SWMU 73-001(a-d)

Goering, Darlene, NMENV

From: John Keck [jkeck@northwind-inc.com]
Sent: Tuesday, September 26, 2006 2:12 PM
To: Nur, Mohamed
Cc: Stephen Matier; djorgensen@northwind-inc.com; Keshian, Berg; Harpur, Andrew; Goering, Darlene, NMENV; Enz, Robert D.
Subject: Emailing: Veneer Stability 9-25-06.doc

Attachments: Veneer Stability 9-25-06.doc

Veneer Stability 9-25-06.doc (...

<<Veneer Stability 9-25-06.doc>> Mohamed, the slope stability analysis we discussed earlier this month is attached, sorry for the delay. Please reply if you have questions or comments, thanks.

The message is ready to be sent with the following file or link attachments:

Veneer Stability 9-25-06.doc

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VENEER STABILITY ANALYSES
SIDE SLOPE COVER SYSTEM

OBJECTIVE

To assess the veneer stability of the proposed sideslope cover system.

BACKGROUND

The proposed sideslope cover system cross-section is shown on Attachment 1. These materials will be placed on both the 3H:1V north and 4H:1V east slopes. The north and east slopes are shown on Attachment 2. The proposed cover system configuration will promote run-off and will minimize infiltration. Test data for the proposed Infiltration Layer soil is presented in Attachment 3.

ANALYSIS

A traditional infinite slope analysis was used to assess the stability of the cover soil (sloughing analysis).

1. Internal stability (sloughing) of the cover soils - Infinite Slope Analysis

Sloughing is evaluated to account for possible shallow failure within the final cover soil and is a function of the soil strength properties, density and moisture conditions. Two conditions were evaluated: a moist condition and a condition considering a hydrostatic seepage force within the cover soil. Given the fine-grained composition of the infiltration layer soil (CL), and in consideration of the inclination of the slopes on which it will be placed (4H:1V to 3H:1V), it is expected that the majority of precipitation will run-off the slope rather than infiltrate into the cover soil.

<u>1. SLOUGHING ANALYSIS – infinite slope:</u>

Sloughing of the final cover soil can be evaluated using the infinite slope equation shown below (Hausmann, 1990). A minimum factor-of-safety of 1.5 is typically required for long-term, steady-state stability. The analysis was completed conservatively assuming no cohesion in the cover soil, an internal friction angle of 26.6°, a slope inclination of 3H:1V (18.4° or 33%) and a cover soil thickness of 24 inches. These parameters are representative of the proposed site conditions.

$$FS = \frac{c' + (z * \gamma * \cos^2 \beta - \mu) * \tan \phi'}{(z * \gamma * \cos \beta * \sin \beta)}$$

where:

z = 2 feet = cover soil thickness
γ = 118 pcf = unit weight of composite soil sample @ 95% DOC
β = 18.4° (3H:1V, 33%) = north slope angle
ϕ' = 26.6° = from literature for CL material reduced by 5% to

reflect 95% DOC – see Attachment 4
c' = 0 psf = cover soil cohesion (conservative estimate)
$\mu = h_w * \gamma_w * \cos^2\beta = 0$ = long term hydrostatic pressure
$h_w = 0$ = height of water within cover soil

$$FS = \frac{0\ psf + ((2\ ft * 118\ pcf * \cos^2 18.4°) - 0\ psf) * \tan 26.6°}{(2\ ft * 118\ pcf * \cos 18.4° * \sin 18.4°)} = 1.51$$

FS = 1.51 > 1.5 ok

The effects of seepage forces on final cover soil stability are normally evaluated. The analysis was completed assuming 25%, 50%, and 75% saturation of the cover soil.

