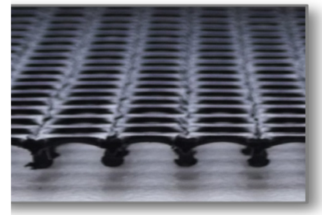
TECHNICAL NOTE

Landfill Closures: Cost Savings of Using High Flow Geocomposite Drainage Systems


[GSE Triaxial Drainage System]

Present economic conditions requires vigilance in identifying methods of saving money by reducing construction related costs while sustaining performance on Superfund, hazardous or municipal waste landfill closure projects. The intent of this technical note is to demonstrate how the increased flow capacity of a Triaxial geocomposite can yield considerable cost savings on projects designed around a biplanar geocomposite, by:

1) Reducing the number of costly lateral drainage swales.

2) Reducing trucking costs by using more permeable but locally available soils.

Design engineers use the industry standard Unit Gradient Method of Design, which is based upon the simple concept of water in vs. water out, as:

Water $_{in}$ = Permeability of saturated vegetative support soil layer (k_{veg}) directly above the geocomposite multiplied by the horizontal slope length (L_H).

Water $_{out}$ = Required Transmissivity[1] ($T_{req'd}$) of the geocomposite multiplied by the slope gradient .

$T_{req'd}$ represents the required long-term design transmissivity prior to liquid exceeding the thickness of the geocomposite along the slope gradient, and it can be determined from the 100-hour-in-soil transmissivity divided by various reduction factors and drainage safety factor. The Unit Gradient Method can be used to determine the horizontal slope length (L_H) where flow within the geocomposite must be discharged into a lateral drainage swale or unstable slope stability conditions may develop. A geocomposite that provides an increased transmissivity value can provide increased distance between lateral drainage swales. The following site conditions are used in this technical note.

Gradient	33%
Total Slope length–Horizontal, crest to toe	80 m (262 ft)
Vegetation support layer Permeability(K_{veg})	1 x 10^{-4} cm/sec

The geocomposites shown below and their related performance and estimated costs are used in this evaluation:

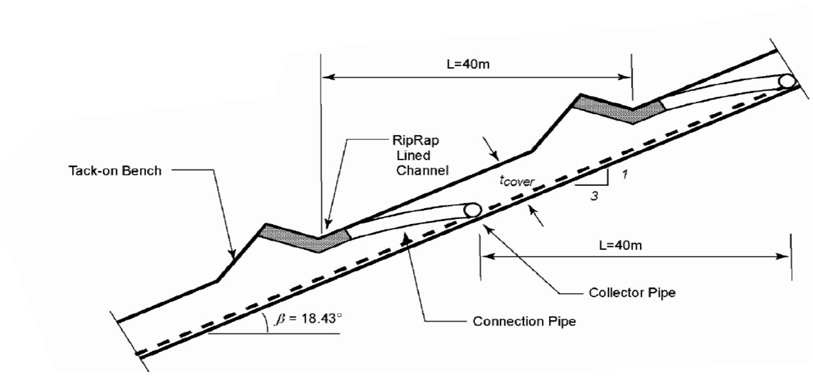
Geocomposite	100-hour-in-soil Transmissivity (T_{100})
Biplanar	1.75 x 10^{-3} m^2/s
TenFlow	3.5 x 10^{-3} m^2/s

Example 1: Mid-slope lateral drainage swales

Compared to the biplanar geocomposite, the Triplanar geocomposite provides a 100% increase in T_{100} which allows for an increase in horizontal distance between drainage swales (L_H). Knowing T_{100} along with the other design input permits the designer to use the Unit Gradient Method to determine L_H for each geocomposite. This design calculation can be performed online by visiting www.landfilldesign.com and it is summarized in the following table:

Case	Geocomposite	L_H	T_{100}
1.	Biplanar	40 m (131 ft)	1.75×10^{-3} m²/sec
2.	TenFlow	80 m (262 ft)	3.5×10^{-3} m²/sec

For simplicity this analysis assumes all reduction factors and the drainage safety factor are identical for both geocomposites (RF_{in}=1.0, RF_{cr}=1.1, RF_{cc}=1.2, RF_{bc}=3.5, FS_d=3). The analysis has determined that a single mid slope drainage swale would be necessary when the biplanar geocomposite is used under these site conditions. An example of mid-slope drainage is illustrated below:



