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EQUIVALENCY DEMONSTRATION

DRAINTUBE® as a Geosynthetic Drainage Geocomposite for Landfill Applications

Afitex-Texel

Prepared for Afitex-Texel
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TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

At the request of AFITEX-Texel Geosynthetics inc., Sanborn Head prepared this Equivalency Demonstration (Demonstration) for the approval of the multi-linear drainage geocomposite DRAINTUBE® as the geosynthetic drainage layer for landfill applications (i.e., in final cover and liner system design). The goal of this Demonstration is to provide solid waste engineers and regulators with a concise technical document that provides key information and guidance related to selecting and designing with the multi-linear drainage geocomposite DRAINTUBE® in landfill applications.

2.0 DRAINTUBE®

Drainage geocomposites are used to meet the regulatory requirements for liquid or gas removal in a variety of applications including: foundations; mechanically stabilized walls; landfills (gas extraction, leachate collection/leak detection, and capping systems); pond leak detection; roadway and pavement drainage; and other subsurface drainage system applications. Cost-effective, efficient, and effective drainage solutions are critical to the operation, maintenance, and regulatory compliance of these systems.

The long-term performance of geonet drainage geocomposites can be limited by several factors including geonet creep, geotextile intrusion, and biological clogging. Multi-linear drainage geocomposites like DRAINTUBE® offer the advantage of better long-term hydraulic performance, and its ease of installation make it an ideal material to increase the performance of a system and reduce the overall construction cost.

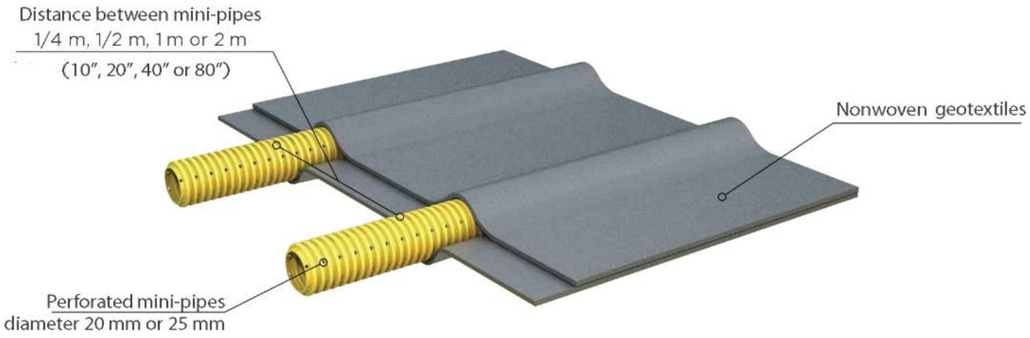
DRAINTUBE®, manufactured by AFITEX-Texel Geosynthetics inc., combines geosynthetic and pipe technology into a product that has a variety of fluid management applications.

DRAINTUBE® has been used for over 30 years by industry professionals

1988 – First installation and use of DRAINTUBE®
I
1991 – First application for liquid drainage under concrete slab
I
1995 – First application for landfill cover (LFG collection & liquid drainage) & gas collection under impoundment
I
2001 – First application for leachate collection
I
2005 – First application for mechanically stabilized wall drainage
I
2010 – First project in the United States (PA)
I
2011 – First application for landfill cover drainage in the US (NY)
I
2014 – First application for LFG collection in the waste mass in the US (NH)
I
2015 – More than 200,000,000 ft^2 (~20,000,000 m^2) installed

DRAINTUBE® is compliant with **ASTM D7931**, **Standard Guide for Specifying Drainage Geocomposites**, and is defined as a multi-linear drainage geocomposite in **ASTM D4439**, **Standard Terminology for Geosynthetics.**

DRAINTUBE® consists of two geotextile layers comprised of short synthetic staple fibers of 100% polypropylene or polyester needle-punched together with perforated corrugated polypropylene pipes regularly spaced inside. The pipes have two perforations per corrugation at 180° and alternate at 90° and can be spaced at intervals of 1, 2, 3, or 4 per meter width (i.e., 10, 20, 40, or 80 inches [center to center]). The remainder of this section presents the physical characteristics of DRAINTUBE®.



