Objective: Determine filter requirement for geotextile

1. Use soil results from ML-GS-02C.

Given: $D_{20} = 0.14$, $D_{10} = 0.05$, $C_c = 1.91$, $C_u = 17.74$

Method: Use Chart 1. (see attached) to determine Soil Retention criteria

From "Linear Particle Distribution Curve"

$d'_0 = 0.051$ mm, $d'_{100} = 5.818$ mm, $d'_{50} = 0.546$

$$C_u' = \sqrt{\frac{d'_{100}}{d'_0}} = 10.7$$

Assume compacted soil is dense

$$O_{95} < \frac{18}{C_u'} d'_{50}, \quad O_{95} = AOS$$

$$AOS < \frac{18}{10.7}(0.546) \rightarrow AOS < 0.918 \text{ mm}$$

Determine geotextile permeability requirements:

Assume $K_s = 1 \times 10^{-3}$ cm/s

$i_s = 1.5$ (for landfill Surface Water Collection & Removal System)

$K_g \geq i_s K_s \rightarrow K_g \geq (1.5)(1 \times 10^{-3} \text{ cm/sec})$

$K_g \geq 1.5 \times 10^{-3}$ cm/sec

Determine anti-clogging requirements:

- Use largest AOS that satisfies retention criteria
- Use largest porosity, not < 30%

Determine survivability requirements

See table 2.

2. For ML-TPD1 B/02C:

$D_{20} = 0.31$, $D_{10} = 0.16$, $C_c = 1.20$

$d_0' = 0.161$, $d_{100}' = 5.373$, $d_{50}' = 0.930$

$C_u' = \frac{5.373}{0.161} \rightarrow C_u' = 5.8$

Assume soil is dense

$AOS < \frac{18}{5.8}(0.930) \rightarrow AOS < 2.9\ mm$

$K_g$ is same as ML-GS-02C.

# EP THREE:

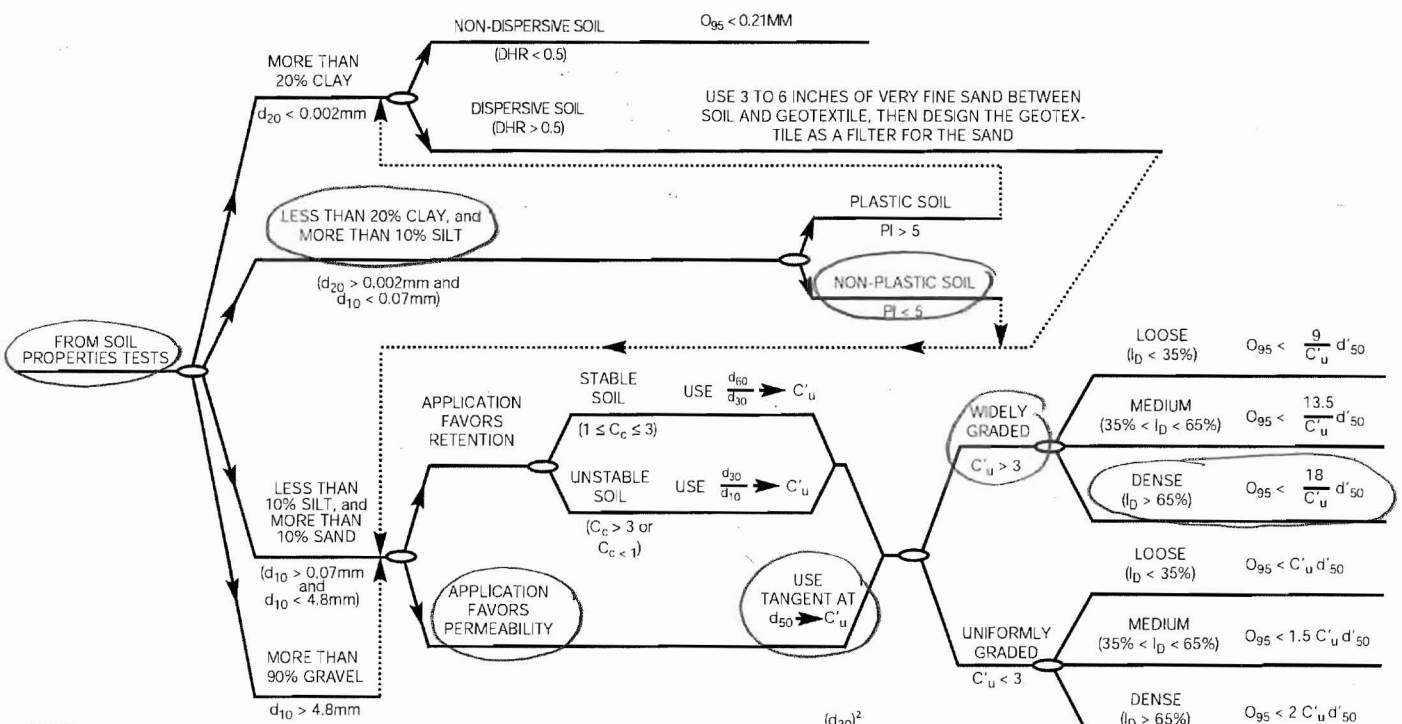
## DETERMINE SOIL RETENTION REQUIREMENTS

Charts 1 and 2 indicate the use of particle-size parameters for determing retention criteria. These charts show that the amount of gravel, sand, silt and clay affects the retention criteria selection process. Chart 1 shows the numerical retention criteria for steady-state flow conditions; Chart 2 is for dynamic flow conditions.

For predominantly coarse grained soils, the grain-size distribution curve is used to calculate specific parameters such as $C_u$, $C'_u$, $C_c$, that govern the retention criteria.

ML-GS-02C

***Chart 1. Soil Retention Criteria of Steady-State Flow Conditions***




NOTES:

$d_x$ = particle diameter of which size *x* percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: $d'_{100}$ and $d'_0$ are the extremeties of a straight line drawn through the particle-size distribution, as directed above and $d'_{50}$ is the midpoint of this line

$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

$I_D$ = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil
$O_{95}$ = geotextile opening size

## Solution

**Input data**

**Actual Particle Distribution Curve**

| | |
|---|---|
| $d_{10}$ | 0.05 mm |
| $d_{20}$ | 0.14 mm |
| $d_{50}$ | 0.5 mm |
| $d_{60}$ | .86 mm |
| $d_{85}$ | 3 mm |

**Output Data**

**Values of the Linear Particle Distribution Curve**

| | |
|---|---|
| $d'_0$ | 0.051 mm |
| $d'_{10}$ | 0.082 mm |
| $d'_{20}$ | 0.132 mm |
| $d'_{50}$ | 0.546 mm |
| $d'_{60}$ | 0.876 mm |
| $d'_{85}$ | 2.861 mm |
| $d'_{100}$ | 5.818 mm |

**Coefficient of Determination ($R^2$)** **0.99858**

Indicates how acurate the linearization is

**Coefficient of Uniformity** **17.20**

&nbspIf greater than 1 and smaller than 5, it is said to be uniformly graded.

&nbspIf greater than 20, it is said to be broadly graded.