where: $\mu = h_w * \gamma_w * \cos^2\beta$
$= (0.5\ ft) * 62.4\ pcf * \cos^2 18.4° = 28.1$ psf (25% saturation)

$$FS = \frac{0\ psf + ((2\ ft * 118\ pcf * \cos^2 18.4°) - 28.1\ psf) * \tan 26.6°}{(2\ ft * 118\ pcf * \cos 18.4° * \sin 18.4°)} = 1.31$$

FS = 1.31 > 1.3 ok

where: $\mu = h_w * \gamma_w * \cos^2\beta$
$= (1.0\ ft) * 62.4\ pcf * \cos^2 18.4° = 56.2$ psf (50% saturation)

$$FS = \frac{0\ psf + ((2\ ft * 118\ pcf * \cos^2 18.4°) - 56.2\ psf) * \tan 26.6°}{(2\ ft * 118\ pcf * \cos 18.4° * \sin 18.4°)} = 1.11$$

FS = 1.11 < 1.3 ng

where: $\mu = h_w * \gamma_w * \cos^2\beta$
$= (1.5\ ft) * 62.4\ pcf * \cos^2 18.4° = 84.3$ psf (75% saturation)

$$FS = \frac{0\ psf + ((2\ ft * 118\ pcf * \cos^2 18.4°) - 84.3\ psf) * \tan 26.6°}{(2\ ft * 118\ pcf * \cos 18.4° * \sin 18.4°)} = 0.91$$