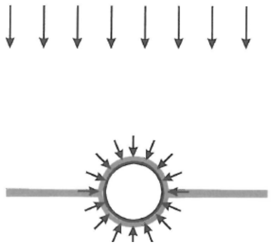
2.1 Interface Shear Strength

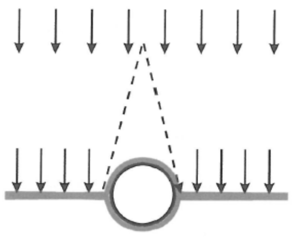
Interface shear strength testing was performed by GAI-LAP certified laboratories on a variety of DRAINTUBE® products and other typical materials. The overall results are summarized below. Engineers are encouraged to base their design on parameters derived from tests performed on site-specific materials under anticipated conditions.

Material Tested	Typical Friction Angle (°) with DRAINTUBE®
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.

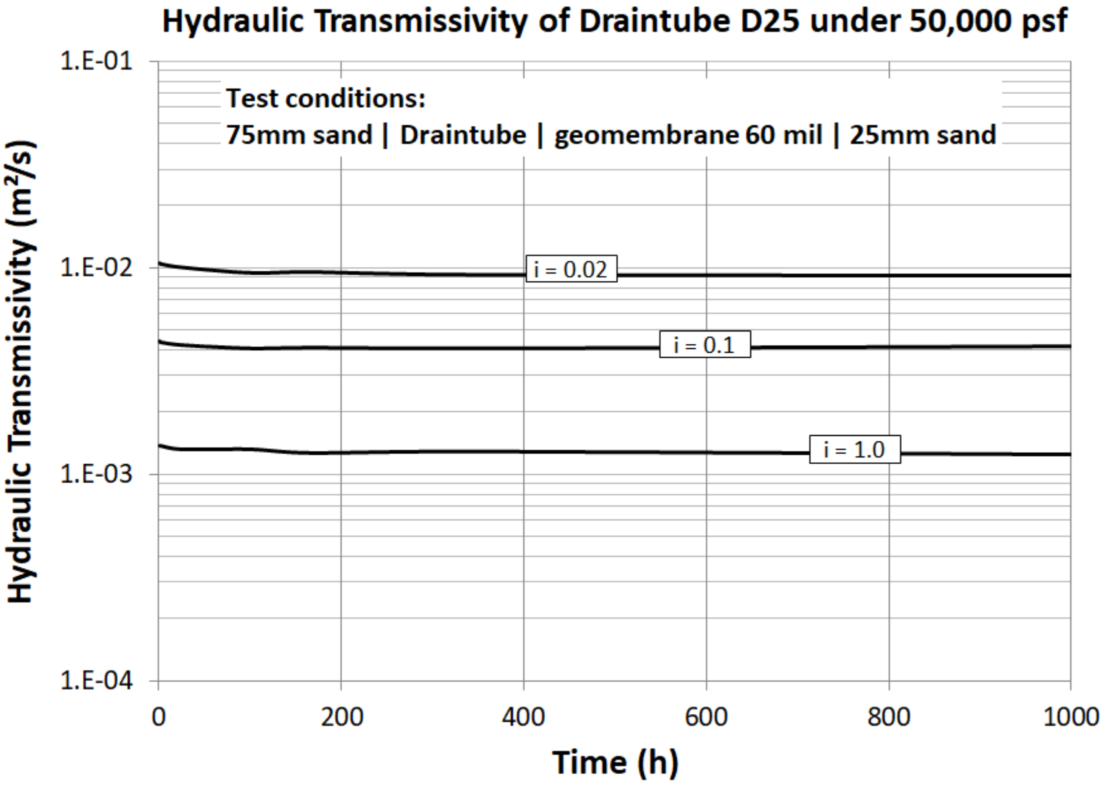
2.2 Mechanical Behavior

Unlike geonet drainage geocomposites, normal load has little effect on the transmissivity of multi-linear drainage geocomposites. Because the normal loads to the mini-pipes are reduced due to soil arching, the pipe/backfill interaction, and corresponding load transfer (when confined), transmissivity is not impacted and there is no geotextile intrusion or creep over time (as per ASTM D7931-17).