For a horizontal slope length of 262 ft, its length along the slope is 276 ft, then the width of a 1 acre area is 158 feet. Therefore, the biplanar geocomposite would require a 158 linear foot mid-slope lateral drainage swale to sustain liquid flow within the thickness of the geocomposite. Based upon an engineer estimate of $60/linear ft to construct a drainage swale, the cost is estimated at $9,480/acre. In comparison, the Triaxial geocomposite would not require a mid-slope lateral drainage swale. The additional cost incurred by using a Triaxial geocomposite is $4,356/acre (assume $0.1/sf). The potential cost savings can be estimated as shown below:

	1 acre	50 acres
Cost to construct drainage swale for biplanar ($)	9,480	474,000
Cost increase to use Triaxial ($)	-4,356	-217,800
Savings ($)	5,124	256,200

Although the savings can vary dependent upon site conditions, this example illustrates the magnitude of potential cost savings that a Triaxial geocomposite can provide under the proper conditions. Additionally, the owner would experience a long term savings since maintenance costs to sustain the lateral drainage swale due to differential settlement over the life of the closure are eliminated.

Example 2: The incredible cost of trucking cover soils.
The increased transmissivity of a Triaxial geocomposite can accommodate the use of a wider range of more accessible cover soils. Case 3 analysis of the Unit Gradient Design Calculator demonstrates that a 2.0 x 10-4 cm/sec permeability (K_{VEG}) of the cover soils can be used when a Triaxial geocomposite is installed on a L_H of 131 ft (40m) between drainage swales, while sustain the original design FS and all RF. This represents a **100% increase** in permissible K_{VEG}, which may allow the use of more locally available soils that would not have been permitted if the biplanar geocomposite is utilized. In this example we will assume two different K_{VEG} soil sources based upon the type of geocomposite that is permissible and are located the distance from the jobsite as shown in the table below:

Geocomposite	K_{VEG} (cm/sec)	Miles to Source
Biplanar	1.0×10^{-4}	30
Triaxial	2.0×10^{-4}	15

The analysis is based upon the following typical costs associated with materials movement as shown:

Cost of Truck/Operator	$750.00/day
Average Truck Speed	30 miles per hour
Capacity	20 yd^3/load
Expenses	Gas at $4.00/gal, 10 miles/gal
Soil Thickness	1.5 ft
Area	50 acres or 2,178,000 ft^2
Total Cover Soil	3,267,000 ft^3 =121,000 yd^3

Approximately 6,050 truckloads would be required for delivery of 121,000 yd^3 of soil over a 50 acre area. We estimate transportation costs as shown below:

	Biplanar Source	Triaxial Source	Savings
Distance, miles	30	15	15
Round Trips/Day	4	8	4
Total Miles	30*2*6050=363,000	15*2*6050=181,500	181,500
Truck/Operator ($)	6050/4*$750=$1,134,375	6050/8*$750=$567,188	$567,188
Fuel ($)	363,000/10*4=$145,200	181,500/10*4-$72,600	$72,600
Subtotal ($)	$1,279,575	$639,788	$639,787
Geocomposite Cost Difference ($)		$217,800	(-$217,800)
Total Cost & Savings ($)	$1,279,575	$857,588	$421,987

Although the $421,987 savings presented within the above example is subjective to many variables, it illustrates the potential costs saving which may be experienced through the use of a Triaxial geocomposite. Additionally, the Environmental Green Credits shown below may have substantial impact on government projects, as illustrated below, assuming the project needs to be complete within 60 days.

	Biplanar	Triaxial	Savings
Truck Days	6050/4=1513	6050/8=757	757
# Trucks/Day	1513/60=25	757/60=13	13
Mileage	363,000	181,500	181,500

Engineering companies are not typically involved in evaluation of different soil sources prior to the bid process. However, a pro-active consideration by the owner and his engineer during design stage can lead to the potential savings. Alternately, a general contractor may have the opportunity to explore this option during the submittal process.

These examples demonstrate that the higher cost of a Triaxial geocomposite is fairly minor when compared to the potential savings that may be experienced when used instead of the lower performing but cost attractive biplanar geocomposite.