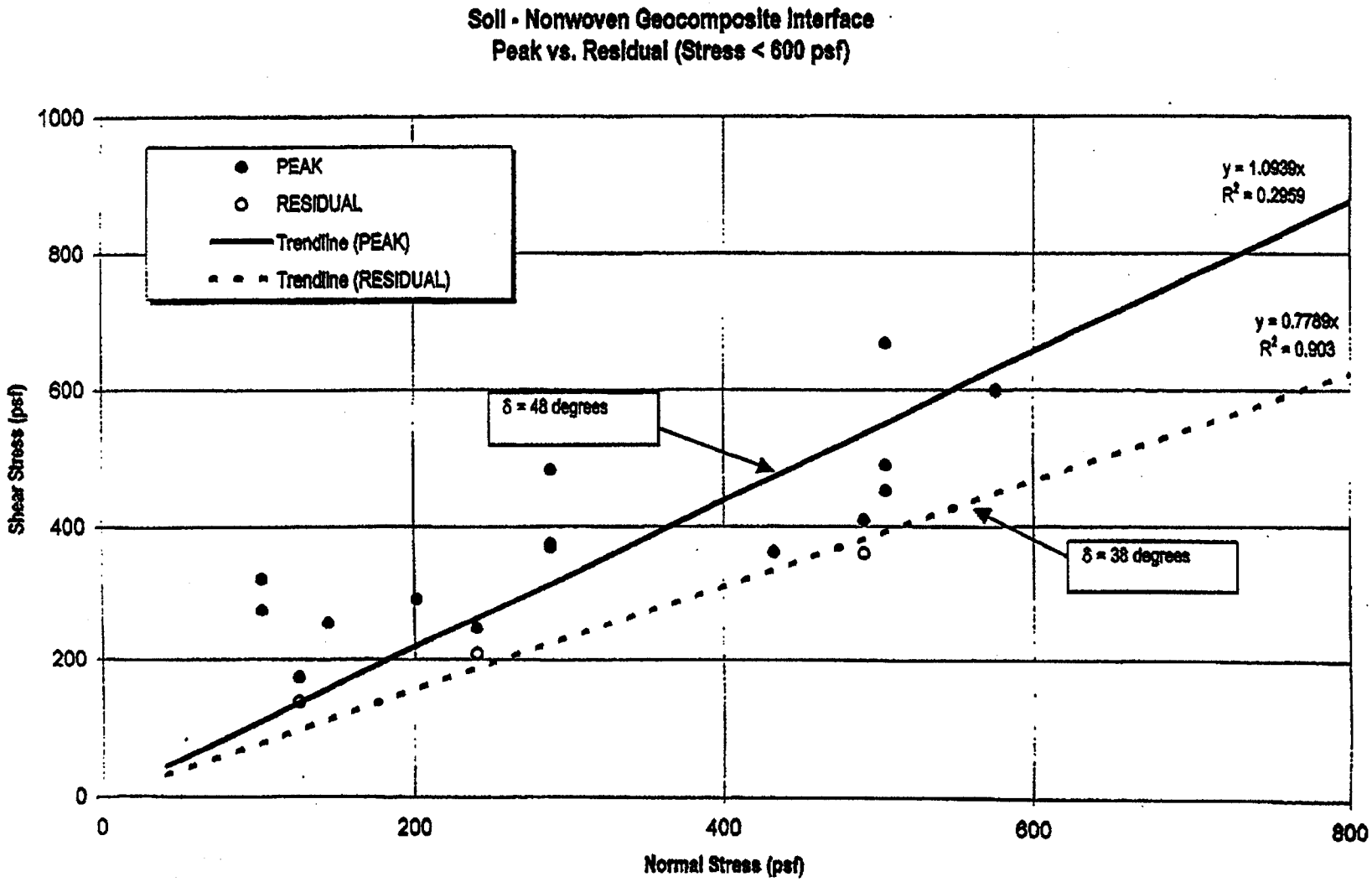
THE CONTENTS OF THIS SECTION ARE
THE HIGHEST QUALITY AVAILABLE

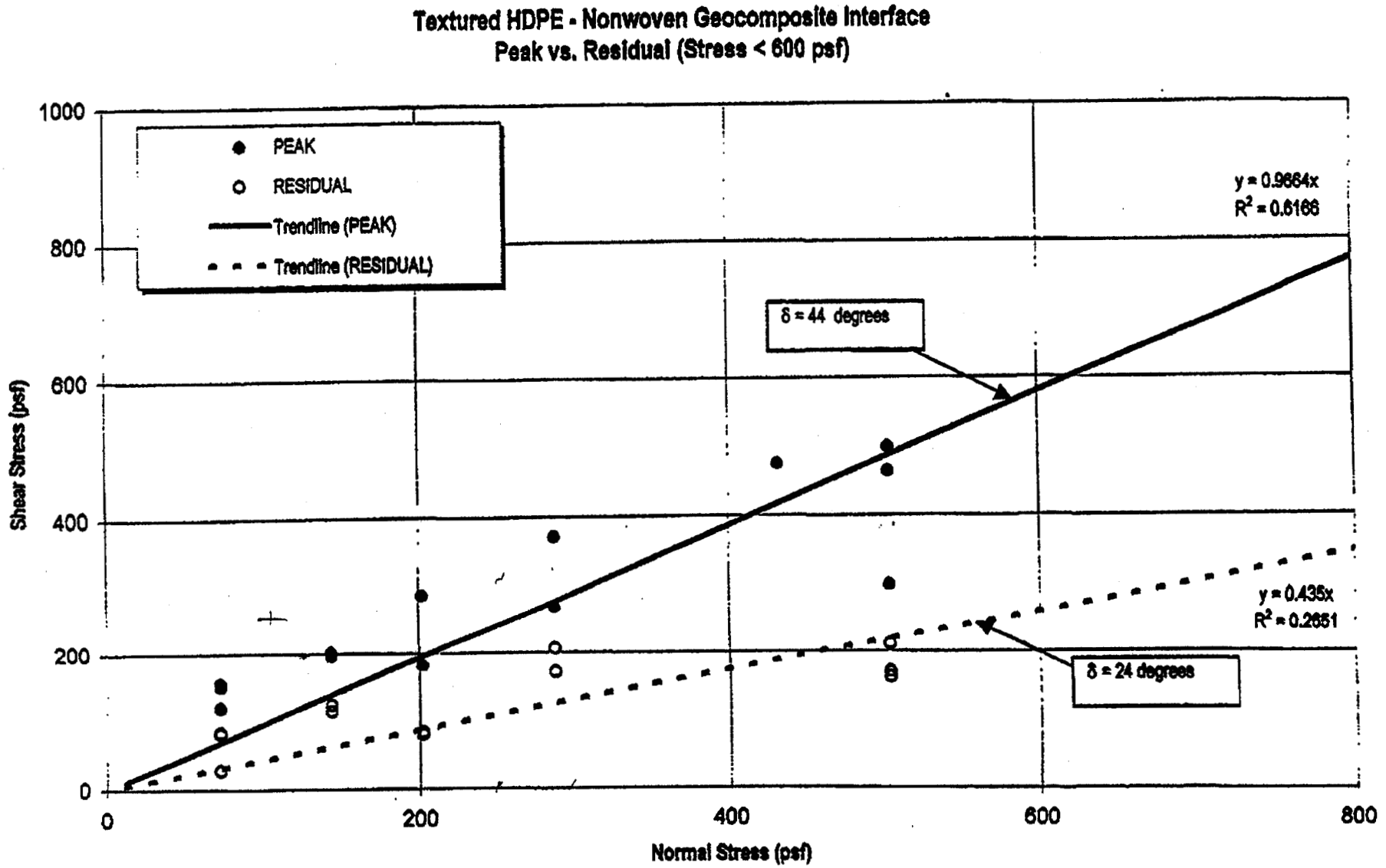
INITIAL gj DATE 9/27/02

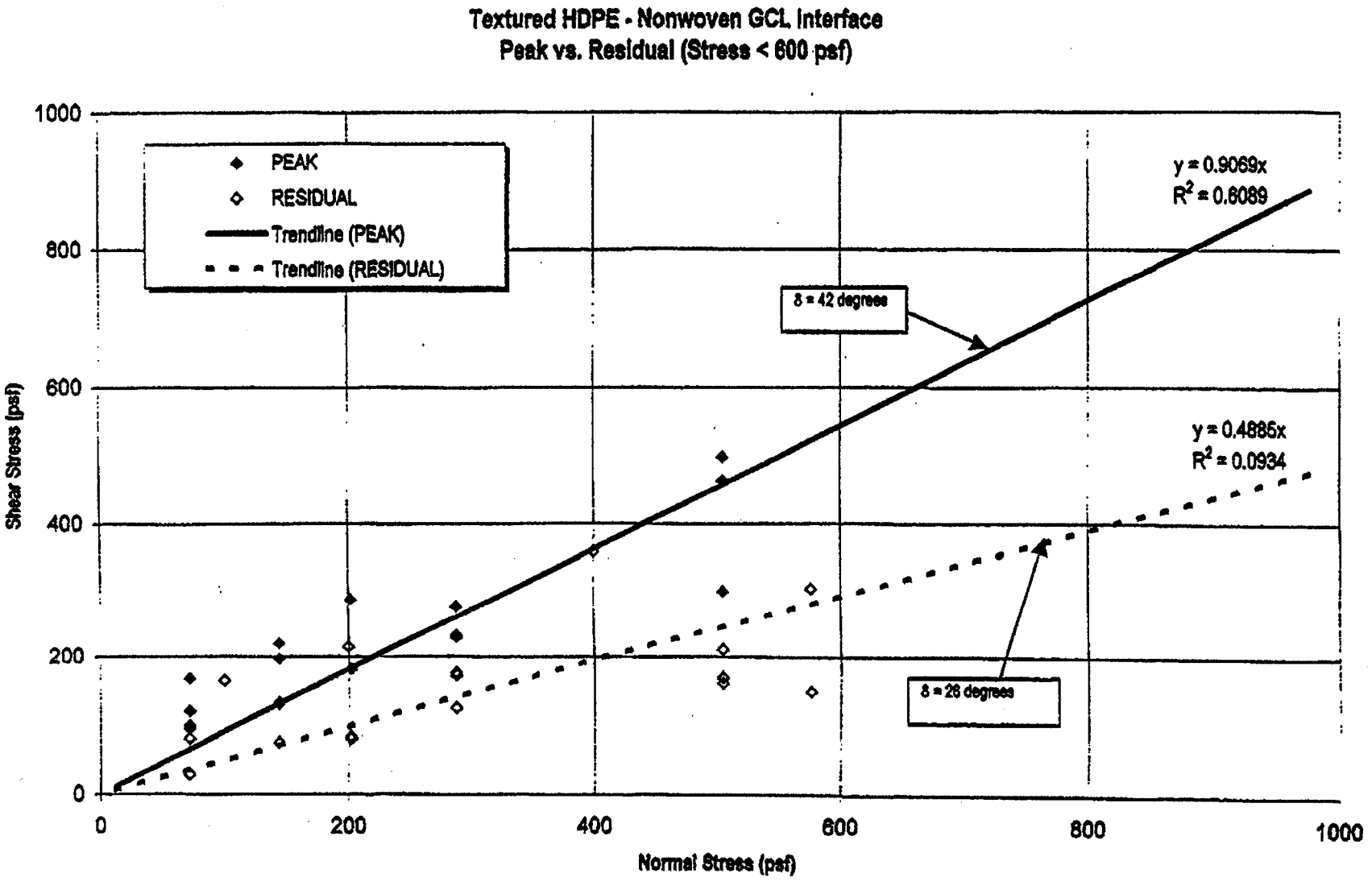