Pipe/Backfill Load Transfer


Soil Arching Effect

DRAINTUBE® has been tested under high compressive loads, and the results indicate that the transmissivity of the product is neither load nor time sensitive. When the product is properly confined, increasing the normal load does not significantly affect the transmissivity at loadings up to 50,000 pounds per square foot (psf)[1]. Additionally, test data indicates no change in transmissivity over the first 1000 hours (Ref. 1).



2.3 Transmissivity and Flow

Multiple studies were performed on the long-term transmissivity of biological clogging of DRAINTUBE®. Over an 18-month long test program, neither the geotextile filter nor pipe of DRAINTUBE® ACB (with non-leachable, silver-based biocide treatment) appeared to clog, and it exhibited same or better long-term hydraulic behavior than the gravel layer (Ref. 2).

Over a 3-year long test program that simulated in-landfill conditions, the residual long-term flow capacity of DRAINTUBE® (designated as NWNP w TUBE in figure below) was about 75%, whereas a typical single-sided geonet geocomposite (designated as NWNP w GN in figure) was about 30% (Ref. 3 & 4). The single-sided geonet geocomposite results should be applicable to double-sided geonet geocomposite because an additional geotextile layer would not improve long-term flow capacity.

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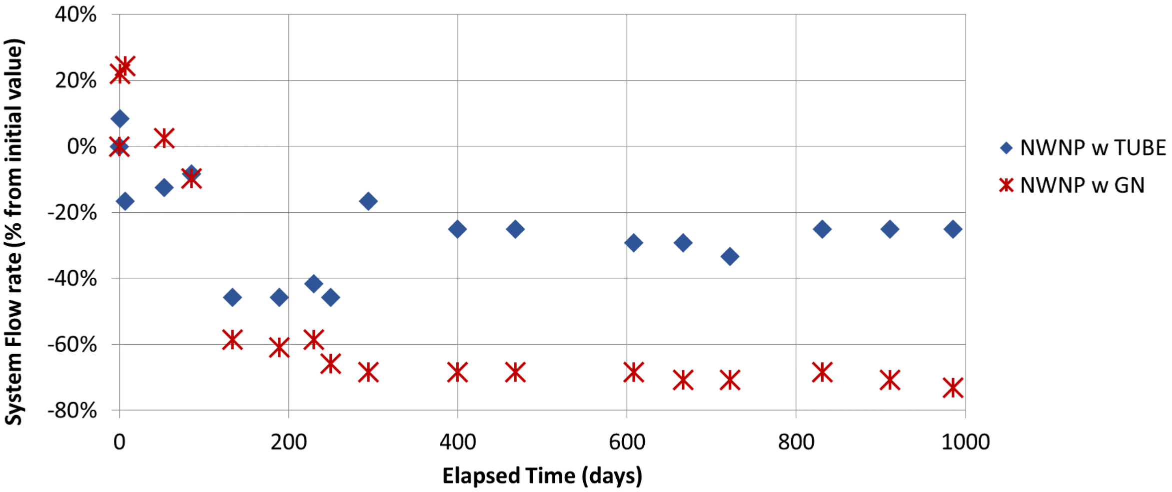
[1] 50,000 psf = 588 feet of waste thickness at 85 lb/ft^2



As expected, the transmissivity of DRAINTUBE® is proportional to the number of pipes per unit width. In other words, the properties that are measured on one pipe and calculated for a unit width of one meter, can be multiplied by the number of pipes per unit width to find the transmissivity of a product with increased number of pipes.

Transmissivity test methods for multi-linear drainage geocomposites, like DRAINTUBE®, are provided in the **Geosynthetic Institute GRI Test Method GC15 (revised in May 2017)** (Ref. 5).

2.4 Peel Strength

Drainage geocomposite materials usually consist of at least one geotextile attached to a geonet or other type of drainage core through heat bonding or the use of an adhesive. Designers and engineers must consider the peel strength of these materials for their application; however, because DRAINTUBE® is a needle-punched geocomposite, peel strength is not a factor nor consideration in the design process.

3.0 SPECIFYING DRAINTUBE™ IN LANDFILL APPLICATIONS

The performance of drainage geocomposites is limited by several factors that should be considered when specifying/designing: (1) geotextile intrusion into the geonet, RF_{GI}; (2) geonet crushing, RF_{CR} (i.e., creep); and (3) biological and chemical impacts, RF_{CC} and RF_{BC}.