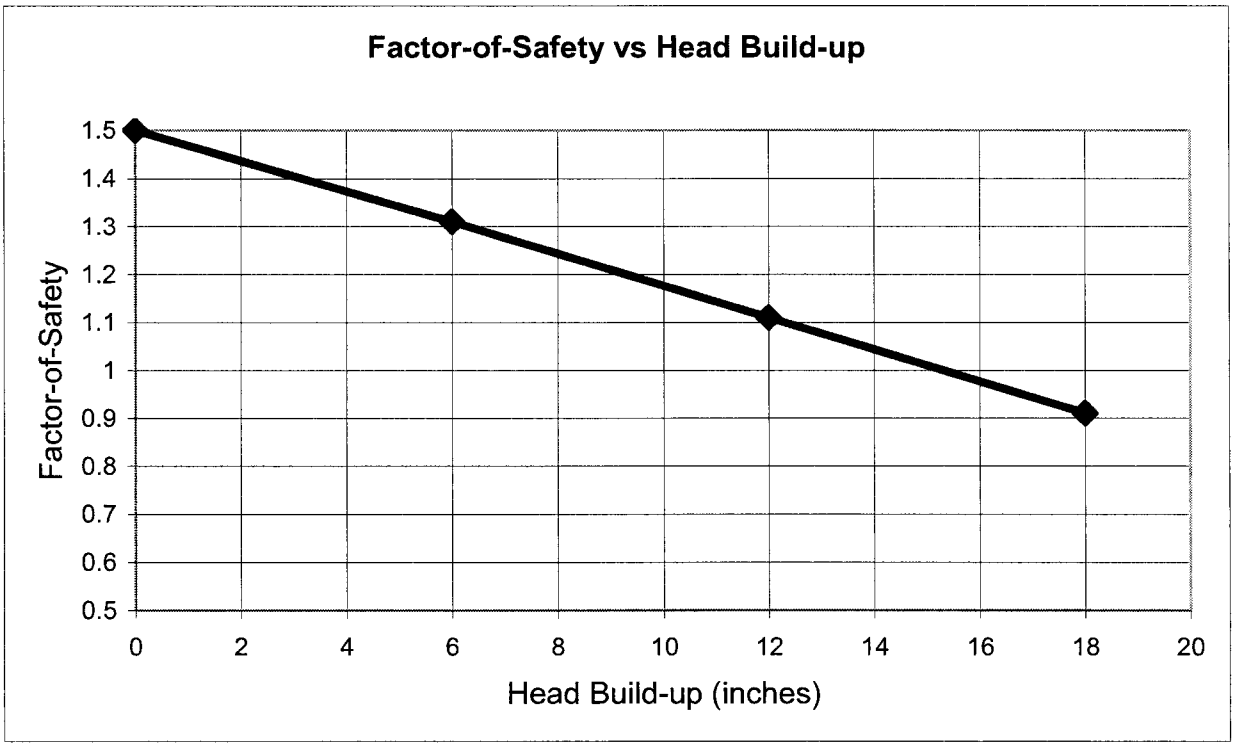
FS = 0.91 < 1.3 ng

RESULTS

Based on the analyses it can be seen that under normal (moist) conditions the sideslope soils will be stable as evidenced by a factor-of-safety greater than 1.5. Based on the hydrostatic conditions analyzed, it can be seen that if the infiltration layer was to become more than 25% saturated (6 inches) that the factor-of-safety would fall below the desired

short-term value of 1.3. A saturation depth of 15 inches (≈60%) represents an incipient failure condition, i.e., factor-of-safety of 1.0. The variation between head build-up and factor-of-safety are shown on Figure 1.

Figure 1



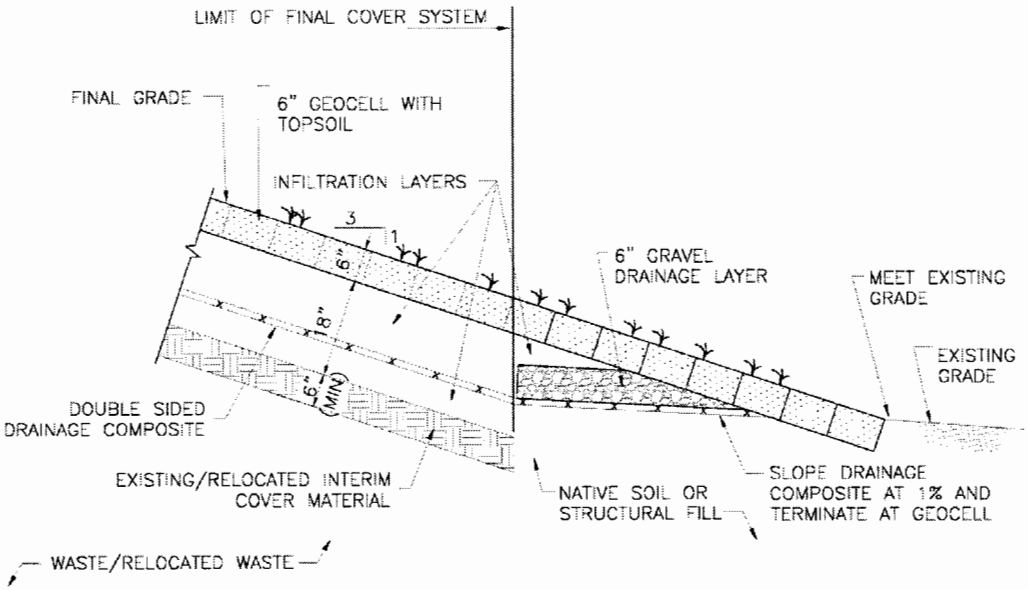
CONCLUSIONS

It can be concluded from these analyses that under normal (moist) conditions the sideslope of the landfill will remain stable. Should the cover soil become partially saturated on a temporary basis, the slope will continue to remain stable. In the unlikely event the cover soil was to be more than 60% saturated, there would be a significant risk for sloughing failures to occur. However, this is unlikely given the slope inclination and the fine-grained composition of the Infiltration Layer soil that is proposed for use as cover soil which will inhibit infiltration and promote runoff. The drainage composite included within the Infiltration Layer will provide a means to convey any water that infiltrates through the Infiltration Layer to the toe of the slope. It is therefore concluded that saturation of the Infiltration Layer is highly unlikely and that the cover system will remain stable.