PAGE NUMBERING SEQUENCE IS INCONSISTENT

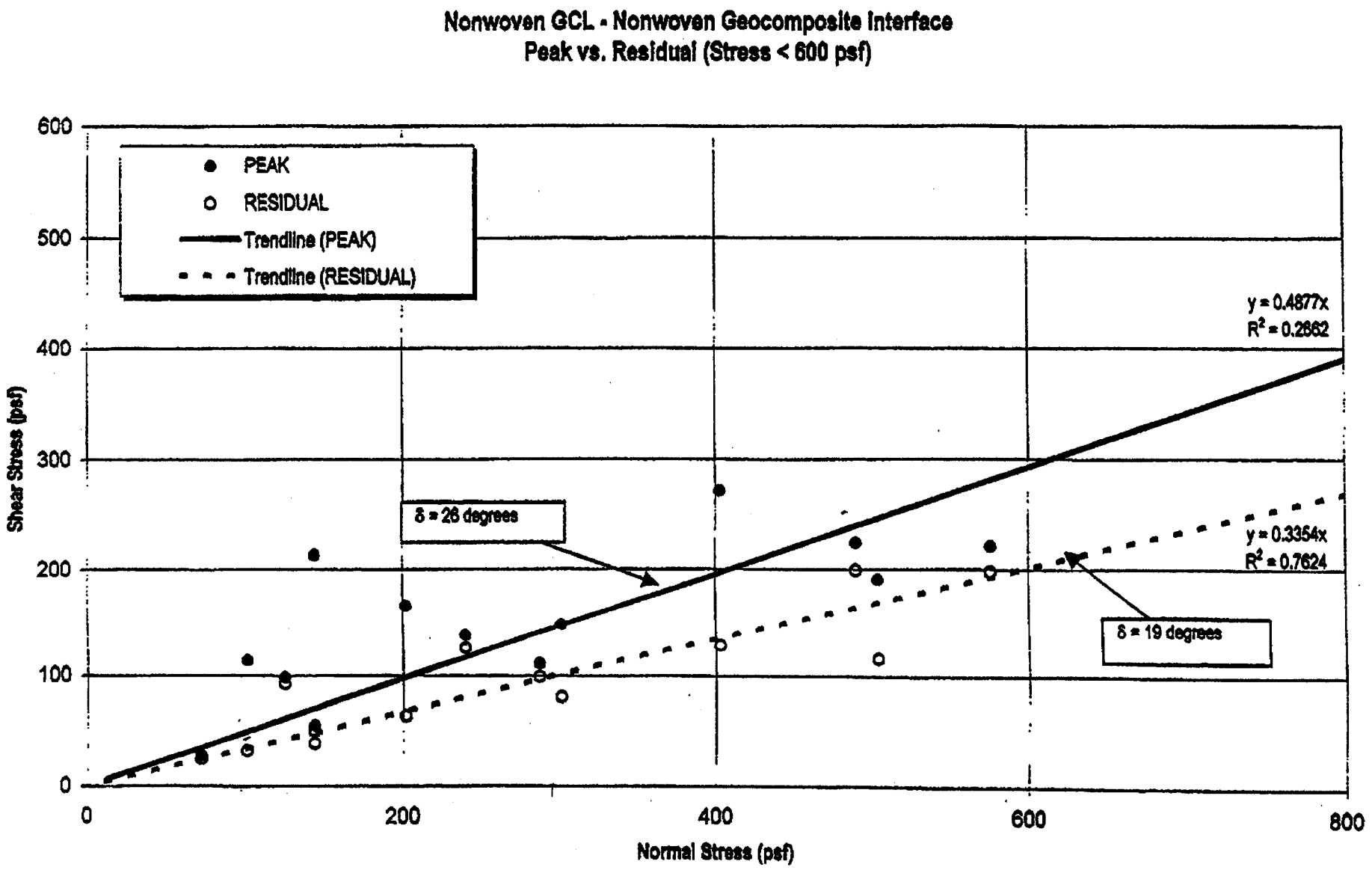
Appendix A

Veneer Stability Calculations and Plots


Soil - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress < 600 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 1.0939x
R² = 0.2959
y = 0.7789x
R² = 0.903
δ = 48 degrees
δ = 38 degrees
Shear Stress (psf)
Normal Stress (psf)
0
200
400
600
800
1000