The basic design formula (see right) can be used to specify/design the appropriate drainage geocomposite for a specific application. A summary of typical ranges for each of the reduction factors for some common applications of drainage geocomposites is provided in Table 1 along with the reduction factors that can be used for DRAINTUBE®, which are based on many of the studies and testing discussed above. One of the benefits of using multi-linear drainage geocomposites is that there is no creep or geotextile intrusion over time and under load.

Basic Design Formula:

$$\mathbf{q_{allow}} = \mathbf{q_{100}} \left(\frac{\mathbf{1}}{\mathbf{RF_{CR}} + \mathbf{RF_{cc}} + \mathbf{RF_{BC}} + \mathbf{RF_{GI}}} \right)$$

$\mathbf{q_{allow}}$ = allowable flow rate for a drainage geocomposite
$\mathbf{q_{100}}$ = initial flow rate determined under simulated conditions for 100-h duration
$\mathbf{RF_{CR}}$ = reduction factor to account for long-term behavior
$\mathbf{RF_{CC}}$ = reduction factor for chemical clogging
$\mathbf{RF_{BC}}$ = reduction factor for biological clogging
$\mathbf{RF_{GI}}$ = reduction factor for geotextile intrusion past the initial 100-h seating time

Table 1
Typical RF Factors for Geonet and Multi-linear Drainage Geocomposites in Landfill Applications

Applications	Type of Geocomposite	Reduction Factors			
		$\mathbf{RF_{CR}}$ (7)	$\mathbf{RF_{CC}}$ (6)	$\mathbf{RF_{BC}}$ (6)	$\mathbf{RF_{GI}}$ (7)
Landfill Liner System	Geonet	1.4 to 2.0	1.5 to 2.0	1.1 to 1.3	1.5 to 2.0
	DRAINTUBE®	**1.0**		**1.0* to 1.3**	**1.0**
Landfill Covers	Geonet	1.1 to 1.4	1.0 to 1.2	1.2 to 3.5	1.3 to 1.5
	DRAINTUBE®	**1.0**		**1.0* to 3.5**	**1.0**

* In cases when using DRAINTUBE® ACB, which contains a non-leachable, silver-based biocide treatment.

The following sections demonstrate the equivalency of designing with a multi-linear drainage geocomposite like DRAINTUBE®, compared to a conventional geonet drainage geocomposite.

4.0 LINER SYSTEM APPLICATIONS

Landfill liner system design regulations will likely vary from state to state. The following sections describe typical requirements and how a multi-linear drainage geocomposite could meet said requirements.

4.1 Geocushion

A Geocushion is typically a needle-punched, nonwoven material appropriately designed and specified to be of a sufficient weight to prevent deformation and damage to the underlying geomembrane layer of the double composite liner system described above.

DRAINTUBE® consists of two geotextile layers comprised of short synthetic staple fibers of 100% polypropylene or polyester needle-punched together, which meets the material requirements described above. Puncture resistance is a term often used to describe the ability of a liner system to limit deformation and damage to the underlying geomembrane. Typically, puncture resistance of the entire double composite liner system is evaluated at the most critical location, which would be where the greatest load occurs.

The puncture resistance of the liner system is typically calculated in two steps: (i) calculating the allowable force to be resisted by the nonwoven geotextile components of the drainage geocomposite due to overburden materials at the critical location; and (ii) calculating the factor of safety (FS) against puncture of the geomembrane using the properties of the drainage geocomposite at the critical location.

The allowable force to be resisted is independent of the drainage geocomposite chosen as part of the liner system design and relies on assessing the force from overburden materials only (i.e., final cover system, waste, and liner system components). Typically, the FS is applied to the allowable force based on literature review and/or engineering judgement. The allowable force calculated can then be compared to that provided on the manufacturer specifications/data sheet for the chosen drainage geocomposite.

To verify that a chosen drainage geocomposite provides adequate protection against puncture, the FS can be calculated and compared to the FS that is required, based on literature review and/or engineering judgement. This calculation relies on assessing the allowable puncture resistance of the geomembrane overlain by geotextile, which considers reduction factors related to long-term chemical/biological degradation from leachate, long-term creep related to the overlying media, and the angularity, density and arching of the overlying media. Designing with a multi-linear drainage geocomposite like DRAINTUBE® as compared to a geonet drainage geocomposite does not change this calculation methodology, however the design engineer will be able to select product-specific factors.