REFERENCES

Hausmann, M.R. 1990. "*Engineering Principles of Ground Modification.*" McGraw-Hill Publishing Co.

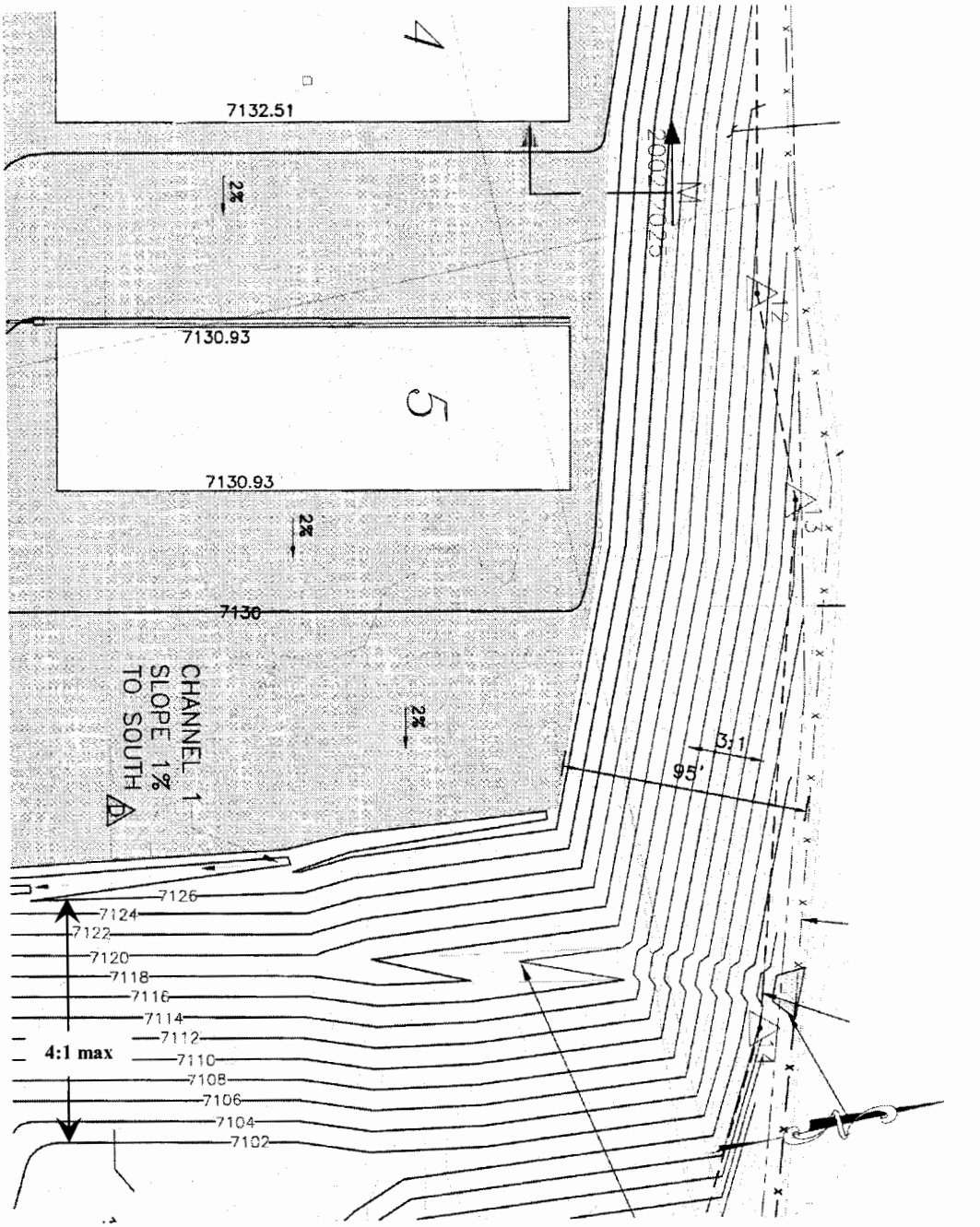
Attachment 1
Typical Sideslope Configuration