Textured HDPE - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress < 600 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.9664x
R² = 0.6166
δ = 44 degrees
y = 0.435x
R² = 0.2651
δ = 24 degrees
Shear Stress (psf)
Normal Stress (psf)
0
200
400
600
800
1000


Textured HDPE - Nonwoven GCL Interface
Peak vs. Residual (Stress < 600 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.9069x
R² = 0.6089
δ = 42 degrees
y = 0.4886x
R² = 0.0934
δ = 26 degrees
Shear Stress (psf)
Normal Stress (psf)
0
200
400
600
800
1000


Nonwoven GCL - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress < 600 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.4877x
R² = 0.2862
y = 0.3354x
R² = 0.7624
δ = 26 degrees
δ = 19 degrees
Shear Stress (psf)
Normal Stress (psf)
0
100
200
300
400
500
600
0
200
400
600
800

NON-WOVEN GCL/NON-WOVEN GEOCOMPOSITE INTERFACE DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level (SL < 600 psf)					
	125	98	78.4	93	MW (2000)
	240	138	110.4	126	MW (2000)
	490	224	179.2	199	MW (2000)
	72	28	22.4	25	Koutsourais et al (1990)
	144	55	44	50	Bentomat (STS, 1996)
	288	111	88.8	99	Bentomat (STS, 1996)
	576	221	176.8	198	Bentomat (STS, 1996)
	504	191	152.8	116	Bentomat (CETCO, 1996)
	144	213	170.4	39	Bentomat (CETCO, 1996)
	302	148	118.4	81	Bentomat (CETCO, 1996)
	101	114	91.2	32	Bentomat (AGP, 1996)
	202	166	132.8	64	Bentomat (AGP, 1996)
	403	271	216.8	128	Bentomat (STS, 1999)
600 < SL < 2,000 psf					
	960	386		335	MW Data - Woven GCL
	1440	553		496	Bentomat (GA, 1992)
	1008	316		233	Bentomat (GSC, 1998)
	1440	424		332	Bentomat (GSC, 1998)
	706	279		189	Bentomat (VE, 1998)
High Normal Stress Level (> 2,000 psf)					
	7488	3708			Bentomat (SL, 1996)
	9936	4737			Bentomat (SL, 1996)
	12528	5826			Bentomat (SL, 1996)

TEXTURED HDPE/ NON-WOVEN GEOCOMPOSITE INTERFACE DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level < 2,000 psf					
SL < 600 psf	72	151	120.8	82	NW Lining - Unsaturated
	144	202	161.6	115	NW Lining - Unsaturated
	288	271	216.8	171	NW Lining - Unsaturated
	72	156	124.8	84	NW Lining - Saturated
	144	196	156.8	124	NW Lining - Saturated
	288	372	297.6	206	NW Lining - Saturated
	432	476	380.8		Koutsourais et al (1990)
	202	289	231.2	84.5	Bentomat (AGP, 1996)
	504	499	399.2	211	Bentomat (AGP, 1996)
	72	120	96	28.9	CETCO (1998)
	202	182	145.6	81.2	CETCO (1998)
	504	464	371.2	169.6	Bentomat (TRI, 1997)
	504	301	240.8	162	Bentomat (TRI, 1997)
600<SL<2000 psf	1296	707			Koutsourais et al (1990)
	1000	651		339	Bentomat (TRI, 1997)
	1000	570		405.2	CETCO (1998)
	1000	850		422	Bentomat (AGP, 1996)
	864	592			Koutsourais et al (1990)
	1000	517		324	Bentomat (TRI, 1997)
	1000	728		496	SERROT Intl. (2000)
	1000	605		392	SERROT Intl. (2000)
High Normal Stress Level (SL>2,000 psf)					
	2016	1024		678.5	Bentomat (TRI, 1997)
	2016	949		647.3	Bentomat (TRI, 1997)
	4000	2131		1286	SERROT Intl. (2000)
	8000	3732		2152	SERROT Intl. (2000)
	4000	1893		1085	SERROT Intl. (2000)
	8000	4064		2337	SERROT Intl. (2000)