**Linear Coefficient of Uniformity** **10.66**

**Maximum Filter Opening Size** **0.922 mm**

## Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name*

Company

Email Address*

Phone

Project Reference

Comments

*required fields

Submit Design Results

# EP THREE:

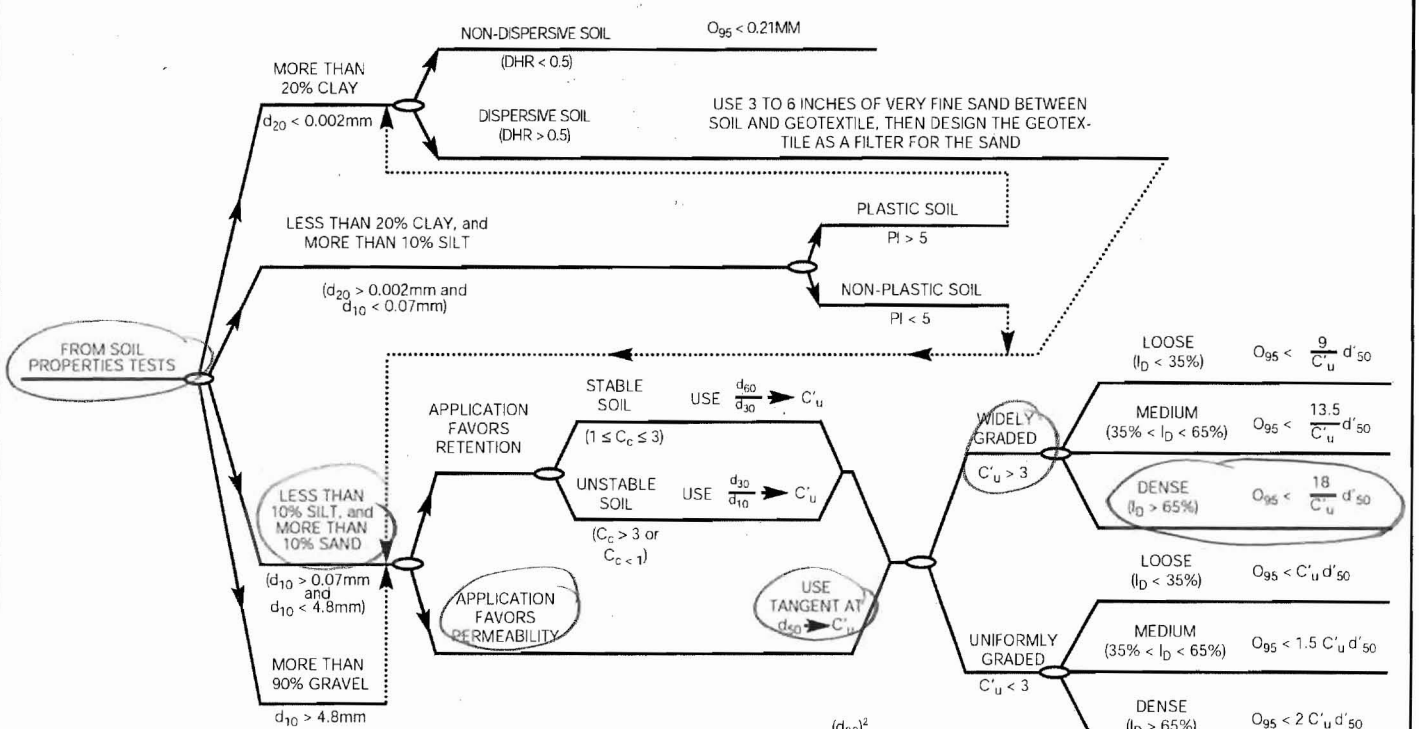
## DETERMINE SOIL RETENTION REQUIREMENTS

Charts 1 and 2 indicate the use of particle-size parameters for determing retention criteria. These charts show that the amount of gravel, sand, silt and clay affects the retention criteria selection process. Chart 1 shows the numerical retention criteria for steady-state flow conditions; Chart 2 is for dynamic flow conditions.

For predominantly coarse grained soils, the grain-size distribution curve is used to calculate specific parameters such as $C_u$, $C'_u$, $C_c$, that govern the retention criteria.

ML-TP01B/02C

***Chart 1. Soil Retention Criteria of Steady-State Flow Conditions***




NOTES:

$d_x$ = particle diameter of which size *x* percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: $d'_{100}$ and $d'_0$ are the extremeties of a straight line drawn through the particle-size distribution, as directed above and $d'_{50}$ is the midpoint of this line

$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

$I_D$ = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil
$O_{95}$ = geotextile opening size

## Solution

**Input data**

**Actual Particle Distribution Curve**

| | |
|---|---|
| $d_{10}$ | 0.16 mm |
| $d_{20}$ | 0.31 mm |
| $d_{50}$ | 1.01 mm |
| $d_{60}$ | 1.35 mm |
| $d_{85}$ | 3 mm |

**Output Data**

**Values of the Linear Particle Distribution Curve**

| | |
|---|---|
| $d'_0$ | 0.161 mm |
| $d'_{10}$ | 0.229 mm |
| $d'_{20}$ | 0.325 mm |
| $d'_{50}$ | 0.930 mm |
| $d'_{60}$ | 1.321 mm |
| $d'_{85}$ | 3.175 mm |
| $d'_{100}$ | 5.373 mm |

**Coefficient of Determination ($R^2$)** **0.99763**

Indicates how acurate the linearization is

**Coefficient of Uniformity** **8.44**

&nbspIf greater than 1 and smaller than 5, it is said to be uniformly graded.

&nbspIf greater than 20, it is said to be broadly graded.

**Linear Coefficient of Uniformity** **5.78**

**Maximum Filter Opening Size** **2.896 mm**

## Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name*

Company

Email Address*

Phone

Project Reference

Comments

*required fields

Submit Design Results

**ENGINEERING/REMEDIATION RESOURCES GROUP, INC.**

ERRG

BY L. BINNING DATE 10/1/08 CLIENT FOREST SERVICE SHEET 1 OF 1

CHECKED BY D. TANG DESCRIPTION GEOCOMPOSITE TENSILE STRENGTH JOB NO. 28-072

OBJECTIVE : DETERMINE TENSILE STRENGTH REQUIREMENTS FOR GEOCOMPOSITE

ASSUMPTIONS : VEHICLE LOADING FROM DIRT BIKE

A TYPICAL DIRT BIKE WEIGHT = 250 lb

PLUS 250 lb RIDER

LOAD = 500 lb ; PER TIRE = 250 lb

TIRE TRACK CONTACT AREA = $4^{IN} \times 9^{IN} = 0.25\ FT^2$

CONTACT STRESS = $250\ lb / 0.25\ FT^2$

= 1000 PSF

METHOD : FROM NAVFAC DM 7.1-167, FIGURE 3

USE SQUARE FOOTING CASE TO DETERMINE VERTICAL STRESS

FOR B = 1 FT & Z = 3 FT OR 3B, $\sigma_z = 0.06P$

$\sigma_z = 0.06 (1000\ PSF) = 60\ PSF$

FOR $1^{FT}$ SECTION = 60 lb

STRUCTURAL EVALUATION : USE GSE PERMANET UL GEOCOMPOSITE ($6\ oz/YD^2$)

GRAB TENSILE 170 lb > 60 lb OK

PUNCTURE STRENGTH 90 lb > 60 lb OK

GSE®

GSE STANDARD PRODUCTS

# Product Data Sheet

## GSE PermaNet® UL Geocomposites (Double-Sided)

GSE PermaNet UL (Ultra Load) Geocomposites are drainage products manufactured with a geonet heat-bonded to a nonwoven, needlepunched geotextile on both sides. The creep resistant structure ensures continuous flow performance over a broad range of conditions and long durations. These products work as an efficient drainage medium and are ideal for extremely high compressive stress applications.

Depending on filtration and interface strength requirements of a specific project, GSE can bond any type of nonwoven, needlepunched geotextiles to the geonet. GSE PermaNet UL Geocomposites are available in a 6, 8, and 10 oz/yd$^2$ geotextile as described in the product specification chart below. For more information on the performance transmissivity under site-specific conditions, please contact a GSE representative.

GSE Advantage Products

GSE GundSeal • GSE Conductive • GSE White • GSE Permanet • GSE BioDrain System

### *Product Specifications*

| TESTED PROPERTY | TEST METHOD | FREQUENCY | AVERAGE VALUE | | |
|---|---|---|---|---|---|
| **Geocomposite** | | | 6 oz/yd$^2$ | 8 oz/yd$^2$ | 10 oz/yd$^2$ |
| Product Code | | | FR82060060T | FR82080080T | FR82100100T |
| Transmissivity[a], gal/min/ft (m$^2$/sec) | ASTM D 4716 | 1/540,000 ft$^2$ | 4.8 (1 x 10$^{-3}$) | 4.8 (1 x 10$^{-3}$) | 4.8 (1 x 10$^{-3}$) |
| Ply Adhesion, lb/in (g/cm) | ASTM D 7005 | 1/50,000 ft$^2$ | 1.0 (178) | 1.0 (178) | 1.0 (178) |
| Roll Width[b], ft (m) | | | 15 (4.5) | 15 (4.5) | 15 (4.5) |
| Roll Length[b], ft (m) | | | 150 (45) | 140 (42) | 130 (39) |
| Roll Area, ft$^2$ (m$^2$) | | | 2,250 (202) | 2,100 (189) | 1,950 (175) |
| **Geonet Properties** | | | AVERAGE VALUE | | |
| Transmissivity[c], gal/min/ft (m$^2$/sec) | ASTM D 4716 | | 24 (5 x 10$^{-3}$) | | |
| Compression Strength, lb/ft$^2$ (kPa) | ASTM D 1621 | 1/540,000 ft$^2$ | 40,000 (1,913) | | |
| Creep Reduction Factor | | once per formulation | 1.3 @ 25,000 psf | | |
| Thickness, mil (mm) | ASTM D 5199 | 1/50,000 ft$^2$ | 300 (7.6) | | |
| Density, g/cm$^3$ | ASTM D 1505 | 1/50,000 ft$^2$ | 0.94 | | |
| Tensile Strength (MD), lb/in (N/mm) | ASTM D 5035 | 1/50,000 ft$^2$ | 100 (17) | | |
| Carbon Black Content, % | ASTM D 1603*/4218 | 1/50,000 ft$^2$ | 2.0 | | |
| **Geotextile Properties[d]** | | | MINIMUM AVERAGE ROLL VALUE | | |
| Mass, oz/yd$^2$ (g/m$^2$) | ASTM D 5261 | 1/90,000 ft$^2$ | 6 (200) | 8 (270) | 10 (335) |
| Grab Tensile, lb (N) | ASTM D 4632 | 1/90,000 ft$^2$ | 170 (755) | 220 (975) | 260 (1,155) |
| Puncture Strength, lb (N) | ASTM D 4833 | 1/90,000 ft$^2$ | 90 (395) | 120 (525) | 165 (725) |
| AOS, US sieve (mm) | ASTM D 4751 | 1/540,000 ft$^2$ | 70 (0.21) | 80 (0.180) | 100 (0.150) |
| Permittivity, (sec$^{-1}$) | ASTM D 4491 | 1/540,000 ft$^2$ | 1.5 | 1.5 | 1.2 |
| Flow Rate, gpm/ft$^2$ (lpm/m$^2$) | ASTM D 4491 | 1/540,000 ft$^2$ | 110 (4,480) | 110 (4,480) | 85 (3,460) |
| UV Resistance, % retained | ASTM D 4355 (after 500 hours) | once per formulation | 70 | 70 | 70 |

