Geocomposites for Drainage
Experiences and Applications

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- Geotextile (1 or 2 sides)
- Drainage Core (4-20mm)
- Waterproofing membrane (optional)
Polypropylene mat with cuspated profile
Polypropylene mat with waved profile (long. channel shape)
High Density Polyethylene Net
- Drainage
- Separation
- Resistance to puncture
- Waterproofing
ADVANTAGES

- Plastic core
- Geotextile

Distributes pressure

- Protects waterproofing from damage when trench is backfilled
- Retains its drainage capacity even under high earth pressure
- Removes excess water from the soil
- Prevents the collector drain from silting up with fine soil particles

Transports water to the collector drain
TRADITIONAL DRAINAGE LAYERS

outer vegetation cover layer: thickness > 1.0 m.

drainage layer: thickness > 0.50 m;

1x10^-8 m/sec permeability barrier layer: thickness > 0.50 m;

biogas drainage layer thickness > 0.50 m;

levelling layer;

body of waste;
Geosynthetics save approx 1.5 m$^3$ volume per m$^2$ surface
GCDs as opposed to granular layers have the following advantages:

- Need less material with required characteristics (cost effective);
- High environmental friendliness (low CO$_2$ emission);
- Can provide geotechnical stability on sloped surfaces (engineered);
- In case of landfills, increase waste capacity (benefit to the municipality).
Technical comparison between gravel layers and GCDs

\[ Q = k \ A \ i \]

- \( K \) is permeability of the granular layer
- \( A \) is area per m width of the draining layer 0.5 m thick x 1 m width = 0.5 m²
- \( i \) is the gradient of the draining layer

\[ i = \sin \beta \]
The permeability of the granular layer is not defined. We estimate it in the range of

\[ 5 \times 10^{-4} < k < 10^{-2} \text{ l/m.sec} \] (typically \( k = 10^{-3} \text{ l/m.sec} \)).

\[ Q_{\text{GCD}} \geq Q_{\text{gravel}} = K \cdot e \cdot i \ (\text{Darcy}) \]

Flow rate (l/m.sec) for a 50 cm gravel layer, according to different K values

<table>
<thead>
<tr>
<th>( K ) (l/m.sec)</th>
<th>( 1 \times 10^{-3} )</th>
<th>( 5 \times 10^{-3} )</th>
<th>( 1 \times 10^{-2} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 20^\circ ) (i=0.34)</td>
<td>0.17</td>
<td>0.85</td>
<td>1.70</td>
</tr>
<tr>
<td>( 25^\circ ) (i=0.42)</td>
<td>0.21</td>
<td>1.06</td>
<td>2.11</td>
</tr>
<tr>
<td>( 30^\circ ) (i=0.50)</td>
<td>0.25</td>
<td>1.25</td>
<td>2.50</td>
</tr>
<tr>
<td>( 35^\circ ) (i=0.57)</td>
<td>0.28</td>
<td>1.43</td>
<td>2.86</td>
</tr>
</tbody>
</table>
The permeability is not constant and depends on

FLOW RATE / GRADIENT

✓ Low gradients: Flow “less” turbulent

✓ High gradients: Flow “more” turbulent.

With the same gravel, the permeability at gradient i=0.1 is higher than permeability at gradient i=0.3.

Darcy Law is not applicable as it is, to obtain flow rates in gravel layers, as the flow is not laminar but turbulent.

For granular layers correction factors are required
GRANULAR LAYER
In this analysis the selected granular layer is assumed as sandy gravel material, with a permeability of $k = 5 \times 10^{-3}$ [m/sec], and a hydraulic gradient of 3% (i=0.03).

The hydraulic capacity of this granular layer, using the Darcy Law equation, may be obtained as

$$Q = k A i = (5 \times 10^{-3}) \times (0.5 \times 1) \times 0.03 = 0.75 \times 10^{-4} \text{ [m}^3/\text{sec]}$$

GCD
Assuming 8 m as a representative height for an embankment, and 20 kPa as the fill unit weight, and assuming a safety factor of 2.5 to account for uncertainties and variability of life loads, the vertical stress considered to act on the geocomposite will be computed as follows:

$$\sigma_h = (20 \times 8) \times 2.5 = 160 \times 2.5 = 400 \text{ kPa}$$
Reduction of the Flow Capacity of a drainage geocomposite
(in blue suggested values in Bibliography for Surface Water drains in cappings)