Because both geonet drainage geocomposites and multi-linear drainage geocomposites like DRAINTUBE® utilize similar geosynthetic components, no change in design methodology is needed and adherence to the regulations relies on the manufacturer specifications for the products and the characteristics of the overlying media.

4.2 Filter Layer

If a filter layer is included in the liner system design, the layer should be designed to prevent the migration of fine soil particles into a coarser grained material, and to allow water or gases to freely enter a drainage structure (e.g., pipe or drainage blanket) without clogging. A geosynthetic filter material must demonstrate adequate permeability, soil particle retention, resistance to clogging, and chemical and physical resistance to adjacent materials so that it is not adversely affected by waste placement, overlying material or leachate generated at the landfill. Each of these requirements is discussed further in the sections below.

4.2.1 Permeability

The permeability of a material can be defined as the materials' quality of having pore or openings that permit liquids or gases to pass through. Should a geosynthetic filter be used in design, then the designer should demonstrate that the geosynthetic filter permeability (k_f) is greater than the overlying soil permeability (k_s) by a factor specified by regulation or standard practice.

Typically, geosynthetic specification/data sheets provided by the manufacturer provide a value for permittivity. Permeability can be calculated based on the permittivity and the thickness of the material being considered. Because both geonet drainage geocomposites and multi-linear drainage geocomposites like DRAINTUBE® utilize similar geosynthetic components, no change in design methodology is needed and adherence to the regulations relies on the manufacturer specifications for the products and the characteristics of the overlying soil.

4.2.2 Apparent Opening Size (AOS)

A comparison of the geotextile AOS to the soil particle size distribution is required when including a geosynthetic filter in the liner system design. The assessment considers the particle size distribution of the soil specified for the application compared to the AOS, or filtration opening size (FOS) provided on the manufacturer specification/data sheets for the drainage geocomposite proposed. Because both geonet drainage geocomposites and multi-linear drainage geocomposites like DRAINTUBE® utilize similar geosynthetic components, no change in design methodology is needed and adherence to the regulations relies on the manufacturer specifications for the products and the characteristics of the overlying soil.

4.2.3 Resistance to Clogging/Chemical and Physical Resistance

The geosynthetic filter's resistance to clogging can be demonstrated using a long-term permeameter test method or other method. Additionally, chemical and physical resistance to adjacent materials may need to be demonstrated. As discussed in Sections 2.2 and 2.3, multiple studies have been performed on the long-term transmissivity of biological clogging of DRAINTUBE®. Over an 18-month long test program, neither the geotextile filter nor pipe of DRAINTUBE® ACB (with non-leachable, silver-based biocide treatment) appeared to clog, and it exhibited same or better long-term hydraulic behavior than gravel layer (Ref. 2). Additionally, over a 3-year long test program that simulated in-landfill conditions, the residual long-term flow capacity of DRAINTUBE® (designated as NWNP w TUBE in figure) was about 75%, whereas a typical single sided geonet geocomposite (designated as NWNP w GN in figure) was about 30% (Refs. 3 & 4).

5.0 LEACHATE COLLECTION AND REMOVAL SYSTEM APPLICATIONS

Primary and secondary leachate collection and removal system design regulations will likely vary from state to state. The following sections describe typical requirements and how a multi-linear drainage geocomposite could meet said requirements. Often, if a geosynthetic drainage layer is designed for use in the primary or secondary leachate collection and removal systems, the layer must meet the structural and transmissivity hydraulic design requirements using actual boundary conditions at the maximum adjusted design load for a minimum period of 100 hours, modified to take into consideration the long-term conditions for creep representative of site conditions and other factors. Additionally, biological clogging and chemical clogging should be considered. Typically, the chemical and physical resistance of the geosynthetic drainage material must be adequate so that its hydraulic transmissivity is not adversely affected by waste placement or leachate.