TYPICAL NORTH FACE TOE OF SLOPE – CROSS SECTION

SECTION A
N.T.S. 2002 2005

Attachment 2
Site Plan



Attachment 3
Infiltration Layer Soil Test Data

Particle Size Distribution Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	3.9	19.0	46.5	30.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in	100.0		
1/2 in.	98.9		
3/8 in.	98.0		
#4	96.1		
#8	94.4		
#10	94.1		
#16	92.5		
#30	89.8		
#40	88.6		
#50	87.5		
#100	84.9		
#200	77.1		

* (no specification provided)

Soil Description

Lean clay with sand

Atterberg Limits

PL= 18 LL= 27 PI= 9

Coefficients

D_{85}= 0.153 D_{60}= 0.0415 D_{50}= 0.0304
D_{30}= 0.0095 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO= A-4(4)

Remarks

F.M.=0.57

Sample No.: 06-102,103,104 **Source of Sample:** Composite of the Barrow Pit samples for Infil **Date:** 5/26/05
Location: Composite of the Barrow Pit samples for Infiltraion Material **Elev./Depth:** -1.0' to -5.0'

KLEINFELDER, INC.

Client: North Wind
Project: TA 73 Los Alamos Landfill
Project No: 71610 **PLATE**

COMPACTION TEST REPORT

Curve No.: 06-102,103,104

Project No.: 71610 **Date:** 5/24/06

Project: TA 73 Los Alamos Landfill

Location: Composite of the Barrow Pit samples for Infiltraion Material

Elev./Depth: -1 0' to -5 0' **Sample No.** 06-102,103,104

Remarks:

MATERIAL DESCRIPTION

Description: Lean clay with sand

Classifications - **USCS:** CL. From DM7 **AASHTO:** A-4(4)

Nat. Moist. = 13 6 % **Sp.G. =**

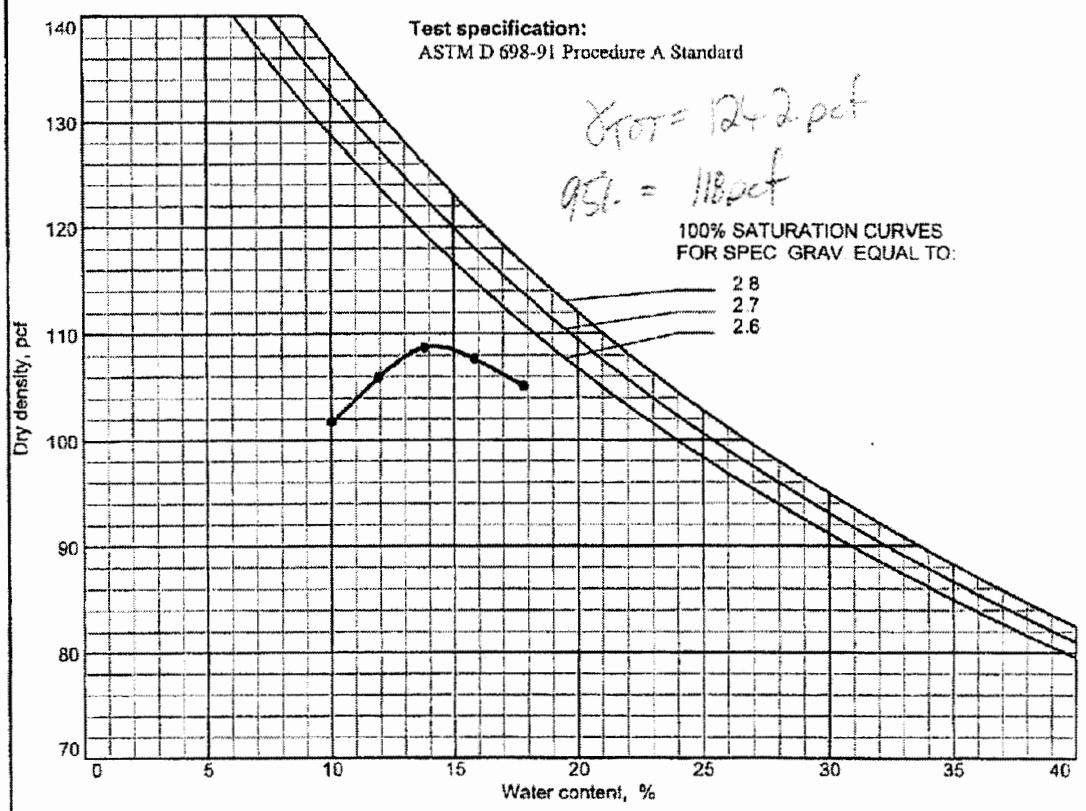
Liquid Limit = 27 **Plasticity Index =** 9