**NOTES:**

- [a]This is an index transmissivity value measured at stress = 25,000 psf; gradient = 0.1; time = 15 minutes; boundary conditions = plate/geocomposite/plate. Contact GSE for performance transmissivity value for use in design.
- [b]Roll widths and lengths have a tolerance of ±1%.
- [c]This is an index transmissivity value measured at stress = 25,000 psf; gradient = 0.1; time = 15 minutes; boundary conditions = plate/geonet/plate
- [d]All geotextile properties are minimum average roll values except AOS ( in mm) which is a maximum average roll value (MaxARV); and UV resistance which is a typical value.
- *Modified.

DS023 PermaNetUL R05/06/08



| | | | | | |
|---|---|---|---|---|---|
| **North America** | GSE Lining Technology, Inc. | Houston, Texas | 800.435.2008 | 281.443.8564 | Fax: 281.230.6739 |
| **South America** | GSE Lining Technology Chile S.A. | Santiago, Chile | | 56.2.595.4200 | Fax: 56.2.595.4290 |
| **Asia Pacific** | GSE Lining Technology Company Limited | Bangkok, Thailand | | 66.2.937.0091 | Fax: 66.2.937.0097 |
| **Europe & Africa** | GSE Lining Technology GmbH | Hamburg, Germany | | 49.40.767420 | Fax: 49.40.7674234 |
| **Middle East** | GSE Lining Technology-Egypt | The 6th of October City, Egypt | | 20.2.828.8888 | Fax: 20.2.828.8889 |

www.gseworld.com

OBJECTIVE : TO DETERMINE FINAL CAP REINFORCEMENT SCHEDULE

GIVEN : 1) FINAL CAP – COMPACTED ON SITE SAND TO 90% COMPACTION

$\phi = 40°$ (TP-01B/02C DIRECT SHEAR TEST RESULT)

$C = 0$

AND OVERLYING GEOCOMPOSITE

$\phi = 37°$ (TP-01B/02C – GSE GEOCOMPOSITE)

ADHESION = 110 PSF

(NEGLECT ADHESION FOR LONG TERM)

USE $\phi = 37°$ AND $C = 0$ PSF IN DESIGN

$\gamma = 120$ PCF, $\gamma_{SUB} = 65$ PCF

2) VEHICLE LOADING FROM DIRT BIKE USE

a) ASSUME A TYPICAL VEHICLE WEIGHT OF 250 lb PLUS 250 lb RIDER

LOAD = 500 lb PER TIRE = 250 lb

b) ASSUME TIRE TRACK CONTACT AREA OF $4^{IN} \times 9^{IN} = 0.25\ FT^2$

c) STRESS = $250\ lb / 0.25\ FT^2$ = 1000 PSF

3) DESIGN IS CONSIDERED GROUNDWATER EFFECT

BEARING CAPACITY : $q_{ULT} = C N_c \left(1 + 0.3 \frac{B}{L}\right) + [\gamma_{SUB} + F(\gamma - \gamma_{SUB})] \times 0.4 B N_\gamma$

$q_{ALLOWABLE} = q_{ULT}/3$ (NAVFAC 7.2-132)

SQUARE CONTACT AREA , $B = L = 1$ FT

$\phi = 37°$ , $N_\gamma = 60$ (NAVFAC 7.2-131)

$C = 0$ , $N_C = 0$

SURFACE FOOTING , $N_q = 0$

$\gamma = 120$ PCF , $\gamma_{SUB} = 65$ PCF

TOTAL THICKNESS OF COVER = 4 FT

BASED ON HELP , PEAK HEAD = 33 INCES (2.8 FT)

$d = 4^{FT} - 2.8^{FT} = 1.2^{FT}$

$\frac{d}{B} = \frac{1.2}{1} = 1.2$ , $\phi = 40°$

$F \cong 0.9$ (NAVFAC 7.2-132)

$$q_{ULT} = \cancel{c N_C}^{0}\left(1 + 0.3\frac{B}{L}\right) + \left[\gamma_{SUB} + \cancel{F}^{0.9}(\gamma - \gamma_{SUB})\right] \times 0.4 B N_\gamma$$

$$q_{ULT} = [65 + 0.9(120 - 65)] \times 0.4 \times 1 \times 60$$

$$= 2{,}748 \text{ PSF}$$

$$q_{ALLOWABLE} = 2{,}748/3$$

$$= 916 \text{ PSF} < 1000 \text{ PSF}$$

ADDITIONAL REINFORCEMENT IS REQUIRED !

REINFORCEMENT DETERMINATION : VERTICAL LOAD = 1000 PSF

HORIZONTAL STRESS = 1000 PSF $\times K_A$
(NEAR CONTACT AREA)

$K_A = \tan^2(45 - \phi/2)$

$= \tan^2(45 - 37/2)$

$K_A = 0.25$

HORIZONTAL STRESS $\cong$ 250 PSF (NAVFAC 7.1-167)
@ 6" BELOW SURFACE

HORIZONTAL STRESS $\cong 0.4 \times 0.25 \times 1000$
@ 12" BELOW SURFACE $\cong$ 100 PSF

TOTAL HORIZONTAL STRESS = 350 PSF
FOR 1 FT SECTION = 350 lb/FT

NEGLECT HORIZONTAL STRESS BELOW 12 INCHES

GEOGRID SELECTION : MIRAFI BXG 11

TENSILE STRENGTH = 300 lb/FT
(@ 1% STRAIN
- KEEP STRAIN LOW TO
AVOID SEPARATION
POTENTIAL IN UNDERLYING
GEOCOMPOSITE & LLDPE)