TEXTURED HDPE/NON-WOVEN GCL INTERFACE DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level (SL < 2,000 psf)					
SL < 600 psf					
	144			75	Geosyntec (?)
	288			125	
	288			230	Geosyntec (?)
	100			165	CH2M HILL (6/93) Mica
	200			215	Nonwoven up
	400			360	
	576			150	
	576			305	Bentofix
	72	99	79.2	81	NW Lining - Saturated
	144	197	157.6	132	NW Lining - Saturated
	288	233	186.4	173	NW Lining - Saturated
	72	168	134.4	95	NW Lining - Unsaturated
	144	220	176	130	NW Lining - Unsaturated
	288	278	222.4	177	NW Lining - Unsaturated
	72	120	96	29	Bentomat (CETCO, 1988)
	202	182	145.6	81	Bentomat (CETCO, 1988)
	202	289	231.2	84	Bentomat (AGP, 1996)
	504	499	399.2	211	Bentomat (AGP, 1996)
	504	464	371.2	170	Bentomat (TRI, 1997)
	504	301	240.8	162	Bentomat (TRI, 1997)
600<SL< 2,000 psf					
	1003	627	501.6	232	Stark et al (1996)
	1008	570	456	405	Bentomat (CETCO, 1998)
	1008	850	680	422	Bentomat (AGP, 1996)
	1008	651	520.8	339	Bentomat (TRI, 1997)
	1008	517	413.6	324	Bentomat (TRI, 1997)
	1000	728	582.4	496	Serrot Intl. (Oakridge Project)
	1000	605	484	392	Serrot Intl. (Oakridge Project)
	1152			390	
	1080	525	420	505	Geosyntec (11/94)
	2000	650	520	473	AGP (7/95)
	2000	611	488.8	572	Geosyntec (1/97)
	1000	677	541.6	490	CH2M HILL (7/98) CHLF
7	1008	652		223	Bentomat (PL, 1999)
7	1008	584		244	Bentomat (PL, 1999)
10	1440	703		413	Bentomat (GSC, 1999)
7	1008	929		328	Bentomat (GSC, 2000)
High Normal Stress Level (SL > 2000 psf)					
	2005	1253	1002.4	463	Stark et al (1996)
	4010	2506	2004.8	926	Stark et al (1996)
	5952	3719	2975.2	1374	Stark et al (1996)
	2016	1024	819.2	678	Bentomat (TRI, 1997)
	2016	949	759.2	647	Bentomat (TRI, 1997)
	4000	2131	1704.8	1286	Serrot Intl. (Oakridge Project)
	8000	3732	2985.6	2152	Serrot Intl. (Oakridge Project)

	4000	1893	1514.4	1085	Serrot Intl. (Oakridge Project)
	8000	4064	3251.2	2337	Serrot Intl. (Oakridge Project)
	5000			1700	STS (10/93)
	7500			1880	Woven up
	10000			2100	
	4500	1980	1584	970	CETCO (8/94)
	6000	2520	2016	940	Woven up
	7500	3150	2520	1140	
	5760	1705	1364	993	TRI (5/93)
	8640	3263	2610.4	1632	Woven up
	11520	3163	2530.4	1881	
	2160	877	701.6	835	Woven up
	4320	1579	1263.2	1495	
	4000	1300	1040	754	Woven up
	10000	3250	2600	1597	
	15000	4875	3900	2300	
	7200	2905	2324		CETCO (7/96)
	10000	3557	2845.6		Woven up
	13000	4225	3380		
	5760	1760	1408	1167	Nonwoven up
	10000	3057	2445.6	1839	
	5000	2850	2280	1656	
	10000	5069	4055.2	2880	
14	2016	871		319	Bentomat (GSC, 1997)
40	5760	2016		912	Bentomat (GSC, 1997)
70	10080	3337		1597	Bentomat (GSC, 1997)
14	2016	1532		385	Bentomat (TRI, 1997)
28	4032	2343		769	Bentomat (TRI, 1997)
56	8064	3964		1538	Bentomat (TRI, 1997)
14	2016	1192		436	Bentomat (Emcon 1997)
28	4032	2094		872	Bentomat (Emcon, 1997)
70	10080	4799		2179	Bentomat (Emcon, 1997)
28	4032	1646		1035	Bentomat (CETCO, 1998)
50	7200	2560		1849	Bentomat (CETCO, 1998)
70	10080	3391		2588	Bentomat (CETCO, 1998)
25	3600	1260		965	Bentomat (GSC, 1998)
50	7200	2224		1929	Bentomat (GSC, 1998)
100	14400	4153		3858	Bentomat (GSC, 1998)
25	3600	1670		1170	Bentomat (GSC, 1998)
50	7200	2981		2339	Bentomat (GSC, 1998)
100	14400	5601		4679	Bentomat (GSC, 1998)
14	2016	995		276	Bentomat (TRI, 1998)
28	4032	1646		552	Bentomat (TRI, 1998)
63	9072	3274		1243	Bentomat (TRI, 1998)
28	4032	2062		894	Bentomat (PL, 1999)
56	8064	3942		1788	Bentomat (PL, 1999)
28	4032	2124		975	Bentomat (PL, 1999)
56	8064	4179		1951	Bentomat (PL, 1999)
25	3600	1532		1032	Bentomat (GSC, 1999)
50	7200	2914		2065	Bentomat (GSC, 1999)
75	10800	4296		3097	Bentomat (GSC, 1999)
14	2016	1487		655	Bentomat (GSC, 2000)
35	5040	3164		1638	Bentomat (GSC, 2000)
35	5040	2065		798	Bentomat (GSC, 2000)
100	14400	5658		2281	Bentomat (GSC, 2000)
150	21600	8421		3421	Bentomat (GSC, 2000)
	20160	6940	5552	2240	Geosyntec (5/96); Nonwoven up

SOIL TO NON-WOVEN GEOCOMPOSITE INTERFACE DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level					
	125	174	139.2	138	MW (2000)
	240	248	198.4	208	MW (2000)
	490	410	328	361	MW (2000)
	432	363	290.4		Koutsourais et al (1990)
	101	276	220.8		Bentomat (STS, 1996)
	288	375	300		Bentomat (STS, 1996)
	504	490	392		Bentomat (STS, 1996)
	101	324	259.2		Bentomat (CETCO, 1996)
	288	483	386.4		Bentomat (CETCO, 1996)
	504	667	533.6		Bentomat (CETCO, 1996)
	202	293	234.4		Bentomat (AGP, 1996)
	504	452	361.6		Bentomat (AGP, 1996)
	144	256	204.8		Bentomat (STS, 1999)
	288	370	296		Bentomat (STS, 1999)
	576	599	479.2		Bentomat (STS, 1999)
High Normal Stress Level					

INEEL CERCLA Disposal Facility
CELL 1 - Veneer Stability (Static)
Filename = CELL1-VENEER.XLS
CASE 1 - Dead Load Only (Self-Weight)

CH2M HILL
Geotechnical Engineering
K. Sampaco/SEA

Method Reference:

Copyright Stephen J. Druschel 1992.

Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.

The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-40411	40	3	120	18.4	35	24	0.40	60.26	48.06	0	0.00
-33435	40	3	120	18.4	35	24	0.45	57.27	44.69	0	0.00
-28173	40	3	120	18.4	35	24	0.50	54.47	41.68	0	0.00
-24022	40	3	120	18.4	35	24	0.55	51.85	38.99	0	0.00
-20646	40	3	120	18.4	35	24	0.60	49.41	36.58	0	0.00
-17838	40	3	120	18.4	35	24	0.65	47.13	34.41	0	0.00
-15462	40	3	120	18.4	35	24	0.70	45.01	32.46	0	0.00
-13424	40	3	120	18.4	35	24	0.75	43.03	30.69	0	0.00
-11654	40	3	120	18.4	35	24	0.80	41.19	29.10	0	0.00
-10103	40	3	120	18.4	35	24	0.85	39.48	27.65	0	0.00
-8732	40	3	120	18.4	35	24	0.90	37.88	26.32	0	0.00
-7510	40	3	120	18.4	35	24	0.95	36.39	25.11	0	0.00
-6415	40	3	120	18.4	35	24	1.00	35.00	24.00	0	0.00

-5427	40	3	120	18.4	35	24	1.05	33.70	22.98	0	0.00
-4532	40	3	120	18.4	35	24	1.10	32.48	22.04	0	0.00
-3717	40	3	120	18.4	35	24	1.15	31.34	21.16	0	0.00
-2971	40	3	120	18.4	35	24	1.20	30.26	20.36	0	0.00
-2286	40	3	120	18.4	35	24	1.25	29.26	19.61	0	0.00
-1655	40	3	120	18.4	35	24	1.30	28.31	18.91	0	0.00
-1072	40	3	120	18.4	35	24	1.35	27.41	18.25	0	0.00
-531	40	3	120	18.4	35	24	1.40	26.57	17.64	0	0.00
-29	40	3	120	18.4	35	24	1.45	25.78	17.07	0	0.00
440	40	3	120	18.4	35	24	1.50	25.02	16.53	0	0.00
878	40	3	120	18.4	35	24	1.55	24.31	16.03	0	0.00
1288	40	3	120	18.4	35	24	1.60	23.64	15.55	0	0.00
1673	40	3	120	18.4	35	24	1.65	22.99	15.10	0	0.00
2035	40	3	120	18.4	35	24	1.70	22.39	14.68	0	0.00
2376	40	3	120	18.4	35	24	1.75	21.81	14.27	0	0.00
2698	40	3	120	18.4	35	24	1.80	21.26	13.89	0	0.00
3002	40	3	120	18.4	35	24	1.85	20.73	13.53	0	0.00
3290	40	3	120	18.4	35	24	1.90	20.23	13.19	0	0.00
3563	40	3	120	18.4	35	24	1.95	19.75	12.86	0	0.00
3822	40	3	120	18.4	35	24	2.00	19.30	12.55	0	0.00
4069	40	3	120	18.4	35	24	2.05	18.86	12.25	0	0.00
4303	40	3	120	18.4	35	24	2.10	18.44	11.97	0	0.00
4527	40	3	120	18.4	35	24	2.15	18.04	11.70	0	0.00
4740	40	3	120	18.4	35	24	2.20	17.66	11.44	0	0.00
4944	40	3	120	18.4	35	24	2.25	17.29	11.19	0	0.00
5139	40	3	120	18.4	35	24	2.30	16.93	10.96	0	0.00
5325	40	3	120	18.4	35	24	2.35	16.59	10.73	0	0.00
5504	40	3	120	18.4	35	24	2.40	16.26	10.51	0	0.00
5675	40	3	120	18.4	35	24	2.45	15.95	10.30	0	0.00
5839	40	3	120	18.4	35	24	2.50	15.65	10.10	0	0.00
5997	40	3	120	18.4	35	24	2.55	15.35	9.90	0	0.00
6149	40	3	120	18.4	35	24	2.60	15.07	9.72	0	0.00
6295	40	3	120	18.4	35	24	2.65	14.80	9.54	0	0.00
6436	40	3	120	18.4	35	24	2.70	14.54	9.36	0	0.00
6571	40	3	120	18.4	35	24	2.75	14.29	9.20	0	0.00
6701	40	3	120	18.4	35	24	2.80	14.04	9.03	0	0.00
6827	40	3	120	18.4	35	24	2.85	13.80	8.88	0	0.00

INEEL CERCLA Disposal Facility — CH2M HILL
CELL 1 - Veneer Stability (Static) — Geotechnical Engineering
Filename = CELL1-VENEER.XLS — K. Sampaco/SEA
CASE 2 - Dead Load + Equipment Load (D6H Caterpillar) - No Seepage