% > No.4 = % **% < No.200 =** 77 1 %

$\phi = 28°$ @100%

$\phi_{95} = 26.6°$

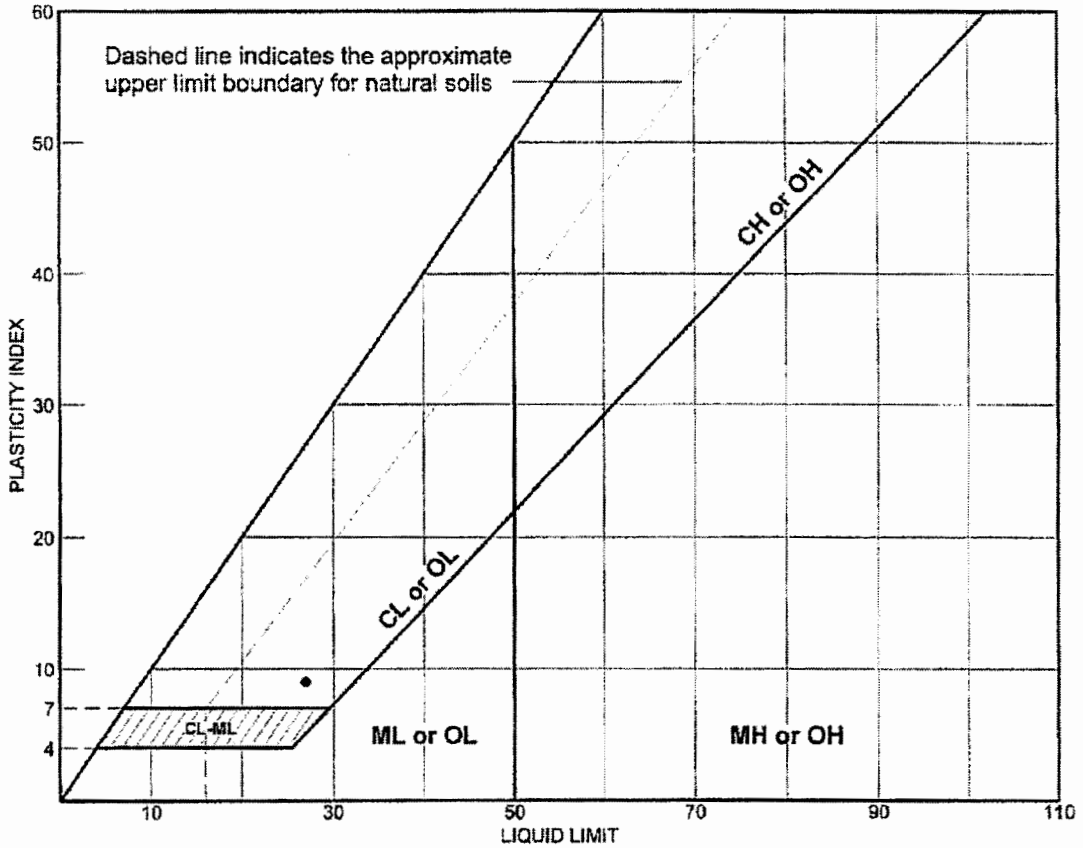
TEST RESULTS
Maximum dry density = 108.8 pcf
Optimum moisture = 14.2 %