TOTAL HORIZONTAL STRESS = 350 lb/FT

USE 2 LAYERS OF GEOGRID @ 6" & 12" BELOW GROUND SURFACE

TOTAL TENSILE STRENGTH = 600 lb/FT > 350

OK ; F.S. = 1.7

**Vector Engineering Inc.**
143E Spring Hill Drive, Grass Valley, CA 95945 (530)272-2448
**Laboratory Services**

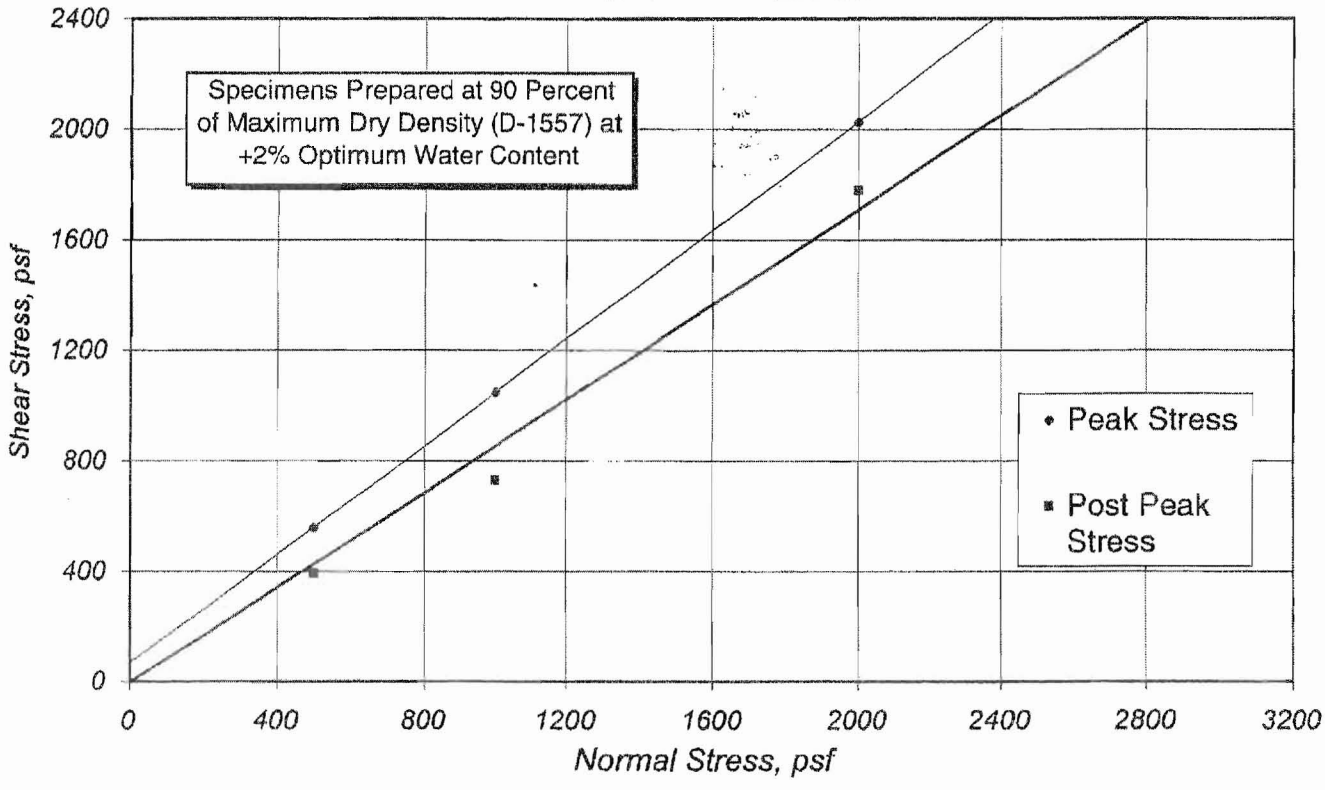
# DIRECT SHEAR REPORT

ASTM D- 3080, Consolidated - Drained Test

| Client / Project Name: | Project No. : | Lab Log: |
|---|---|---|
| ERRG / Meyers Landfill, # 28-072 | 071713.01 | 2589AR |

| Sample : | Soil Description: | Report Date: |
|---|---|---|
| ML-TP-01B / 02C Combined (Rec'd 7/25) | Well Graded Sand w/ Silt (SW-SM) | September 12, 2008 |

## STRENGTH ENVELOPE




| | | Peak | Post Peak |
|---|---|---|---|
| Coefficient of Friction | : | 0.978 | 0.842 |
| Friction Angle | : | 44.4 | 40.1 |
| Cohesion, psf: | : | 70 | 0 |

Note: Intercept changed to "0" for post peak

| Point No. | Normal Stress psf | Shear Stress Peak psf | Shear Stress Post-Peak psf | | Initial Water Content % | Initial Dry Density pcf | Final Water Content % | Final Dry Density pcf |
|---|---|---|---|---|---|---|---|---|
| 1 | 500 | 557 | 393 | | 13.6 | 105.1 | 18.0 | 105.7 |
| 2 | 1000 | 1048 | 729 | | 13.3 | 105.3 | 18.6 | 106.7 |
| 3 | 2000 | 2025 | 1780 | | 13.9 | 104.5 | 17.8 | 106.6 |

*Horizontal Displacement Rate, in. / min. :* 0.017 *Sample Diameter, in.:* 2.50

# Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

# LARGE SCALE DIRECT SHEAR REPORT

Test Method D-5321-B

Report Date: October 21, 2008

Client Name: ERRG  Project Name: **MEYERS LANDFILL, #28-072**  Project No: 071713.01

| | | | | |
|---|---|---|---|---|
| Superstrate: | ⇦ | Drain Gravel | | |
| Material 1: | ⇦ | ML-TP-01B & ML-TP-02C Mix (Well Graded Sand w/ Silt) | LSN: 2589A | Remolded |
| Material 2: | ⇨ | GSE PermaNet UL Geocomposite (Double sided 6 oz.) Roll# 131244854 | LSN: APZ | Clamped |
| Substrate: | ⇨ | ML-TP-01B & ML-TP-02C Mix (Well Graded Sand w/ Silt) | LSN: 2589A | Remolded |

***PEAK STRENGTH***

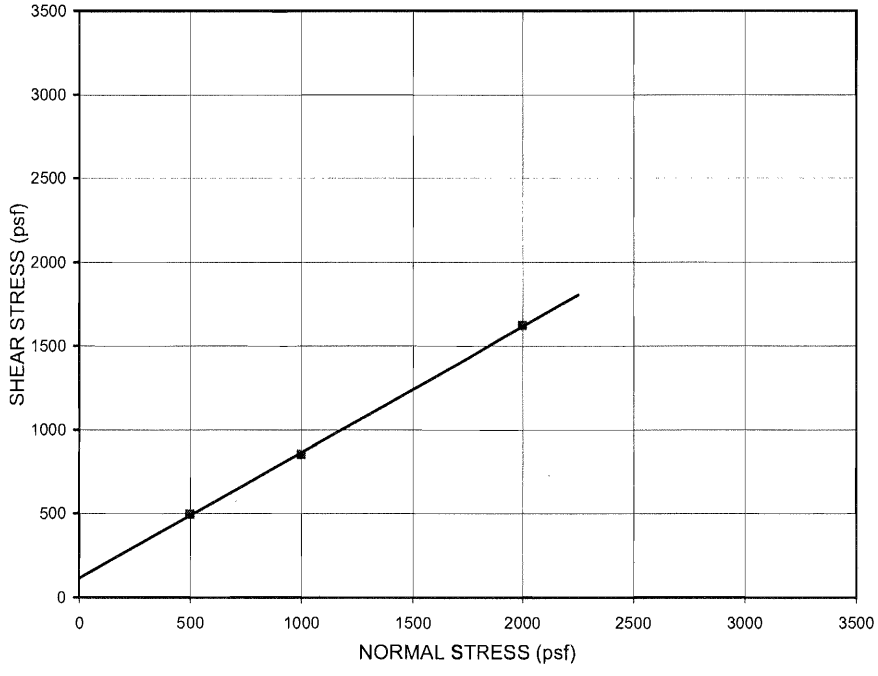
| Test Point | Normal Stress | | Shear Stress | Secant Friction Angle |
|---|---|---|---|---|
| | psi | psf | psf | |
| **1.** | 3.5 | 500 | 500 | 45 |
| **2.** | 6.9 | 1000 | 850 | 40 |
| **3.** | 13.9 | 2000 | 1620 | 39 |

*Adhesion:* 110 psf

*Friction Angle:* 37 degrees

*Coefficient of Friction:* 0.75

NOTE: GRAPH NOT TO SCALE




***STRENGTH ENVELOPE***

(at 3.0 in. displacement)

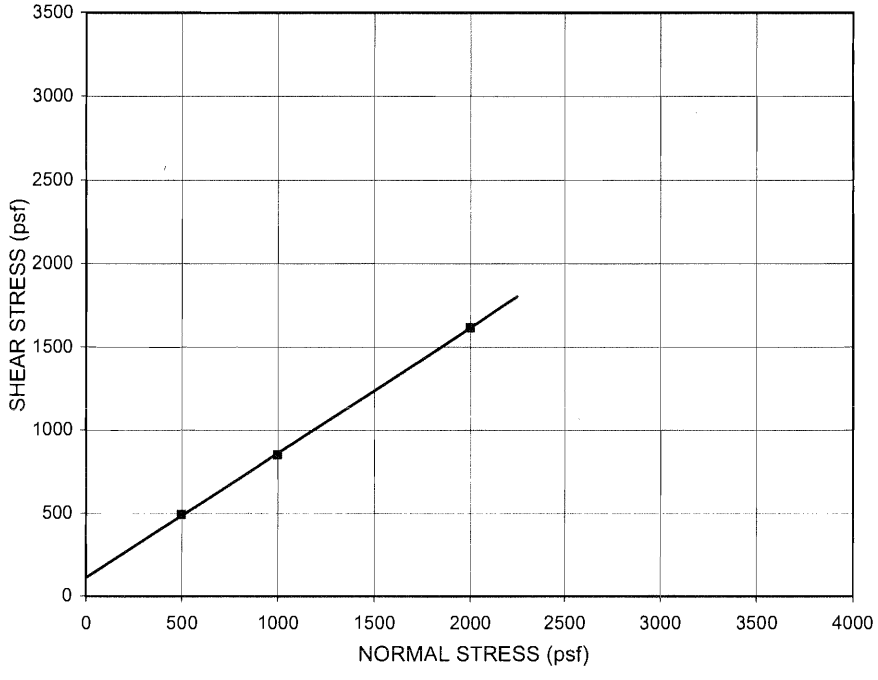
| Test Point | Normal Stress | | Shear Stress | Secant Friction Angle |
|---|---|---|---|---|
| | psi | psf | psf | |
| **1.** | 3.5 | 500 | 490 | 44 |
| **2.** | 6.9 | 1000 | 850 | 40 |
| **3.** | 13.9 | 2000 | 1620 | 39 |