1) **Clogging** or blinding of the core due to:
   - chemical precipitation (1.0 – 1.2, according Koerner)
   - biological intrusion (1.5 - 3.5, according Koerner)

2) Long term **compressive creep** deformation of the core of the geocomposite due to the constant load applied.
   (it depends of the configuration of the product, raw material, gradient & pressure ; for high quality products it ranges from 1.1 – 1.5)

3) **Intrusion of the geotextiles into the core** when loaded - reduction of the effective cross draining section – (it depends of the core, pressure, gradient and stiffness of the geotextile)
   - short -term intrusion (Transmissivity Test on Laboratory)
   - ✓ 1 when is run hard/soft or soft/soft conditions
   - ✓ 1.3 – 2.0 at least, when the tests are run in hard/hard conditions
   - ❑ long-term intrusion of the geotextile due his creep
   - ✓ 1.3 – 1.6 according
From the nominal $Q_{STreq}$ short term value, the $Q_{LTreq}$ long term design value may be calculated under serviceability conditions, by means of adequate reduction factors, in accordance with:

$$Q_{LTreq} = Q_{STreq} \cdot RF_{in} \cdot RF_{cr} \cdot RF_{bc} \cdot RF_{cc}$$

Partial Reduction Factors:
- $RF_{in}=1.10$ Reduction factor for elastic deformation or geotextile intrusion;
- $RF_{cr}=1.00$ Reduction factor for creep deformation over time. Already considered in the load applied by the embankment;
- $RF_{bc}=1.20$ Reduction factor for intrusion of biological material;
- $RF_{cc}=1.10$ Reduction factor by chemical clogging of the draining network.

The overall reduction factor will be $RF_{tot}=1.10 \times 1.00 \times 1.20 \times 1.10 = 1.45$
Assuming that the required discharge was:
$Q_{STreq} = Q = 0.75 \times 10^{-4}$ $[m^3/s]$, we have

$$Q_{LTreq} = Q_{STreq} \cdot 1.45 = 0.11 \times 10^{-3} [m^3/s]$$
Parameters affecting long term performance of GCDs

- **Long term properties of the core** (crash test and compressive creep);
- **Long term mechanical properties of the geofilter** in relation to effects on the core (depending the soil in contact and loads applied).
- **Method for evaluating the flow capacity** (hard or soft contact).

The soft contact is a more realistic simulation of the soil contact, as it measures the partial (short term) penetration of the geotextile into the core.

The hard contact completely does not take into account this factor and provides higher results for the drainage performance. This difference can be relevant.

In landfill (capping) applications the real working condition is a soft/hard contact to simulate the membrane on one side and the soil on the other one. The hard/hard contact is more suitable to the drainage composites placed between two geomembranes.
### TECHNICAL COMPARISON

**Drainage Flow Capacity (l/m·s) ISO 12958 (Test run in SKZ Laboratory)**

<table>
<thead>
<tr>
<th>Config.</th>
<th>120 g/m² gtx + HDPE geonet + 120 g/m² / Thickness at 2 kPa: 5.45 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact</td>
<td>hard/hard</td>
</tr>
<tr>
<td>Gradient</td>
<td>0.1 0.3 1</td>
</tr>
</tbody>
</table>

| σ = 20 kPa capping | 0.241 0.520 1.026 | 0.116 0.287 0.653 | - - 0.505 |
| RF = 2.1 RF = 1.8 RF = 1.6 |

| σ = 100 kPa | 0.221 0.462 0.909 | 0.086 0.204 0.453 | - - - |
| Aprox. Slope New Landfill hr = 20 m; ϕ' r = 25°; δr = 12 kN/m³ |
| RF = 2.6 RF = 2.3 RF = 2.0 |

| σ = 200 kPa | 0.198 0.400 0.839 | 0.045 0.094 0.259 | - - - |
| Aprox. Slope New Landfill hr = 40 m; ϕ' r = 25°; δr = 12 kN/m³ |
| RF = 4.4 RF = 4.3 RF = 3.2 |
## Comparative analysis between a conventional drainage and the use of MACDRAIN behind a wall:

### MacDrain®

<table>
<thead>
<tr>
<th>Materiales</th>
<th>Cant. para 1m.l.</th>
<th>Costo unitario US$</th>
<th>Costo Total US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geocompuesto Macdrain® 2L</td>
<td>10.00 m²</td>
<td>5.65 /m²</td>
<td>56.50 /ml</td>
</tr>
<tr>
<td>Grava n. 1</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Geotextil no-tejido 300g/m²</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Tubo-drén Ø 100 mm</td>
<td>1.00 m</td>
<td>3.25 /ml</td>
<td>3.25 /ml</td>
</tr>
<tr>
<td>Maestro (+ enc. sociales)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Obrero (+ enc. sociales)</td>
<td>1.60 h</td>
<td>2.25 /h</td>
<td>3.60 /ml</td>
</tr>
<tr>
<td>Costo total por metro lineal</td>
<td></td>
<td></td>
<td>63.35 /ml</td>
</tr>
<tr>
<td>Costo total+B.D.I. (30 %)</td>
<td></td>
<td></td>
<td>86.35 /ml</td>
</tr>
</tbody>
</table>

### Drenaje convencional

<table>
<thead>
<tr>
<th>Materiales</th>
<th>Cant. para 1m.l.</th>
<th>Costo unitario US$</th>
<th>Costo Total US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grava n. 1</td>
<td>3.30 m³</td>
<td>14.80 /m³</td>
<td>48.84 /ml</td>
</tr>
<tr>
<td>Geotextil no-tejido 300g/m²</td>
<td>21.00 m²</td>
<td>1.36 /m²</td>
<td>28.56 /ml</td>
</tr>
<tr>
<td>Tubo-drén Ø 100 mm</td>
<td>1.00 m</td>
<td>3.25 /ml</td>
<td>3.25 /ml</td>
</tr>
<tr>
<td>Tabla 1” x 12” (5 reapr.)</td>
<td>0.30 m²</td>
<td>1.80 /m²</td>
<td>0.54 /ml</td>
</tr>
<tr>
<td>Maestro (+ enc. sociales)</td>
<td>1.43 h</td>
<td>4.50 /h</td>
<td>6.43 /ml</td>
</tr>
<tr>
<td>Obrero (+ enc. sociales)</td>
<td>4.39 h</td>
<td>2.25 /h</td>
<td>9.88 /ml</td>
</tr>
<tr>
<td>Costo total por metro lineal</td>
<td></td>
<td></td>
<td>97.50 /ml</td>
</tr>
<tr>
<td>Costo total+B.D.I. (30 %)</td>
<td></td>
<td></td>
<td>126.75 /ml</td>
</tr>
</tbody>
</table>

**COST EFFECTIVENESS**

-35%
<table>
<thead>
<tr>
<th>Materiales</th>
<th>Costo unitario US$</th>
<th>Grava + geotextil</th>
<th>MacDrain® 2L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cant. para 1m²</td>
<td>Costo Total US$</td>
<td>Cant. para 1m²</td>
</tr>
<tr>
<td>Geocompuesto Macdrain® 2L</td>
<td>5.65 / m²</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Grava n°. 1</td>
<td>14.80 / m³ *</td>
<td>0.22 m³ / m</td>
<td>3.26 / ml</td>
</tr>
<tr>
<td>Geotextil no-tejido 300g/m²</td>
<td>1.36 / m² **</td>
<td>1.05 m² / m</td>
<td>1.43 / ml</td>
</tr>
<tr>
<td>Tubo-drén Ø 100 mm</td>
<td>3.25 / m</td>
<td>0.40 m / m</td>
<td>1.30 / ml</td>
</tr>
<tr>
<td>Escavación y remoción de suelo (mec.)</td>
<td>4.50 / m³</td>
<td>0.40 m³</td>
<td>1.80 / ml</td>
</tr>
<tr>
<td>Maestro (encargos sociales inclusos)</td>
<td>4.50 / m³</td>
<td>0.10 h / m</td>
<td>0.45 / ml</td>
</tr>
<tr>
<td>Obrero (Encargos sociales inclusos)</td>
<td>2.25 / m²</td>
<td>0.85 h / m</td>
<td>1.91 / ml</td>
</tr>
<tr>
<td>Costo total por metro lineal</td>
<td>10.15 / ml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costo total+B.D.I. (30 %)</td>
<td>13.20 / ml</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparative analysis between a conventional drainage and the use of a MacDrain in a flat horizontal application:

-21%
### Comparative analysis between a conventional drainage and the use of a MacDrain composite in a draining trench:

<table>
<thead>
<tr>
<th>Sistema tradicional Materiales</th>
<th>Cant. p/ 1 m.l.</th>
<th>Costo unit. US$</th>
<th>Costo total US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grava n. 1</td>
<td>0.33 m³</td>
<td>14.80 /m³</td>
<td>4.88 / m</td>
</tr>
<tr>
<td>Geotextil no tejido 300g/m²</td>
<td>2.73 m²</td>
<td>1.36 /m²</td>
<td>3.71 / m</td>
</tr>
<tr>
<td>Tubo-drén Ø 100 mm</td>
<td>1.00 m</td>
<td>3.25 /m</td>
<td>3.25 / m</td>
</tr>
<tr>
<td>M. de obra (+ enc. sociales)</td>
<td>0.15 h</td>
<td>2.29 /h</td>
<td>0.34 / m</td>
</tr>
<tr>
<td>Obrero (+ enc. sociales)</td>
<td>1.81 h</td>
<td>2.25 /h</td>
<td>4.07 / m</td>
</tr>
<tr>
<td>Costo total por metro lineal</td>
<td></td>
<td></td>
<td>16.59 / m</td>
</tr>
<tr>
<td>Costo total + B.D.I. (30%)</td>
<td></td>
<td></td>
<td>21.57 / m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MacDrain® Materiales</th>
<th>Cant. p/ 1 m.l.</th>
<th>Costo unit. US$</th>
<th>Costo total US$/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geocompuesto MacDrain® 2L TD</td>
<td>1.00 m³</td>
<td>5.65 /m³</td>
<td>5.65</td>
</tr>
<tr>
<td>Tubo-drén Ø 100 mm</td>
<td>1.00 m</td>
<td>3.25 /m</td>
<td>3.25</td>
</tr>
<tr>
<td>Ajudante geral(+ enc. sociales)</td>
<td>1.76 h</td>
<td>2.25 /h</td>
<td>3.96</td>
</tr>
<tr>
<td>Costo total por metro lineal</td>
<td></td>
<td></td>
<td>12.86</td>
</tr>
<tr>
<td>Costo total + B.D.I. (30%)</td>
<td></td>
<td></td>
<td>16.72</td>
</tr>
</tbody>
</table>
Installation time and labor is less than with conventional granular layers
No waste due to “the overlapping flap”
• Drainage blankets are light and easy to handle;

• In vertical applications workers handle the roll and keep it in place while fixing;

• No backfilling required (gravel, sand);

• Easy overlapping when joining rolls;

• No skilled labor or special tools required. Cutters, nails and just a hammer.
• **LANDFILLS**
  (1-Capping - soil veneer, 2-LCS)

• **VERTICAL, SEMI-VERTICAL LAYERS**
  (1-RCC walls, 2-MSE walls, 3-Tunnels, 4-Others)

• **HORIZONTAL LAYERS**
  (1-Embankments, 2-Roofing, 3-Sporting fields)
Gas ventilation & LC in landfills
Prot. layer against membrane puncture
Gas ventilation & LC in landfills
Prot. layer against membrane puncture
Drainage of RCC walls

A 20 mm thickness GCD is equivalent to a 200 mm traditional vertical drain with high permeability confined between two geotextiles filters.
Drainage of RCC walls
Drainage of RCC walls
Drainage of RCC walls
Drainage of RCC walls
Drainage of MSE walls

Soil reinforced Steep slope

Drainage composite
Drainage of MSE walls
Drainage of MSE walls
Drainage of MSE walls
Drainage in tunnel applications

Tunnel

Drainage composite

pipe
Drainage in tunnel applications
Drainage in tunnel applications

- Artificial tunnel
- MacDrain
- Gravel filling
- Drainage composite
Drainage in tunnel applications
Drainage in road applications

Concrete

Drainage composite with Polyethylene membrane

Pipe

Drainage composite
Drainage in road applications
Drainage in road applications
Drainage in road applications
Drainage in road applications
Drainage geotechnical consolidation
Drainage geotechnical consolidation
Drainage geotechnical consolidation
Anticapillary & drainage layer
Anticapillary & drainage layer
Anticapillary & drainage layer
Anticapillary & drainage layer
Drainage layer in roofing applications

- Garden
- Pavimentation
- Sand bed
- MacDrain
- Concrete base
Drainage layer in roofing applications
Drainage layer in roofing applications
Drainage layer in roofing applications
Drainage of sporting fields
Drainage of sporting fields
Drainage of sporting fields

HORIZONTAL LAYERS
THANK YOU FOR YOUR ATTENTION!

Questions are welcome

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