5.1 Primary Leachate Collection System

5.1.1 Hydraulic Conductivity and System Head

Hydraulic conductivity is typically specified within state regulations and may vary from state to state. However, designing with drainage geocomposites can be simplified into calculating a design transmissivity (T_{Design}) for the specified application and assessing what the required transmissivity ($T_{Required}$) will need to be, after considering a FS and applicable RFs, as shown in the equations below.

$$T_{Required} = T_{Design} \times FS \times \sum RF$$

$$\sum RF = RF_{CR} \times RF_{CC} \times RF_{BC} \times RF_{GI}$$

For a primary drainage geocomposite, the T_{Design} is typically based on a calculated or estimated leachate impingement rate (i.e., leachate production rate considering worst case scenario) and the requirement that no more than 12 inches of leachate depth (i.e., head) is maintained above the primary liner, except during the 24-hour, 25-year storm event and in sump areas. Because there are multiple methods to calculate this T_{Design}, and the drainage geocomposite characteristics does not impact this calculation, we will not address the methods in this demonstration.

However, once a T_{Design} is calculated that meets the requirements described above, then the $T_{Required}$ must be evaluated. The $T_{Required}$ is the transmissivity that will be required for any drainage geocomposite that is specified by the engineer, which takes into account both a FS and RFs. Therefore, the difference in designing with a multi-linear drainage geocomposite like DRAINTUBE® and a geonet drainage geocomposite are the product specific $R_{CC,}$ R_{BC}, R_{CR}, and R_{GI} values selected by the engineer.

As noted in Table 1, the R_{CR}, R_{BC}, and R_{GI} values for DRAINTUBE® can be lower than those of a geonet drainage geocomposite. Therefore, designing with DRAINTUBE® RFs should decrease the $T_{Required}$ of the system and/or increase the FS of the system. See the design method equivalency calculation included in Appendix A for an example calculation.

5.2 Secondary Leachate Collection System

5.2.1 Design Capacity and Hydraulic Conductivity

Secondary leachate collection system design should exhibit a specific design capacity (i.e., gal/ac/d) and/or meet a hydraulic conductivity and a maximum leachate depth (i.e., head) requirement.

As noted above in Section 5.1, designing with drainage geocomposites can be simplified into calculating a design transmissivity (T_{Design}) for the specified application and assessing what the required transmissivity ($T_{Required}$) will need to be, after considering a FS and applicable RFs, as shown in the equation below.

$$T_{\text{Required}} = T_{\text{Design}} \times \text{FS} \times \sum \text{RF}$$

$$\sum \text{RF} = \text{RF}_{\text{CR}} \times \text{RF}_{\text{CC}} \times \text{RF}_{\text{BC}} \times \text{RF}_{\text{GI}}$$

For a secondary drainage geocomposite, the T_{Design} is typically based multiple conditions; (i) a capacity in gal/ac/d; (ii) a hydraulic conductivity; and (iii) a leachate depth. For slopes, the leachate thickness is ruled by the thickness of the confined drainage layer and there is no specified hydraulic conductivity. Because there are multiple methods to calculate T_{Design}, and the drainage geocomposite characteristics do not impact this calculation, we will not address the methods in this demonstration.

However, once a T_{Design} is calculated that meets the requirements described above, then the T_{Required} must be evaluated. The T_{Required} is the transmissivity that will be required for any drainage geocomposite that is specified by the engineer, that takes into account both a FS and RFs. Therefore, the difference in designing with a multi-linear drainage geocomposite like DRAINTUBE® and a geonet drainage geocomposite are the product specific R_{CC}, R_{BC}, R_{CR}, and R_{GI} values selected by the engineer.

As noted in Table 1, the R_{CR}, R_{GI}, and R_{BC} values for DRAINTUBE® can be lower than those of a geonet drainage geocomposite. Therefore, designing with DRAINTUBE® RFs should decrease the T_{Required} of the system and/or increase the FS of the system. See the design method equivalency calculation included in Appendix A for an example calculation.

5.2.2 Secondary Leak Detection

The secondary leachate collection system design should demonstrate that the system has a maximum leak detection time of 24 hours using steady flow calculations in a saturated medium. Typically, the critical flow paths of the system would be assessed and a travel time in the leachate collection pipe (as applicable) would be calculated and subtracted from the 24-hour requirement to arrive at the allowable travel time in the drainage geocomposite portion of the secondary leachate collection system. The T_{Design} for the drainage geocomposite would then be calculated, using the T_{Required} as described in the previous section.