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-42349	40	3	120	18.4	35	24	0.40	60.26	48.06	4400	0.00
-34856	40	3	120	18.4	35	24	0.45	57.27	44.69	4400	0.00
-29182	40	3	120	18.4	35	24	0.50	54.47	41.68	4400	0.00
-24693	40	3	120	18.4	35	24	0.55	51.85	38.99	4400	0.00
-21035	40	3	120	18.4	35	24	0.60	49.41	36.58	4400	0.00
-17989	40	3	120	18.4	35	24	0.65	47.13	34.41	4400	0.00
-15409	40	3	120	18.4	35	24	0.70	45.01	32.46	4400	0.00
-13194	40	3	120	18.4	35	24	0.75	43.03	30.69	4400	0.00
-11289	40	3	120	18.4	35	24	0.80	41.19	29.10	4400	0.00
-9581	40	3	120	18.4	35	24	0.85	39.48	27.65	4400	0.00
-8088	40	3	120	18.4	35	24	0.90	37.88	26.32	4400	0.00
-6758	40	3	120	18.4	35	24	0.95	36.39	25.11	4400	0.00
-5[illegible]	40	3	120	18.4	35	24	1.00	35.00	24.00	4400	0.00

[illegible]	40	3	120	18.4	35	24	1.05	33.70	22.98	4400	0.00
[illegible]	40	3	120	18.4	35	24	1.10	32.48	22.04	4400	0.00
-2624	40	3	120	18.4	35	24	1.15	31.34	21.16	4400	0.00
-1811	40	3	120	18.4	35	24	1.20	30.26	20.36	4400	0.00
-1065	40	3	120	18.4	35	24	1.25	29.26	19.61	4400	0.00
-376	40	3	120	18.4	35	24	1.30	28.31	18.91	4400	0.00
260	40	3	120	18.4	35	24	1.35	27.41	18.25	4400	0.00
850	40	3	120	18.4	35	24	1.40	26.57	17.64	4400	0.00
1398	40	3	120	18.4	35	24	1.45	25.78	17.07	4400	0.00
1910	40	3	120	18.4	35	24	1.50	25.02	16.53	4400	0.00
2388	40	3	120	18.4	35	24	1.55	24.31	16.03	4400	0.00
2835	40	3	120	18.4	35	24	1.60	23.64	15.55	4400	0.00
3255	40	3	120	18.4	35	24	1.65	22.99	15.10	4400	0.00
3650	40	3	120	18.4	35	24	1.70	22.39	14.68	4400	0.00
4023	40	3	120	18.4	35	24	1.75	21.81	14.27	4400	0.00
4374	40	3	120	18.4	35	24	1.80	21.26	13.89	4400	0.00
4706	40	3	120	18.4	35	24	1.85	20.73	13.53	4400	0.00
5021	40	3	120	18.4	35	24	1.90	20.23	13.19	4400	0.00
5319	40	3	120	18.4	35	24	1.95	19.75	12.86	4400	0.00
5602	40	3	120	18.4	35	24	2.00	19.30	12.55	4400	0.00
5871	40	3	120	18.4	35	24	2.05	18.86	12.25	4400	0.00
6127	40	3	120	18.4	35	24	2.10	18.44	11.97	4400	0.00
6371	40	3	120	18.4	35	24	2.15	18.04	11.70	4400	0.00
6604	40	3	120	18.4	35	24	2.20	17.66	11.44	4400	0.00
6827	40	3	120	18.4	35	24	2.25	17.29	11.19	4400	0.00
7040	40	3	120	18.4	35	24	2.30	16.93	10.96	4400	0.00
7243	40	3	120	18.4	35	24	2.35	16.59	10.73	4400	0.00
7438	40	3	120	18.4	35	24	2.40	16.26	10.51	4400	0.00
7625	40	3	120	18.4	35	24	2.45	15.95	10.30	4400	0.00
7805	40	3	120	18.4	35	24	2.50	15.65	10.10	4400	0.00
7977	40	3	120	18.4	35	24	2.55	15.35	9.90	4400	0.00
8143	40	3	120	18.4	35	24	2.60	15.07	9.72	4400	0.00
8302	40	3	120	18.4	35	24	2.65	14.80	9.54	4400	0.00
8456	40	3	120	18.4	35	24	2.70	14.54	9.36	4400	0.00
8604	40	3	120	18.4	35	24	2.75	14.29	9.20	4400	0.00
8746	40	3	120	18.4	35	24	2.80	14.04	9.03	4400	0.00
8884	40	3	120	18.4	35	24	2.85	13.80	8.88	4400	0.00

INEEL CERCLA Disposal Facility
CELL 1 - Veneer Stability (Static)
Filename = CELL1-VENEER.XLS
CASE 3A - Dead Load + 3" Seepage

CH2M HILL
Geotechnical Engineering
K. Sampaco/SEA

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-38318	40	3	120	18.4	35	24	0.40	60.26	48.06	0	0.25
-31575	40	3	120	18.4	35	24	0.45	57.27	44.69	0	0.25
-26500	40	3	120	18.4	35	24	0.50	54.47	41.68	0	0.25
-22500	40	3	120	18.4	35	24	0.55	51.85	38.99	0	0.25
-19251	40	3	120	18.4	35	24	0.60	49.41	36.58	0	0.25
-16550	40	3	120	18.4	35	24	0.65	47.13	34.41	0	0.25
-14267	40	3	120	18.4	35	24	0.70	45.01	32.46	0	0.25
-12308	40	3	120	18.4	35	24	0.75	43.03	30.69	0	0.25
-10608	40	3	120	18.4	35	24	0.80	41.19	29.10	0	0.25
-9119	40	3	120	18.4	35	24	0.85	39.48	27.65	0	0.25
-7802	40	3	120	18.4	35	24	0.90	37.88	26.32	0	0.25
-6629	40	3	120	18.4	35	24	0.95	36.39	25.11	0	0.25
-[illegible]8	40	3	120	18.4	35	24	1.00	35.00	24.00	0	0.25

