Elements of Design of Multi-linear Drainage Geocomposites for Landfills

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Multi-linear drainage geocomposites

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

Drainage conduits:
- Perforated PP mini-pipes,
- Strip drains
- Etc.

Distance between mini-pipes
1/4 m, 1/2 m, 1 m or 2 m
(10", 20", 40" or 80")

Perforated mini-pipes
diameter 20 mm or 25 mm

Nonwoven geotextiles
Geocomposite Standardization

Multi-linear drainage geocomposite as per ASTM D4439 Standard Terminology for Geosynthetics.

Designation: D4439 – 17

Standard Terminology for Geosynthetics

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.

(a) Corrugated perforated pipe enclosures
(b) Strip drain enclosures with discrete high flow components

Fig. 1 - Drainage geocomposites (GSI photos).
Multi-linear drainage geocomposites are 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.
Specific points on installation
Specific points on installation
Specific points on installation
Specific points on installation
Specific points on installation

For gas

For water

Connection kits from manufacturers may be used to optimize the gas collection
### Specific points on installation

<table>
<thead>
<tr>
<th></th>
<th>Geonet geocomposite</th>
<th>Multi-linear drainage geocomposite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Side by side connections</strong></td>
<td>Plastic ties every 5 feet (typical)</td>
<td>No plastic ties</td>
</tr>
<tr>
<td></td>
<td>Geotextile overlapped and heat bonded</td>
<td>Geotextile overlapped and heat bonded or sewed</td>
</tr>
<tr>
<td><strong>End to end connections</strong></td>
<td>Plastic ties every foot (typical)</td>
<td>Couplers to connect tubes</td>
</tr>
<tr>
<td></td>
<td>Geotextile overlapped and heat bonded</td>
<td>Geotextile overlapped and heat bonded</td>
</tr>
</tbody>
</table>
Specific points on installation
Common applications in Landfills

Final covers:
- Rainfall water drainage on GM
- LFG collection below GM

Temporary covers:
- Fugitive gas collection

Waste mass:
- Horizontal LFG collection
- Intermediate leachate drainage

Bottom of the cell:
- Primary/Secondary leachate collection system
- Ground water suppression system
Elements of design

- Transmissivity
Elements of design

- Transmissivity
- Puncture protection
Elements of design

- Transmissivity
- Puncture protection
- Stability
Elements of design

- Transmissivity
- Puncture protection
- Stability
- Reduction factors for transmissivity
Elements of design

- Transmissivity
**Elements of design**

### Transmissivity function of the distance between drainage conduits

<table>
<thead>
<tr>
<th>Perforated Pipe D20</th>
<th>Perforated Pipe D25</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outside Diameter</strong></td>
<td>25 mm</td>
</tr>
<tr>
<td><strong>Pipe stiffness at 5% deflection</strong></td>
<td>3 000 kPa</td>
</tr>
<tr>
<td><strong>Spacing between pipes</strong></td>
<td>Up to 4 pipes per meter of width</td>
</tr>
<tr>
<td><strong>Geocomposite Transmissivity</strong></td>
<td>DRAINTUBE 606 ST0.5 D20</td>
</tr>
<tr>
<td><strong>Normal load = 480 kPa (10,000 psf)</strong></td>
<td>DRAINTUBE 606 ST1 D20</td>
</tr>
<tr>
<td><strong>Hydraulic gradient = 0.1</strong></td>
<td>DRAINTUBE 606 ST2 D20</td>
</tr>
<tr>
<td><strong>Seating time = 100 h</strong></td>
<td>DRAINTUBE 606 ST4 D20</td>
</tr>
</tbody>
</table>

1 - Transmissivity measured on a 250 mm wide specimen with one pipe in the middle of the sample in the longitudinal direction, installed as follows: sealed sand / geocomposite / geomembrane / sealed sand. The given transmissivity is obtained from a linear relationship between the number of pipes and the measured transmissivity.
Elements of design

Transmissivity function of the distance between drainage conduits

Assessment of the Effect of Specimens Dimensions on the Measured Transmissivity of Planar Tubular Drainage Geocomposites

Eric Blond, eng., M.Sc.A., CTT GROUP / SAGEOS, Canada, eblond@gcttg.com
Pascal Saunier, eng., AFITEX-TEXEL, Canada, psaunier@afitex-texel.com
Tarik Daqoune, Eng., M.Sc.A., CTT GROUP / SAGEOS, Canada, tdagoune@Gcttg.Com
Stephane Fourmont, AFITEX-TEXEL, Canada, stephane.fourmont@afitex.com
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Transmissivity function of the distance between drainage conduits
Elements of design

Transmissivity function of the distance between drainage conduits

GRI Test Method GC15

Standard Test Method for

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

10. Calculation

10.1 Calculate the flow rate per unit specimen width, , as follows:

\[ q_u = \frac{Q}{W \cdot t} \]  (1)

where:

\[ q_u = \text{flow rate per unit width, } m^3/s \cdot m [gpm/ft], \]
\[ Q = \text{measured quantity of water collected during collection time } m^3 [gal] \]
\[ t = \text{collection time, s}, \]
\[ W = \text{distance between drainage conduits of the geocomposite, } m (ft) \]

10.2 Calculate the average of the three flow rate measurements obtained at each load and gradient.

10.3 Results can be expressed as a plot of flow rate per unit width versus hydraulic gradient at various normal compressive stress.
Elements of design

- Transmissivity
- Puncture protection
Multi-linear drainage geocomposite’s geotextile layers provide puncture on the geomembrane

