_{original}) - (1 - n_{original})}{(t_{CR}/t_{original}) - (1 - n_{original})}\right]^3$$

where

RF_{CR} = reduction factor for creep
$t_{original}$ = original thickness (m)
t_{CO} = thickness at 100-hours (m)
t_{CR} = thickness at >>100-hours, e.g., at 10,000 hours (m)
$n_{original}$ = original porosity (see Equation 7)

$$n_{original} = 1 - \frac{\mu}{\rho t_{original}}$$

where

μ = mass per unit area (kg/m^2)
ρ = density of the formulation (kg/m^3)

Monofilamento altas prestaciones

Pressure (kPa)	$t_{original}$ (cm)	100hrs reduction	t_{co} (cm)	1.000.000hrs reduction	t_{cr} (cm)	m (g/cm^2)	r (g/cm^3)		$n_{original}$	RFcr
20	0,65	93,40%	0,607	90,72%	0,590	0,06	0,95		0,90	1,10
50	0,65	88,80%	0,577	80,00%	0,520	0,06	0,95		0,90	1,42
100	0,65	72,40%	0,471	48,93%	0,318	0,06	0,95		0,90	4,09

Accelerated Compressive Creep via SIM (ASTM D7361)
Laboratorio TRI Austin TX.

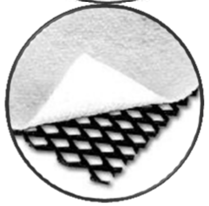
FACTORES REDUCTORES

$$FR_{total} = RF_{in} \cdot RF_{cc} \cdot RF_{bc} \cdot RF_{cr}$$

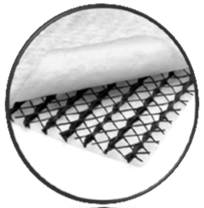
Nueva celda de vertedero:

>100 kPa

$FR_{total} = (1,5 - 2,0) \cdot (1,5 - 2,0) \cdot (1,5 - 2,0) \cdot (1,03) = \mathbf{3,47 - 8,24}$



$FR_{total} = (1,5 - 2,0) \cdot (1,5 - 2,0) \cdot (1,5 - 2,0) \cdot (1,08) = \mathbf{3,64 - 8,64}$



$FR_{total} = (1,5 - 2,0) \cdot (1,5 - 2,0) \cdot (1,5 - 2,0) \cdot (1,08) = \mathbf{3,64 - 8,64}$

$FR_{total} = (1,5 - 2,0) \cdot (1,5 - 2,0) \cdot (1,5 - 2,0) \cdot (>4,09) = \mathbf{13,80 - 32,72}$

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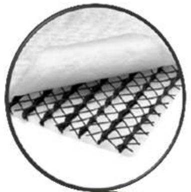
FACTORES REDUCTORES

$$FR_{total} = RF_{in} \cdot RF_{cc} \cdot RF_{bc} \cdot RF_{cr}$$

Sellado de vertedero:

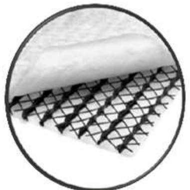
50 kPa



$FR_{total} = (1,3 – 1,5) \cdot (1,0 - 1,2) \cdot (1,5 - 2,0) \cdot (1,06) =$ **2,06 - 3,82**

$FR_{total} = (1,3 – 1,5) \cdot (1,0 - 1,2) \cdot (1,5 - 2,0) \cdot (1,42) =$ **2,76 - 5.11**