However, designing with a multi-linear drainage geocomposite like DRAINTUBE® as comparted to a geonet drainage geocomposite actually simplifies this calculation method because the leak detection time under saturated conditions will be based on the travel time in the mini-pipes utilized by DRAINTUBE® and the travel time in the main leachate collection pipe that receives flow from the mini-pipes. The calculation is simply calculating flow in pipe using the Manning's Equation as follows:

$$v = \frac{1.49\,(R_h^{\frac{2}{3}} \times S^{\frac{1}{2}})}{n}$$

Where:

v = velocity (ft/sec)
R_h = Hydraulic radius = A/P_w
A = Flow area = $\frac{r^2(\theta-\sin\theta)}{2}$
P_W = Wetted perimeter = $r \times \theta$
r = Radius
θ = Central angle (radians) = $2 \arccos \frac{r-h}{r}$
h = Depth of flow
S = Slope
n = Manning's Roughness Coefficient

6.0 FINAL COVER SYSTEM APPLICATIONS

As with the design regulations discussed above, the final cover system requirements will also likely vary from state to state. A final cover system often consists of a composite barrier that includes a layer of soil and/or a geosynthetic drainage layer with a geomembrane, and sometimes a geosynthetic clay liner. The geosynthetic drainage layers designed for use in a final cover system for either drainage or gas venting should meet the structural and hydraulic transmissivity design requirements using actual boundary conditions at the maximum adjusted design load for a minimum period of 100 hours, and appropriate reduction factors and must consider any proposed landfill end use structures.

6.1 Liquid Drainage

Typically, drainage layers for a final cover system are designed to limit the depth of liquid to less than the thickness that would yield a slope stability FS less than 1.5. Similar to the design of drainage geocomposites in liner systems, a design transmissivity would be calculated for this condition assuming a design storm event. Additionally, similar to landfill liner applications, a factor of safety should be used for hydraulic flow capacity calculations and the hydraulic design should be performed using the saturated hydraulic conductivity of the soil protection layer.

Once the design transmissivity is calculated, designing a drainage geocomposite for the final cover system is similar to that for the liner system. See Appendix A for an example calculation sheet. Additionally, designing with DRAINTUBE® as compared to a geonet drainage geocomposite does not change this calculation methodology; however, the engineer will be able to select product specific R_{CC}, R_{BC}, R_{GI}, and R_{CR} values. As noted in Table 1, the R_{CR} and R_{GI} values for DRAINTUBE® can be lower than those for a geonet drainage geocomposite. Therefore, designing with DRAINTUBE® RFs should decrease the required transmissivity and increase the FS of the drainage layer.

6.2 Landfill Gas (LFG) Venting

For a final cover system for the landfill, it may be required to demonstrate that LFG will be adequately controlled and removed from the landfill in a manner to ensure the overall stability of the landfill and the final cover system, and to reduce the concentration and pressure gradient of explosive gases to control gas migration.

Because there are often no specific requirements for a LFG venting layer within the final cover system of the landfill, there are no specific design method modifications to consider should an engineer design a layer that includes a geonet drainage geocomposite or multilinear drainage geocomposite, like DRAINTUBE®. However, because liquid and gas flow are calculated similarly, should a design flow rate or transmissivity be calculated for the LFG venting layer, the same equivalency as demonstrated on the calculation sheet included in Appendix A can be applied.

Should a drainage geocomposite be required or considered for the LFG venting layer, a benefit of a product like DRAINTUBE® is the ability for the operator of the landfill to connect into the tubes of the geocomposite through an installed manifold and apply a vacuum to the venting layer. This provides an opportunity to actively control LFG emissions within the final cover system of the landfill. A geonet drainage geocomposite and/or soil layer do not provide this additional benefit for the LFG venting layer.

REFERENCES:

(1) Saunier, Pascal, William Ragen, and Eric Blond, "Assessment of the Resistance of Drain Tubes Planar Drainage Geocomposites to High Compressive Loads," International Conference on Geosynthetics (Brazil) Vol. 3, p. 1131, May 23-27, 2010.

(2) Blond, Eric, Stephan Fourmont, and Pascal Saunier, "Biological Clogging Resistance of Tubular Drainage Geocomposites in Leachate Collection Layers," Geosynthetics 2013, Long Beach, California, pp.1135-1144

(3) Fourmont, Stephan and George Koerner, "Determining the Long-Term Transmissivity of Selected Drainage Geocomposites to Landfill Leachate," Geotechnical Frontiers 2017, pp. 274-279

(4) Saunier, Pascal, Eric Steinhauser, and Stephan Fourmont, "Statement on the long-term flow rate of tubular drainage geocomposites to landfill leachate," Geosynthetics 2017 First International Conference on Technology and Application of Geosynthetics.