2 x 6 Oz/sy geotextiles
~ 12 Oz/sy geotextile puncture protection

2 x 8 Oz/sy geotextiles
~ 16 Oz/sy geotextile puncture protection

The same method should be considered for both multi-linear and geonet geocomposites (see ref. from Koerner)
Elements of design

- Transmissivity
- Puncture protection
- Stability
Elements of design

Stability

Interface multi-linear geocomposite / Sand

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

No peel adhesion issue
Elements of design

- Transmissivity
- Puncture protection
- Stability
- Reduction factors for transmissivity
Elements of design

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

\[
Q_{allow} = \frac{Q_{ult}}{RF_{in} \cdot RF_{cr} \cdot RF_{cc} \cdot RF_{bc}}
\]

- \(q_{allow}\) = 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.
Elements of design

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Elements of design

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).
Reduction factor for creep and geotextile intrusion
Function of the shape of the drainage core

For tubular drainage conduits

Arching effect when confined in soil
Elements of design

Reduction factor for creep and geotextile intrusion
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Arching effect when confined in soil
Elements of design

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
Elements of design

Reduction factor for creep and geotextile intrusion
Function of the shape of the drainage core

For tubular drainage conduits

Arching effect when confined in soil

Published related reference

Assessment of the Resistance of Drain Tubes planar drainage geocomposites to high compressive loads
Eric Blond (SAGEOS) and Pascal Saunier (AFITEX-Texel), *ICG 2010*
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Designation: D7931 – 17

Standard Guide for Specifying Drainage Geocomposites¹

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.
Elements of design

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Reduction Factors for Biological and Chemical clogging

3 years test (2013-2016) with Koerner at Fairless Hills Landfill (PA)
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Reduction Factors for Biological and Chemical clogging
Elements of design

Reduction Factors for Biological and Chemical clogging

Tubular geocomposite: NWNP w TUBE

Single sided biaxial geonet: NWNP w GN
"it is important to note that the needle punched nonwoven geotextile performed the best when placed over the tubular drainage composite. It is well designed with respect to the concrete sand’s gradation to avoid piping and is open enough to resist long term clogging. This is demonstrated by its ability to remain free flowing with leachate as a permeant for over three years of testing."
“Because tubular drainage geocomposites require smaller reduction factor values, especially when anti-biological geotextile components are used, and because the overall transmissivity of tubular drainage geocomposites does not decrease with normal load, tubular drainage geocomposites are a valid alternative to geonet drainage composites in landfill leachate collection systems.”

Published related reference

Biological Clogging Resistance of Tubular Drainage Geocomposites in Leachate Collection Layers
E. Blond (SAGEOS), S. Fourmont and P. Saunier (AFITEX-Texel), Geosynthetics 2013

Evaluating Tubular drainage geocomposites for use in Lined Leachate Collection Systems,
E. Steinhauser (Sanborn, Head & Ass.) and S. Fourmont (AFITEX-Texel), Geo-Environmental Engineering 2015

Determining the Long-Term Transmissivity of Selected Drainage Geocomposites to Landfill Leachate, G. Koerner (Geosynthetic Institute) and S. Fourmont (AFITEX-Texel), Geo-Frontiers 2017
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<table>
<thead>
<tr>
<th>Applications</th>
<th>Type of Geocomposite</th>
<th>Reduction Factors</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>$RF_{CR}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$RF_{CC}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$RF_{BC}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$RF_{GI}$</td>
</tr>
<tr>
<td>Landfill Leachate Collection</td>
<td>Geonet</td>
<td>1.4 to 2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 to 2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1 to 1.3</td>
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<tr>
<td></td>
<td></td>
<td>1.5 to 2.0</td>
</tr>
<tr>
<td>Retaining Walls</td>
<td>Geonet</td>
<td>1.2 to 1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1 to 1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0 to 1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3 to 1.5</td>
</tr>
<tr>
<td>Sport Fields</td>
<td>Geonet</td>
<td>1.0 to 1.5</td>
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<tr>
<td></td>
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<td>1.0 to 1.2</td>
</tr>
<tr>
<td></td>
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<td>1.1 to 1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0 to 1.2</td>
</tr>
<tr>
<td>Landfill Covers</td>
<td>Geonet</td>
<td>1.1 to 1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0 to 1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 to 3.5</td>
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<tr>
<td></td>
<td></td>
<td>1.3 to 1.5</td>
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</tbody>
</table>


## Elements of design

<table>
<thead>
<tr>
<th>Applications</th>
<th>Type of Geocomposite</th>
<th>Reduction Factors</th>
<th>ΣRFs</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill Leachate Collection</td>
<td>Geonet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tubular</td>
<td>2.6</td>
<td>10.4</td>
<td>(4 times more long term drainage capacity)</td>
</tr>
<tr>
<td>Retaining Walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sport Fields</td>
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</tr>
<tr>
<td>Landfill Covers</td>
<td>Geonet</td>
<td></td>
<td>8.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tubular</td>
<td>4.2</td>
<td>12.8</td>
<td>(2 times more long term drainage capacity)</td>
</tr>
</tbody>
</table>

(6) GRI Standard – GC8, 2013. Determination of the Allowable Flow Rate of a Drainage Geocomposite, Rev. 1, Geosynthetic Institute, Folsom, PA.

Multi-linear drainage geocomposites:

- Available on the market for 30 years
- GRI and ASTM standards
- Solid technical background
- Function of the type of drainage conduits: super high flow capacity
Thank you for your attention