PLATE

Kleinfelder, Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
•	Composite of	06-102,103,	-1.0' to -5.0'	13.6	18	27	9	CL

LIQUID AND PLASTIC LIMITS TEST REPORT

KLEINFELDER, INC.

Client: North Wind
Project: TA 73 Los Alamos Landfill
Project No.: 71610

PLATE

Attachment 4
Engineering Properties of Soil Based on Soil Classification

TABLE 3.31
TYPICAL PROPERTIES OF COMPACTED SOILS*

Group symbol	Soil type	Range of maximum dry unit weight, pcf	Range of optimum moisture, %	Typical value of compression: Percent of original height: At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Typical strength characteristics: Cohesion (as compacted), psf	Cohesion (saturated), psf	Effective stress envelope ϕ, degrees	tan ϕ	Typical coefficient of permeability, ft/min	Range of CBR values	Range of subgrade modulus k_s, lb/in³
GW	Well-graded clean gravels, gravel-sand mixtures	125–135	11–8	0.5	0.6	0	0	>38	>0.78	5×10^{-3}	40–80	300–500
GP	Poorly graded clean gravels, gravel-sand mix	115–125	14–11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30–60	250–400
GM	Silty gravels, poorly graded gravel-sand silt	120–135	12–8	0.5	1.1	...	...	>34	>0.67	$>10^{-4}$	20–60	100–400
GC	Clayey gravels, poorly graded gravel-sand-clay	115–130	14–9	0.7	1.6	...	...	>31	>0.60	$>10^{-7}$	20–40	100–300
SW	Well-graded clean sands, gravelly sands	110–130	16–9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20–40	200–300
SP	Poorly-graded clean sands, sand-gravel mix	100–120	21–12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10–40	200–300
SM	Silty sands, poorly graded sand-silt mix	110–125	16–11	0.9	1.6	1050	420	33	0.67	5×10^{-5}	10–40	100–300
SM-SC	Sand-silt clay mix with slightly plastic fines	110–130	15–11	0.8	1.4	1050	300	33	0.66	2×10^{-6}		
SC	Clayey sands, poorly graded sand-clay mix	105–125	19–11	1.1	2.2	1550	250	31	0.60	5×10^{-7}	5–20	100–300
ML	Inorganic silts and clayey silts	95–120	24–12	0.9	1.7	1400	190	32	0.62	10^{-5}	15 or less	100–200
ML-CL	Mixture of inorganic silt and clay	100–120	22–12	1.0	2.2	1350	460	32	0.62	5×10^{-5}	...	
CL	Inorganic clays of low to medium plasticity	95–120	24–12	1.3	2.5	1800	270	28	0.54	10^{-7}	15 or less	50–200
OL	Organic silts and silt-clays, low plasticity	80–100	33–21	...	...	...	...	...	...		5 or less	50–100
MH	Inorganic clayey silts, elastic silts	70–95	40–24	2.0	3.8	1500	420	25	0.47	5×10^{-7}	10 or less	50–100
CH	Inorganic clays of high plasticity	75–105	36–19	2.5	3.9	2150	230	19	0.35	10^{-7}	15 or less	50–150
OH	Organic clays and silty clays	65–100	45–21	...	...	...	...	...			5 or less	25–100

*From NAVFAC Manual DM 7 (1971).[6] All properties are for condition of "standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data. Compression values are for vertical loading with complete lateral confinement. ... indicates insufficient data available for an estimate.