HELP Model Simulation and Hydraulic Calculations

?? Two HELP Model runs were performed to conduct the water balance analysis on the above referenced liner system. The first run is for the initial phase of waste placement, assuming 10 ft of waste (120 inches) and 2,000 psf design normal stress. The second run is for the phase of the landfill prior to final closure, assuming 150 ft of waste (1800 inches) and 15,000 psf design normal stress. In both runs, the weather data are taken for Jacksonville, FL. Other relevant information could be referred to the attached HELP Model output.

?? Based on the given dimensions of the designed cells, a 2.0% slope with 700 feet in length has been considered in the analysis.

?? The calculations enclosed below, *"Determining the Design Hydraulic Conductivity for ULDM Tri-Planar Geocomposites",* present HELP model input: design thickness (t_{dsg}) and design hydraulic conductivity (k_{dsg}) for the proposed ULDM drainage geocomposite at the cases simulated in the HELP Model runs. For the first case, t_{dsg} = 0.29 inches, k_{dsg} = 15.8 cm/sec, and for the second case, t_{dsg} = 0.20 inches, k_{dsg} = 11.0 cm/sec.

?? HELP Model output (Peak Daily Values) indicates that the liquid head on the primary liner is calculated to be 0.263 inches and 0.166 inches for the first and the second case respectively, which ensures an ***unconfined flow*** (head contained within the drainage media) in both cases.

Determining HELP Model Input for ULDM Tri-Planar Geocomposite

Given: Leachate Collection and Removal System

Slope of lateral drainage system = 2.0%

Equations:

$$T_{all} = \frac{T_{ult}}{RF_{IN} * RF_{CR} * RF_{CC} * RF_{BC}} \quad (1)$$

Where,

T_{all} = allowable Transmissivity [cm^2/s]

T_{ult} = ultimate Transmissivity measured in the lab [cm^2/s]

RF_{IN} = reduction factor for geotextile intrusion

RF_{CR} = reduction factor for creep deformation

RF_{CC} = reduction factor for chemical clogging

RF_{BC} = reduction factor for biological clogging

$$T_{dsg} = \frac{T_{all}}{FS} = k_{dsg} * t_{dsg} \quad (2)$$

Where

T_{dsg} = design Transmissivity used in calculations [cm^2/s]

k_{dsg} = design hydraulic conductivity used in calculations [cm^2/s]

t_{dsg} = design thickness used in calculations [cm]

FS = overall factor of safety

Solution:

Case 1: Initial Phase of Waste Placement:

1) Estimated design load on landfill liner system = 2,000 psf

2) Ultimate Transmissivity = T_{ult} = 7.5 * 10E-3 m^2/sec = 75 cm^2/s

(geocomposite tested in soil boundary condition under 2,000 psf, and a seating period of 100 hours)

3) Using attached Table[1] for typical value of reduction factor: RF_{IN} = 1.2

4) Using attached Table[2] RF_{CC} = 2.0, RF_{BC} = 1.3

5) Using RF_{CR} = 1.05 (see attached a Technical Note[3])

6) FS = 2.0 (state of practice typical value)

t_{dsg} = 0.735 cm (0.29 inches)

Substituting in Equation (1): T_{all} = 23.3 cm^2/sec

Substituting in Equation (2): T_{dsg} = 11.6 cm^2/sec

k_{dsg} = 15.8 cm/sec

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[1] Giroud, J.P., Zornberg, J.G. and Zhao, A. 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", *Geosynthetics International*, Vol. 7, Nos. 4-6, pp.285-380.

[2] "Determination of the Allowable Flow Rate of a Drainage Geocomposite" GRI standard-GC8

[3] Technical Note, "Determining Creep Reduction Factor for Tri-Planar Geonets"

Case 2: Landfill Prior to Final Closure:

1) Estimated design load on landfill foundation = 15,000 psf

2) Ultimate Transmissivity = T_{ult} = 4.2 * 10E-3 m^2/sec = 42 cm^2/s

(geocomposite tested in soil boundary condition under 15,000 psf, and a seating period of 100 hours)

3) Using attached Table[1] for typical value of reduction factor: RF_{IN} = 1.2

4) Using attached Table[2] RF_{CC} = 2.0, RF_{BC} = 1.3

5) Using RF_{CR} = 1.2 (see attached a Technical Note[3])

6) FS = 2.0 (state of practice typical value)

t_{dsg} = 0.514 cm (0.20 inches)

Substituting in Equation (1): T_{all} = 11.3 cm^2/sec

Substituting in Equation (2): T_{dsg} = 5.6 cm^2/sec

k_{dsg} = 11.0 cm/sec

Table 1. Guidance for the selection of some of the reduction factors on the flow capacity of geonets and geocomposites having a geonet transmissive core.

Examples of application	Normal stress	Liquid	RF_{IN}	RF_{CR}	RF_{CC}	RF_{BC}
Landfill cover drainage layer, Low retaining wall drainage	Low	Water	1.0 – 1.2	1.1 – 1.4	1.0 – 1.2	1.2 – 1.5
Embankment, Dams, Landslide repair, High retaining wall drainage	High	Water	1.0 – 1.2	1.4 – 2.0	1.0 – 1.2	1.2 – 1.5
Landfill leachate collection layer, Landfill leakage collection and detection layer, Leachate pond leakage collection and detection layer	High	Leachate	1.0 – 1.2	1.4 – 2.0	1.5 – 2.0	1.5 – 2.0

Notes: The reduction factors, RF_{IN}, RF_{CR}, RF_{CC}, and RF_{BC} are defined in Section 1.7.2. Table 1 was developed for the present paper, using some reduction factor values from Koerner (1998). Design engineers are cautioned that the values of the reduction factors may significantly vary depending on the type of geocomposite and the exposure conditions (stress, chemical composition of the soil and liquid). Also, as discussed in Section 1.7.2, RF_{IN} and RF_{CR} depend on the testing conditions under which the hydraulic transmissivity is measured. The reduction factor values given in Table 1 correspond to the case where the seating time exceeds 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test. Finally, due to lack of relevant data, no guidance is provided for RF_{CD} and RF_{PC}. Additional information on reduction factors may be found in a paper by Zanzinger and Gartung (1999).

Reference: Giroud, J.P., Zornberg, J.G. and Zhao, A. 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", *Geosynthetics International*, Vol. 7, Nos. 4-6, pp.285-380.

Table 2

Range of Clogging Reduction Factors (modified from Koerner, 1998)

Application	Chemical Clogging (RF_{CC})	Biological Clogging (RF_{BC})
Sport fields	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.0 to 1.2	1.1 to 1.3
Roof and plaza decks	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.1 to 1.5	1.0 to 1.2
Drainage blankets	1.0 to 1.2	1.0 to 1.2
Landfill caps	1.0 to 1.2	1.2 to 3.5
Landfill leak detection	1.1 to 1.5	1.1 to 1.3
Landfill leachate collection	1.5 to 2.0	1.1 to 1.3