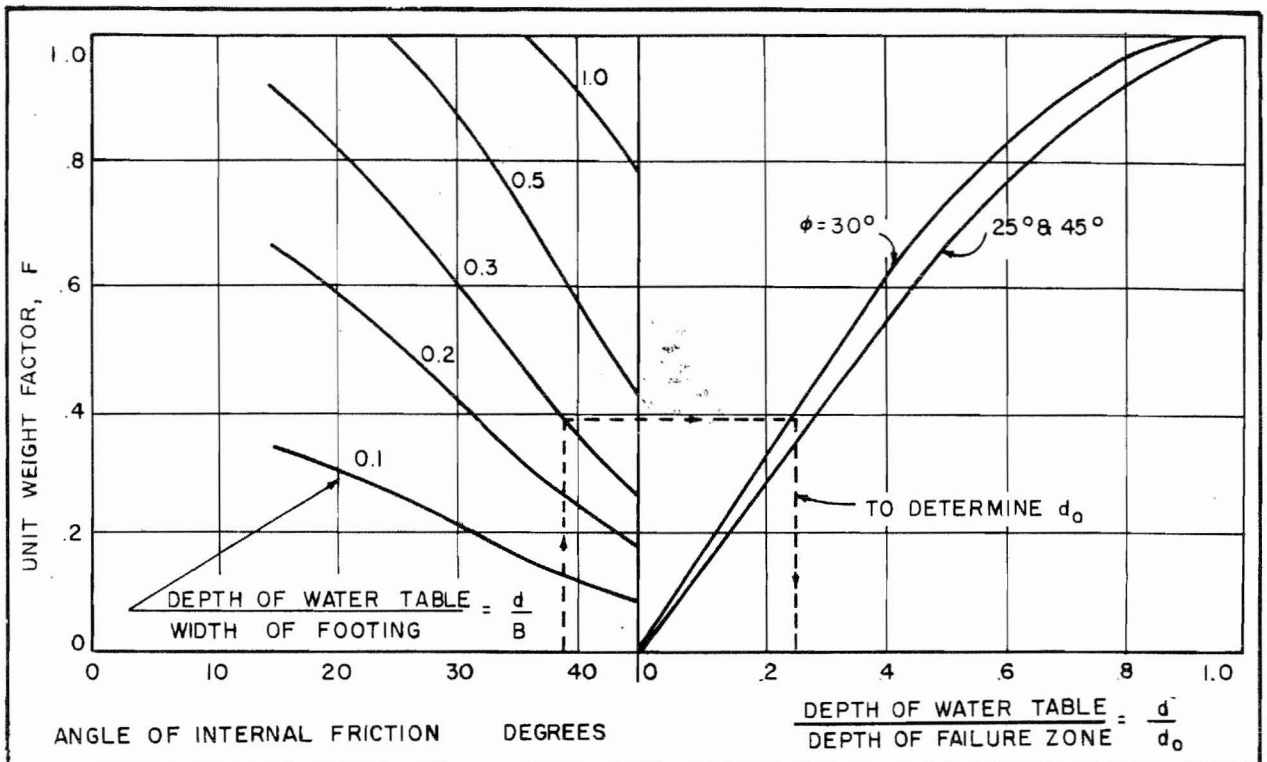
*Adhesion:* 110 psf

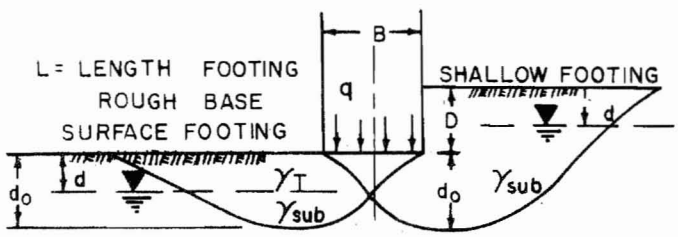
*Friction Angle:* 37 degrees

*Coefficient of Friction:* 0.75

NOTE: GRAPH NOT TO SCALE






ASSUMED CONDITIONS:

1. GROUNDWATER LEVEL IS HORIZONTAL
2. PRESENCE OF GROUNDWATER HAS NO EFFECT ON COHESIVE SOIL WITH $\phi$ = 0.

**CONTINUOUS FOOTING:**

**SURFACE FOOTING: D = 0**

$$q_{ult} = cN_c + \left[\gamma_{sub} + F(\gamma_T - \gamma_{sub})\right] \frac{B}{2} N\gamma$$

**SHALLOW FOOTING: D ≤ B**

IF $d \leq D$

$$q_{ult} = cN_c + \left[\gamma_{sub} D + (\gamma_T - \gamma_{sub})d\right] Nq + 0.5\gamma_{sub} BN\gamma$$

IF $D < d \leq (D + d_o)$

$$q_{ult} = cN_c + \gamma_T DNq + \left[\gamma_{sub} + F(\gamma_T - \gamma_{sub})\right] \frac{B}{2} N\gamma$$

VALUES OF BEARING CAPACITY FACTORS $N_c$ $N_q$ AND $N\gamma$ ARE SHOWN IN FIGURE 1.

**RECTANGULAR FOOTING:**

**SURFACE FOOTING: D = 0**

$$q_{ult} = cN_c\left(1 + .3\frac{B}{L}\right) + \left[\gamma_{sub} + F(\gamma - \gamma_{sub})\right] 0.4\, BN\gamma$$

**SHALLOW FOOTING:** $D \leq B$, IF $d \leq D$

$$q_{ult} = cN_c\left(1 + .3\frac{B}{L}\right) + \left[\gamma_{sub} D + (\gamma_T - \gamma_{sub})d\right] Nq + 0.4\gamma_{sub} BN\gamma$$

IF $D < d \leq (D + d_o)$

$$q_{ult} = cN_c\left(1 + .3\frac{B}{L}\right) + \gamma_T DNq + \left[\gamma_{sub} + F(\gamma_T - \gamma_{sub})\right] 0.4\, BN\gamma$$

**CIRCULAR FOOTING:** RADIUS = R = B/2

**SURFACE FOOTING:** D = 0

$$q_{ult} = 1.3cN_c + \left[\gamma_{sub} + F(\gamma_T - \gamma_{sub})\right] 0.6\, RN\gamma$$

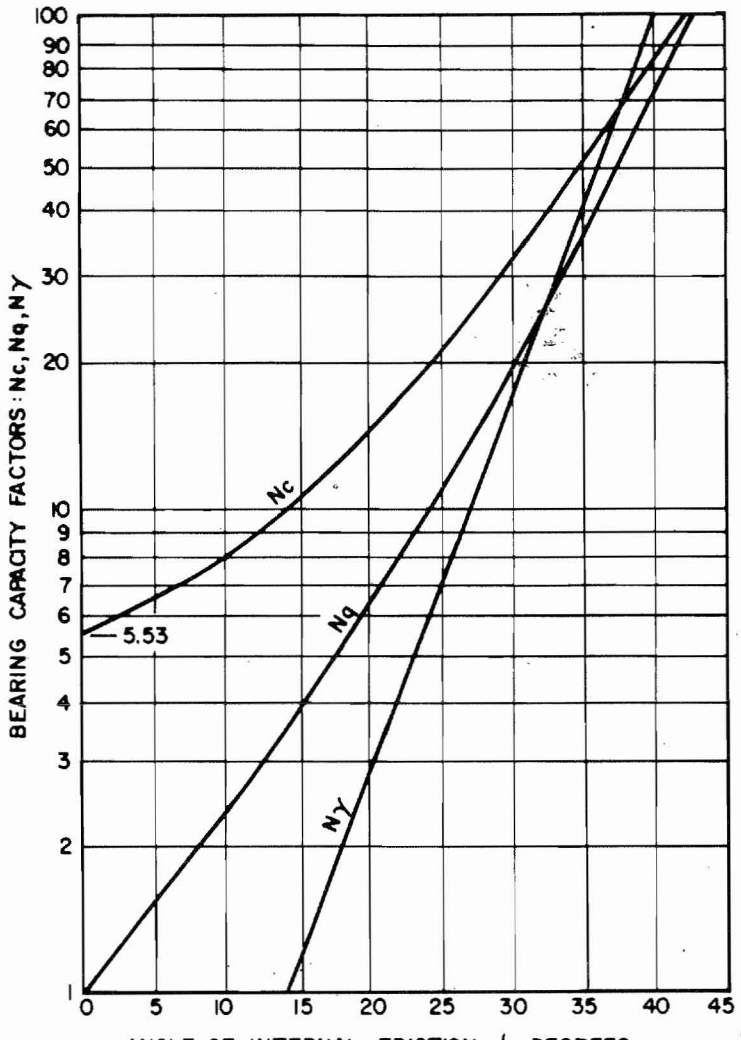
**SHALLOW FOOTING:** $D \leq 2R$, IF $d \leq D$