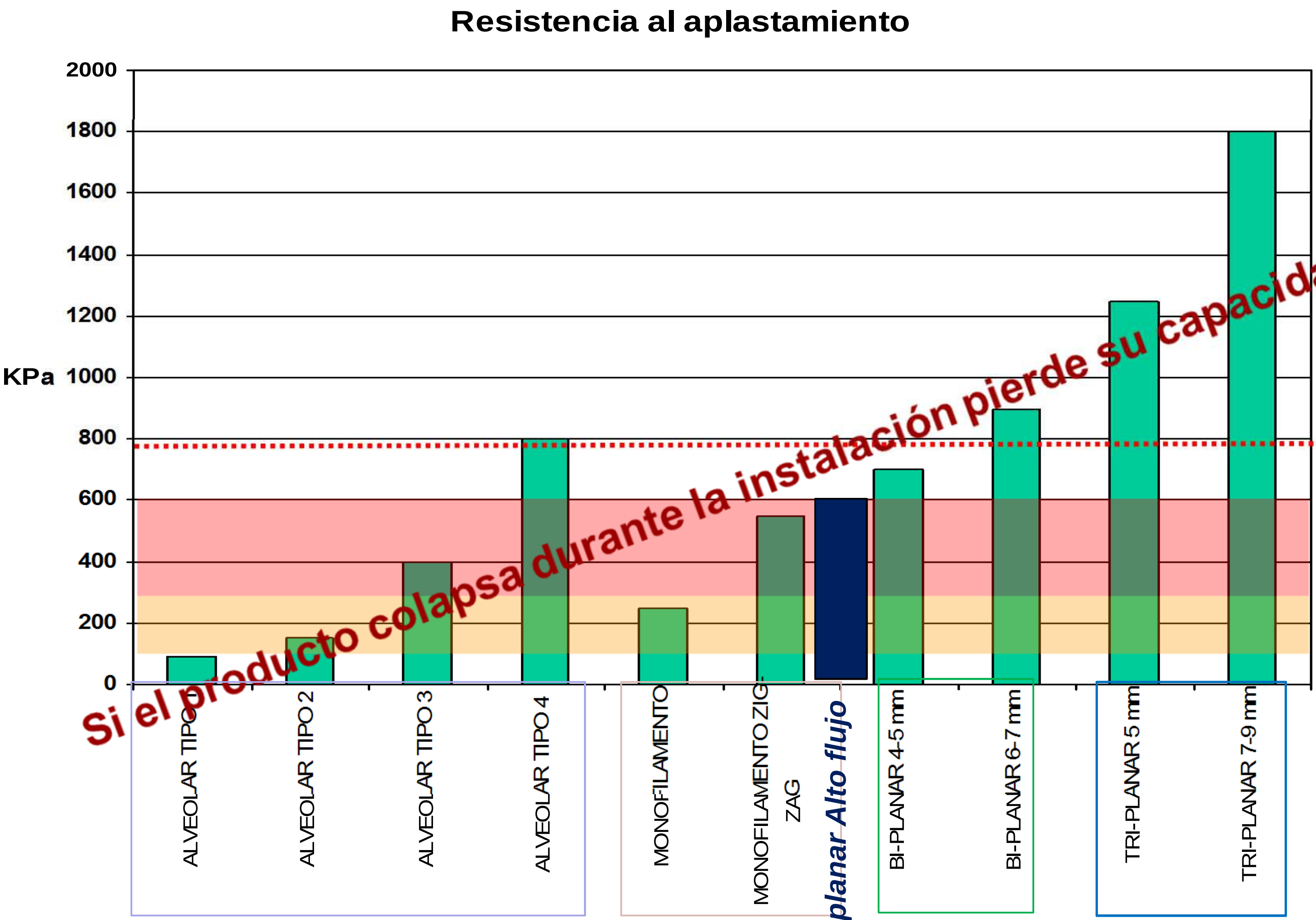
100 kPa



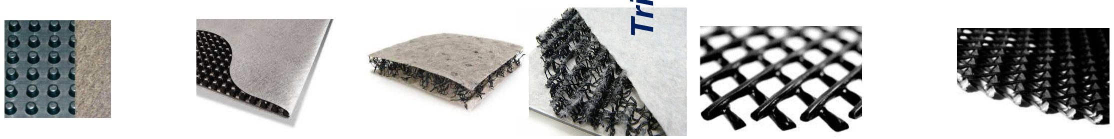
$FR_{total} = (1,3 – 1,5) \cdot (1,0 - 1,2) \cdot (1,5 - 2,0) \cdot (1,08) =$ **2,10 - 3,88**

$FR_{total} = (1,3 – 1,5) \cdot (1,0 - 1,2) \cdot (1,5 - 2,0) \cdot (4,09) =$ **7,97 - 14.72**

INSTALACIÓN - CARGAS



Si el producto colapsa durante la instalación pierde su capacidad drenante.



Rueda camión

(500 – 800 KPa)

Rango compactación tierras (posición horizont

(500 – 600 KPa)

Rango compactación tierras (posición vertical)

(100 – 250 KPa)

versos vertederos y sostenibilidad

Bilbao
9-10 Noviembre 2016

intermas

versos
vertederos y sostenibilidad

Jorge Gutiérrez y Oihane Ansa

intermas group