(5) GRI Standard – GC15, 2017 Determining the Flow rate per Unit width of Drainage Geocomposites with Discrete High Flow Components. Geosynthetic Institute, Folsom, PA

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

(7) Koerner, Robert M. and George R. Koerner, 2007, GSI White Paper #4, Reduction Factors (RFs) Used in Geosynthetic Design, Rev 1. Geosynthetic Institute, Folsom, PA

(8) Giroud, J.P., Zhao, A., and Bonaparte, R., 2000, "The Myth of Hydraulic Transmissivity Equivalency Between Geosynthetic and Granular Liquid Collection Layers", Geosynthetics International, Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp. 381-401.

APPENDIX A

DESIGN METHOD EQUIVALENCY CALCULATION

Equivalency Calculation

Specifying DRAINTUBE® as a Drainage Geocomposite for Landfill Applications

Prepared by: Sanborn Head & Associates, Inc.

Calculate the required transmissivity ($T_{Required}$) for a drainage geocomposite based on the design transmissivity (T_{Design}), a Factor of Safety (FS), and Reduction factors ($\sum RF$). The T_{Design} may be calculated for a variety of conditions and applications.

$$T_{Required} = T_{Design} \times FS \times \sum RF \qquad \text{[Ref 8, Eq 8.12]}$$

$$\sum RF = RF_{CR} \times RF_{CC} \times RF_{BC} \times RF_{GI}$$

Where:

FS = factor of safety = 1.5, for geosynthetic drainage layers
RF_{CR} = reduction factor for creep deformation of the drainage core
RF_{CC} = reduction factor for chemical clogging
RF_{BC} = reduction factor for biological clogging
RF_{GI} = reduction factor for intrusion of the adjacent geotextiles into the drainage core

Applications	Type of Geocomposite	Reduction Factors			
		RF_{CR}[6]	RF_{CC}[5]	RF_{BC}[5]	RF_{GI}[6]
Landfill Leachate Collection	Geonet	1.4 to 2.0	1.5 to 2.0	1.1 to 1.3	1.5 to 2.0
	DRAINTUBE®	**1.0**		**1.0* to 1.3**	**1.0**
Landfill Covers	Geonet	1.1 to 1.4	1.0 to 1.2	1.2 to 3.5	1.3 to 1.5
	DRAINTUBE®	**1.0**		**1.0* to 3.5**	**1.0**

* In cases when using DRAINTUBE® ACB, which contains a non-leachable, silver-based biocide treatment

Example calculation for a drainage geocomposite being designed for a landfill liner system:

Using a Multi Linear Geocomposite (i.e. DRAINTUBE®)

$$\sum RF = RF_{CR} \times RF_{CC} \times RF_{BC} \times RF_{GI}$$

$RF_{CR} = 1.0$
$RF_{CC} = 1.7$
$RF_{BC} = 1.2$
$RF_{GI} = 1.0$

$$\sum RF = 1.0 \times 1.7 \times 1.2 \times 1.0 = 2.04$$

$$T_{Required} = T_{Design} \times FS \times \sum RF$$

$$T_{Required} = T_{Design} \times 1.5 \times 2.04$$

$$T_{Required} = 3.06\ T_{Design}$$

Using a Geonet Geocomposite

$$\sum RF = RF_{CR} \times RF_{CC} \times RF_{BC} \times RF_{GI}$$

$RF_{CR} = 1.7$
$RF_{CC} = 1.7$
$RF_{BC} = 1.2$
$RF_{GI} = 1.7$

$$\sum RF = 1.7 \times 1.7 \times 1.2 \times 1.7 = 5.9$$

$$T_{Required} = T_{Design} \times FS \times \sum RF$$

$$T_{Required} = T_{Design} \times 1.5 \times 5.9$$

$$T_{Required} = 8.85\ T_{Design}$$

For Additional Information, including technical data sheets, product specifications, detail drawings, and additional publications, visit the manufacturer's website: www.draintube.net

References:

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