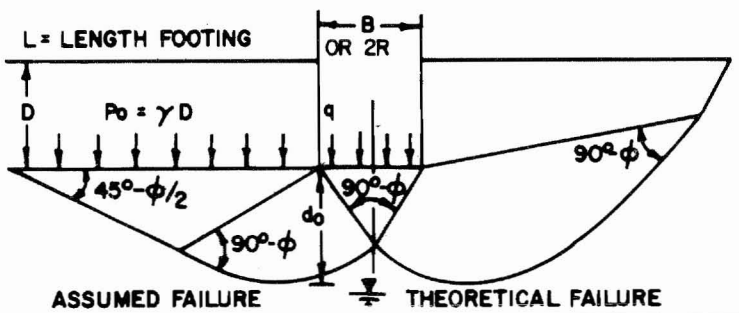
$$q_{ult} = 1.3\, cN_c + \left[\gamma_{sub} D + (\gamma_T - \gamma_{sub})d\right] Nq + 0.6\gamma_{sub} \cdot RN\gamma$$

IF $D < d \leq (D + d_o)$

$$q_{ult} = 1.3\, cN_c + \gamma_T DNq + \left[\gamma_{sub} + F(\gamma_T - \gamma_{sub})\right] 0.6RN\gamma$$

FIGURE 2
Ultimate Bearing Capacity With Groundwater Effect




ASSUMED CONDITIONS:

1. $D \leq B$
2. SOIL IS UNIFORM TO DEPTH $d_o > B$.
3. WATER LEVEL LOWER THAN $d_o$ BELOW BASE OF FOOTING.
4. VERTICAL LOAD CONCENTRIC.
5. FRACTION AND ADHESION ON VERTICAL SIDES OF FOOTING ARE NEGLECTED.
6. FOUNDATION SOIL WITH PROPERTIES $C, \phi, \gamma$

ULTIMATE BEARING CAPACITY = $q_{ult}$

CONTINUOUS FOOTING; GENERAL CASE

$q_{ult} = q' + q''$

$q'$ = PORTION OF BEARING CAPACITY ASSUMING WEIGHTLESS FOUNDATION SOIL

$q''$ = PORTION OF BEARING CAPACITY FROM WEIGHT OF FOUNDATION SOILS

$q' = cN_c + \gamma DN_q$

$q'' = \gamma \frac{B}{2} N\gamma$

$q_{ult} = cN_c + \gamma DN_q + \frac{\gamma B}{2} N\gamma$

SQUARE OR RECTANGULAR FOOTING

$q_{ult} = cN_c (1 + .3\frac{B}{L}) + \gamma DN_q + 0.4\gamma BN_\gamma$

CIRCULAR FOOTING: $R = B/2$

$q_{ult} = 1.3\, cN_c + \gamma DN_q + 0.6\gamma RN_\gamma$

FOR COHESIONLESS FOUNDATION SOILS ($c = 0$)

CONTINUOUS FOOTING:

$q_{ult} = \gamma DN_q + \frac{\gamma B}{2} N\gamma$

SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = \gamma DN_q + 0.4\gamma BN_\gamma$

CIRCULAR FOOTING:

$q_{ult} = \gamma DN_q + 0.6\gamma RN_\gamma$

FOR COHESIVE FOUNDATION SOILS ($\phi = 0$)

CONTINUOUS FOOTING:

$q_{ult} = cN_c + \gamma D$

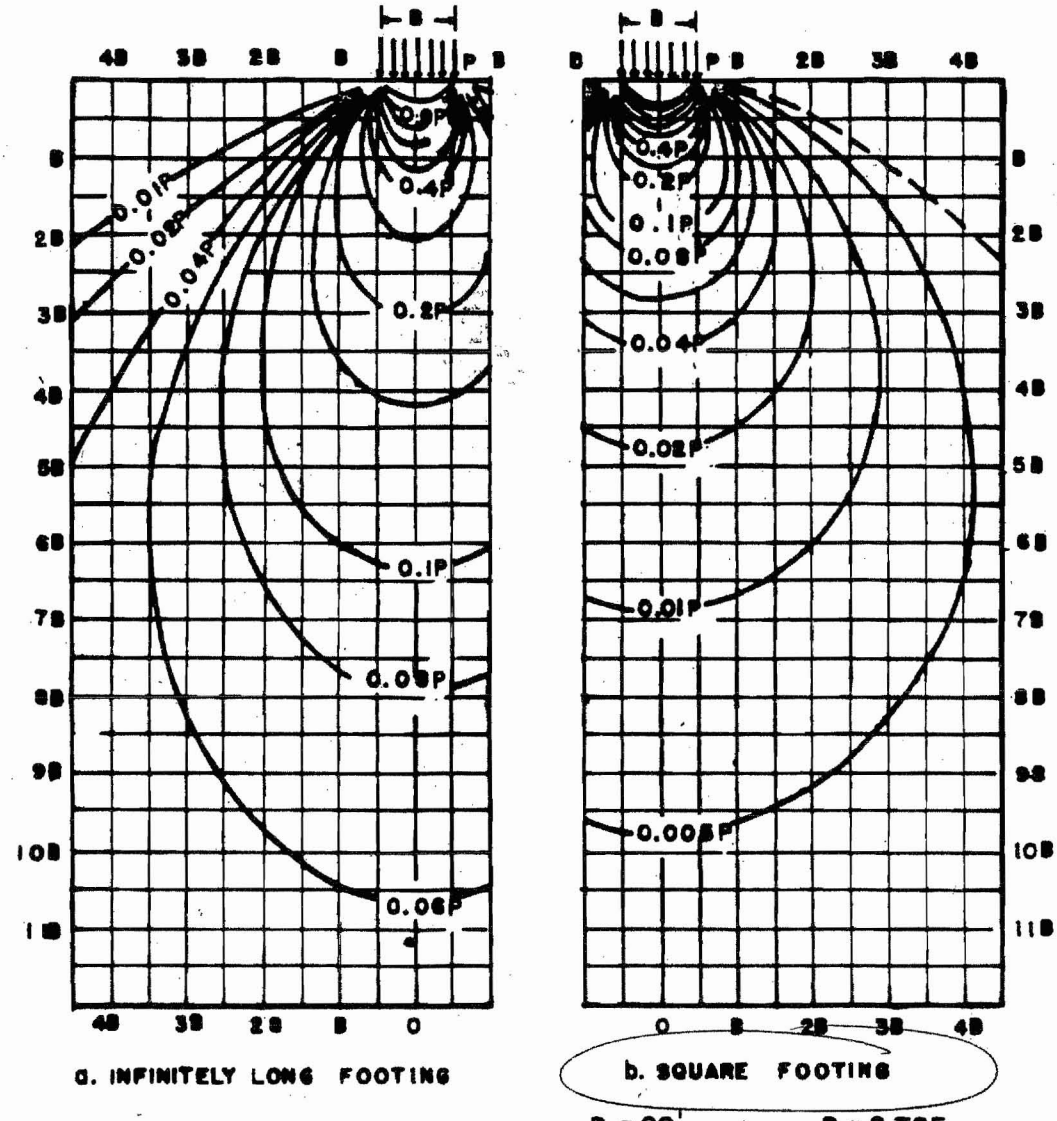
SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = cN_c (1 + .3\frac{B}{L}) + \gamma D$

CIRCULAR FOOTING:

$q_{ult} = 1.3\, cN_c + \gamma D$

FIGURE 1
Ultimate Bearing Capacity of Shallow Footings With Concentric Loads




a. INFINITELY LONG FOOTING

b. SQUARE FOOTING

B = 20' P = 2 TSF

SQUARE FOOTING

GIVEN

FOOTING SIZE = 20'X 20'

UNIT PRESSURE P=2TSF

FIND

PROFILE OF STRESS INCREASE BENEATH CENTER OF FOOTING DUE TO APPLIED LOAD

| $\frac{Z}{(FT)}$ | $\frac{Z}{B}$ | $\sigma_z$ TSF |
|---|---|---|
| 10 | 0.5 | 0.70 X 2 = 1.4 |
| 20 | 1 | 0.38 X 2 = 0.76 |
| 30 | 1.5 | 0.19 X 2 = 0.38 |
| 40 | 2.0 | 0.12 X 2 = 0.24 |
| 50 | 2.5 | 0.07 X 2 = 0.14 |
| 60 | 3.0 | 0.05 X 2 = 0.10 |

FIGURE 3
Stress Contours and Their Application

TENCATE
# Mirafi



## Mirafi® BXG 11

Mirafi® BXG 11 geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns which are woven in tension and finished with a PVC coating. Mirafi® BXG 11 geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

| Mechanical Properties | Test Method | Unit | Minimum Average Roll Value | |
|---|---|---|---|---|
| | | | MD | CD |
| Tensile Strength (at ultimate) | ASTM D 6637 | kN/m (lbs/ft) | 29.2 (2000) | 29.2 (2000) |
| Tensile Strength (at 1% strain) | ASTM D 6637 | kN/m (lbs/ft) | 4.4 (300) | 4.4 (300) |
| Tensile Strength (at 2% strain) | ASTM D 6637 | kN/m (lbs/ft) | 7.3 (500) | 7.3 (500) |
| Tensile Strength (at 5% strain) | ASTM D 6637 | kN/m (lbs/ft) | 13.4 (920) | 13.4 (920) |
| Tensile Modulus (at 1% strain) | ASTM D 6637 | kN/m (lbs/ft) | 437.8 (30000) | 437.8 (30000) |
| UV Resistance (at 500 hours) | ASTM D 4355 | % strength retained | 70 | |

| Physical Properties | Test Method | Unit | Typical Value |
|---|---|---|---|
| Percent Open Area | COE CW-02215 | % | 70 |
| Grid Aperture Size (MD) | -- | mm (in) | 25.4 (1.0) |
| Grid Aperture Size (CMD) | -- | mm (in) | 25.4 (1.0) |
| Mass/Unit Area | ASTM D 5261 | $g/m^2$ ($oz/yd^2$) | 308.5 (9.1) |
| Roll Dimensions (width x length) | -- | m (ft) | 4 (13.1) x 50 (164) |
| Roll Area | -- | $m^2$ ($yd^2$) | 200 (239) |
| Estimated Roll Weight | --- | kg (lbs) | 80 (176) |



TENCATE
materials that make a difference

**Scope/Objective:**
The objective of this calculation is to determine the settlement in the refuse over the 30-year post closure period to evaluate if slope reverse will occur.

**Assumptions:**
The compression characteristics of the refuse are constant throughout the entire depth. Existing refuse has already undergone the both primary and secondary settlement.

**1. Primary Settlement from Regrading of Refuse and Multilayer Cap Surcharge**

**Method:**

From NAVFAC DM 7.3, Section 6, Special Problem Soil:

$$\Delta H = H \frac{C_c}{1 + e_0} \log\left(\frac{\sigma'_0 + \Delta p'}{\sigma'_0}\right)$$

$$\frac{C_c}{1 + e_0} = 0.1 \text{ to } 0.4$$

Use 0.25 for settlement in the additional refuse (average value)
Use 0.10 for settlement in the existing refuse (low value, assumes that primary settlement has already occurred)

**2. Secondary Settlement from Regrading of Refuse and Multilayer Cap Surcharge**

**Method:**

From NAVFAC DM 7.3, Section 6, Special Problem Soil:

$$\Delta H = H C_\alpha \log\left(\frac{t_2}{t_1}\right)$$

$$C_\alpha = 0.02 \text{ to } 0.07$$

Use 0.04 for settlement in the additional refuse (average value)
Use 0.02 for settlement in the existing refuse (low value, assumes that secondary settlement has already occurred)

$t_1$ = time for pseudo-primary settlement to occur after completion of fill
$t_1$ = 1 to 4 months (NAVFAC 7.3)
Use $t_1$ = 4 months

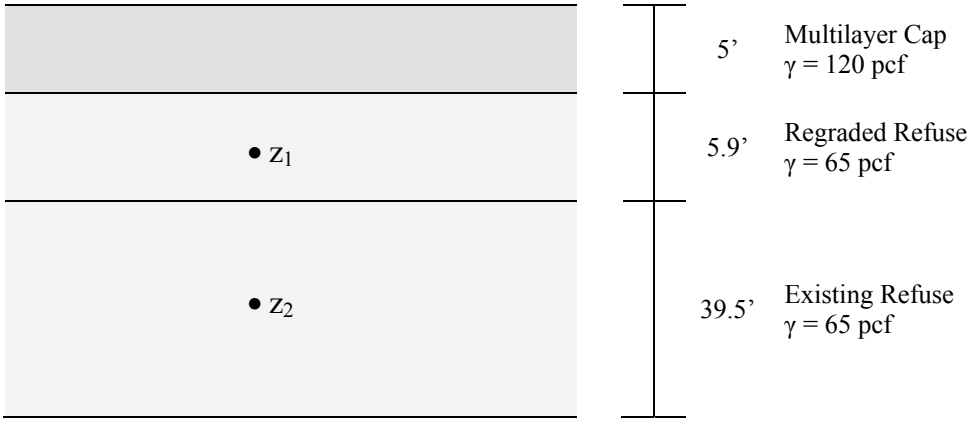
$t_2$ = 30 years (post-closure period)

**Results:**

| | Waste Thickness (ft) | | $z_1$ | | $z_2$ | | $\Delta H_p$ | $\Delta H_s$ | $\Delta H$ total |
|---|---|---|---|---|---|---|---|---|---|
| Point | Additional | Existing | $\sigma'_0$ (psf) | $p'_0$ (psf) | $\sigma'_0$ (psf) | $p'_0$ (psf) | (psf) | (psf) | (psf) |
| a | 0.0 | 32.4 | 0 | 600 | 1054 | 600 | 0.6 | 1.3 | 1.9 |
| b | 0.7 | 23.7 | 22 | 600 | 772 | 645 | 0.9 | 1.0 | 1.9 |
| c | 10.2 | 46.9 | 333 | 600 | 1523 | 1265 | 2.4 | 2.6 | 5.0 |
| d | 16.5 | 35.0 | 535 | 600 | 1136 | 1669 | 2.7 | 2.7 | 5.4 |
| e | 3.3 | 23.3 | 109 | 600 | 757 | 817 | 1.4 | 1.2 | 2.6 |
| f | 0.0 | 22.3 | 0 | 600 | 724 | 600 | 0.6 | 0.9 | 1.5 |
| g | 14.2 | 29.3 | 462 | 600 | 951 | 1525 | 2.5 | 2.3 | 4.8 |
| h | 10.8 | 40.8 | 350 | 600 | 1326 | 1299 | 2.4 | 2.4 | 4.8 |
| i | 5.9 | 39.5 | 190 | 600 | 1285 | 981 | 1.9 | 2.0 | 3.9 |

**Sample Calculation for point i:**

**Given:**




**Calculation:**

1. **Primary Settlement**

At point $z_1$:

$$\sigma'_0 = \frac{5.9 \text{ ft}}{2}(65 \text{ pcf})$$

$$\sigma'_0 = 191.8 \text{ psf}$$

$$\Delta p' = (5 \text{ ft})(120 \text{ pcf})$$

$$\Delta p' = 600 \text{ psf}$$

At point $z_2$:

$$\sigma'_0 = \frac{39.5 \text{ ft}}{2}(65 \text{ pcf})$$

$$\sigma'_0 = 1283.8 \text{ psf}$$

$$\Delta p' = (5 \text{ ft})(120 \text{ pcf}) + (5.9 \text{ ft})(65 \text{ pcf})$$

$$\Delta p' = 983 \text{ psf}$$

Primary Settlement:

$$\Delta H_p = (5.9 \text{ ft})(0.25)\log\left(\frac{192 \text{ psf} + 600 \text{ psf}}{192 \text{ psf}}\right) + (39.5 \text{ ft})(0.1)\log\left(\frac{1284 \text{ psf} + 983 \text{ psf}}{1284 \text{ psf}}\right)$$

$$\Delta H_p = 0.9 \text{ feet} + 1.0 \text{ feet}$$

$$\Delta H_p = 1.9 \text{ feet}$$

**2. Secondary Settlement**

$$\Delta H_s = HC_\alpha \log\left(\frac{t_2}{t_1}\right)$$

$$\Delta H_s = (5.9 \text{ feet})(0.04)\log\left(\frac{30 \text{ years}}{0.33 \text{ years}}\right) + (39.5 \text{ feet})(0.02)\log\left(\frac{30 \text{ years}}{0.33 \text{ years}}\right)$$

$$\Delta H_s = 1.5 \text{ feet} + 0.5 \text{ feet}$$

$$\Delta H_s = 2.0 \text{ feet}$$

**3. Total Settlement**

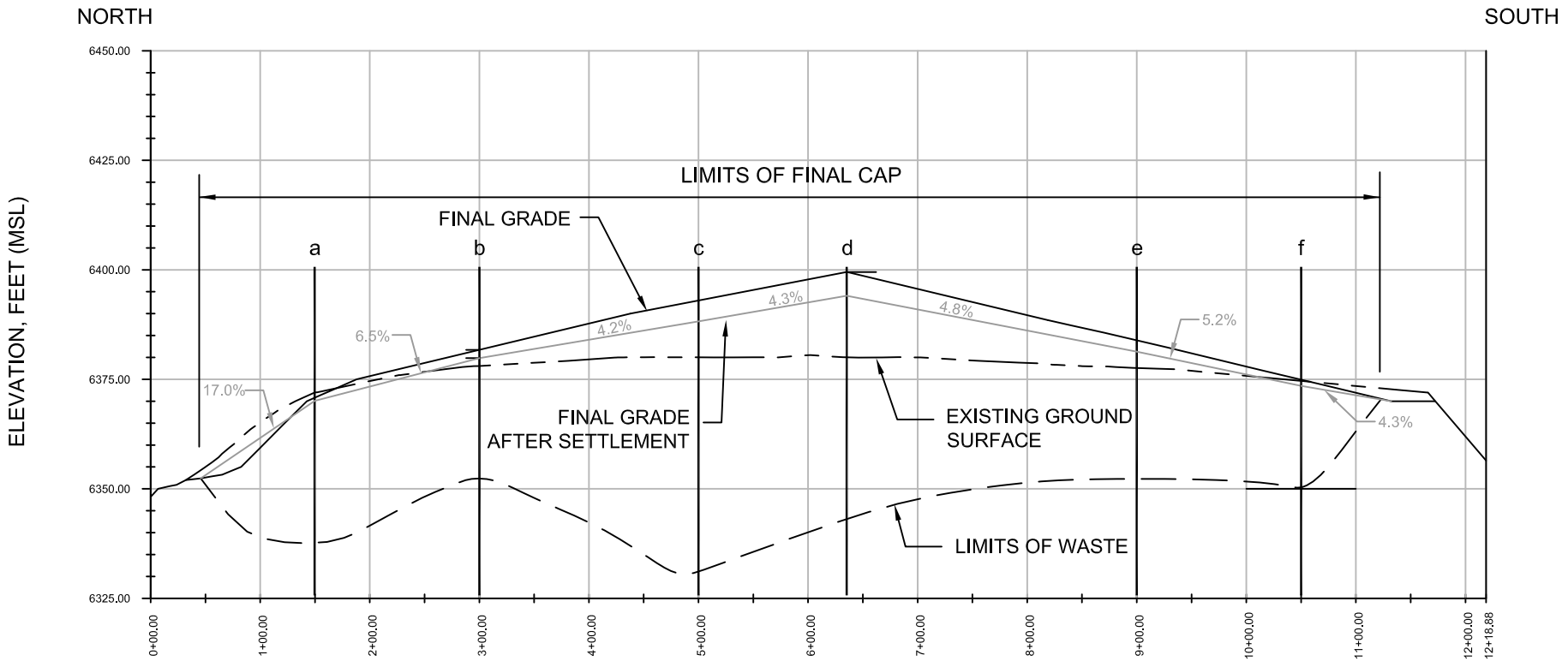
$$\Delta H_T = H_p + H_s$$

$$\Delta H_T = 1.9 \text{ feet} + 2.0 \text{ feet}$$

$$\Delta H_T = 3.9 \text{ feet}$$

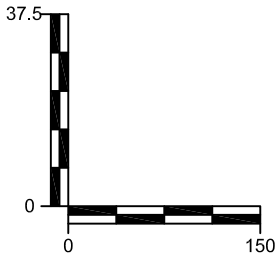
**References:**


1. NAVFAC DM 7.3, April 1983.




SECTION E-E'

SEE DRAWING 6




APPROXIMATE SCALE IN FEET
VERTICAL EXAGGERATION = 4X

ERRG
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| | | | | | | |
|---|---|---|---|---|---|---|
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| | CHECKED BY: EB 11-24-08 | | | | | |
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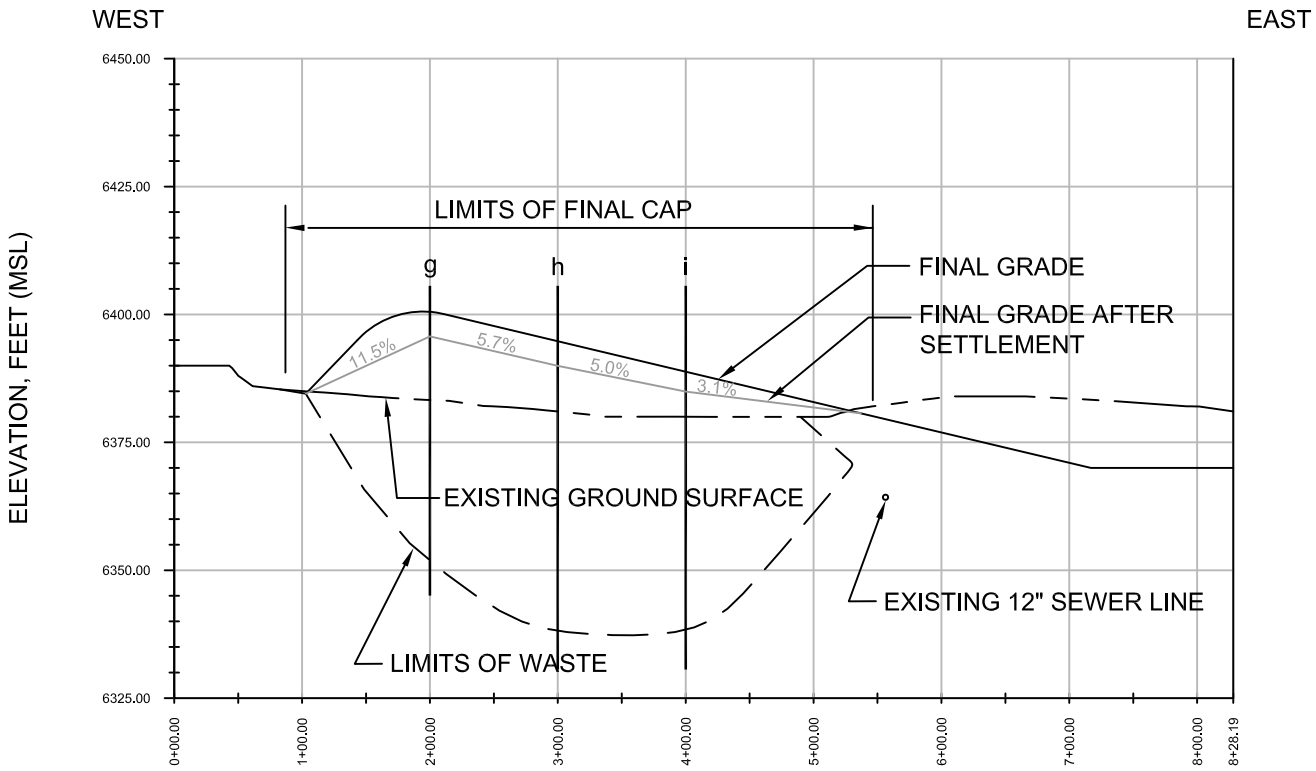
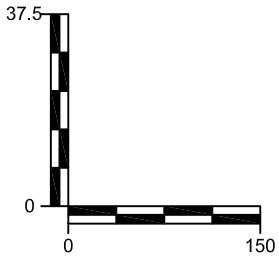



SECTION F-F'
SEE DRAWING 6

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| LOCATION: MEYERS LANDFILL EL DORADO COUNTY, CA | P.E/P.G.: DT 11-24-08 | ERRG PROJECT NO. 28-072 | REV. NO. 0 | SHEET 1 | OF 1 | FIG NO. D-11 |

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