-4630	40	3	120	18.4	35	24	1.05	33.70	22.98	0	0.25
-3771	40	3	120	18.4	35	24	1.10	32.48	22.04	0	0.25
-2989	40	3	120	18.4	35	24	1.15	31.34	21.16	0	0.25
-2274	40	3	120	18.4	35	24	1.20	30.26	20.36	0	0.25
-1617	40	3	120	18.4	35	24	1.25	29.26	19.61	0	0.25
-1012	40	3	120	18.4	35	24	1.30	28.31	18.91	0	0.25
-452	40	3	120	18.4	35	24	1.35	27.41	18.25	0	0.25
66	40	3	120	18.4	35	24	1.40	26.57	17.64	0	0.25
549	40	3	120	18.4	35	24	1.45	25.78	17.07	0	0.25
998	40	3	120	18.4	35	24	1.50	25.02	16.53	0	0.25
1418	40	3	120	18.4	35	24	1.55	24.31	16.03	0	0.25
1811	40	3	120	18.4	35	24	1.60	23.64	15.55	0	0.25
2180	40	3	120	18.4	35	24	1.65	22.99	15.10	0	0.25
2527	40	3	120	18.4	35	24	1.70	22.39	14.68	0	0.25
2854	40	3	120	18.4	35	24	1.75	21.81	14.27	0	0.25
3163	40	3	120	18.4	35	24	1.80	21.26	13.89	0	0.25
3454	40	3	120	18.4	35	24	1.85	20.73	13.53	0	0.25
3731	40	3	120	18.4	35	24	1.90	20.23	13.19	0	0.25
3992	40	3	120	18.4	35	24	1.95	19.75	12.86	0	0.25
4241	40	3	120	18.4	35	24	2.00	19.30	12.55	0	0.25
4477	40	3	120	18.4	35	24	2.05	18.86	12.25	0	0.25
4702	40	3	120	18.4	35	24	2.10	18.44	11.97	0	0.25
4916	40	3	120	18.4	35	24	2.15	18.04	11.70	0	0.25
5121	40	3	120	18.4	35	24	2.20	17.66	11.44	0	0.25
5316	40	3	120	18.4	35	24	2.25	17.29	11.19	0	0.25
5503	40	3	120	18.4	35	24	2.30	16.93	10.96	0	0.25
5681	40	3	120	18.4	35	24	2.35	16.59	10.73	0	0.25
5853	40	3	120	18.4	35	24	2.40	16.26	10.51	0	0.25
6017	40	3	120	18.4	35	24	2.45	15.95	10.30	0	0.25
6174	40	3	120	18.4	35	24	2.50	15.65	10.10	0	0.25
6326	40	3	120	18.4	35	24	2.55	15.35	9.90	0	0.25
6471	40	3	120	18.4	35	24	2.60	15.07	9.72	0	0.25
6611	40	3	120	18.4	35	24	2.65	14.80	9.54	0	0.25
6746	40	3	120	18.4	35	24	2.70	14.54	9.36	0	0.25
6875	40	3	120	18.4	35	24	2.75	14.29	9.20	0	0.25
7000	40	3	120	18.4	35	24	2.80	14.04	9.03	0	0.25
7121	40	3	120	18.4	35	24	2.85	13.80	8.88	0	0.25

INEEL CERCLA Disposal Facility
CELL 1 - Veneer Stability (Static)
Filename = CELL1-VENEER.XLS
CASE 3B - Dead Load + 6" Seepage

CH2M HILL
Geotechnical Engineering
K. Sampaco/SEA

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-36217	40	3	120	18.4	35	24	0.40	60.26	48.06	0	0.50
-29707	40	3	120	18.4	35	24	0.45	57.27	44.69	0	0.50
-24818	40	3	120	18.4	35	24	0.50	54.47	41.68	0	0.50
-20972	40	3	120	18.4	35	24	0.55	51.85	38.99	0	0.50
-17850	40	3	120	18.4	35	24	0.60	49.41	36.58	0	0.50
-15257	40	3	120	18.4	35	24	0.65	47.13	34.41	0	0.50
-13066	40	3	120	18.4	35	24	0.70	45.01	32.46	0	0.50
-11187	40	3	120	18.4	35	24	0.75	43.03	30.69	0	0.50
-9558	40	3	120	18.4	35	24	0.80	41.19	29.10	0	0.50
-8130	40	3	120	18.4	35	24	0.85	39.48	27.65	0	0.50
-6868	40	3	120	18.4	35	24	0.90	37.88	26.32	0	0.50
-5744	40	3	120	18.4	35	24	0.95	36.39	25.11	0	0.50
-4737	40	3	120	18.4	35	24	1.00	35.00	24.00	0	0.50

30	40	3	120	18.4	35	24	1.05	33.70	22.98	0	0.50
-3007	40	3	120	18.4	35	24	1.10	32.48	22.04	0	0.50
-2258	40	3	120	18.4	35	24	1.15	31.34	21.16	0	0.50
-1573	40	3	120	18.4	35	24	1.20	30.26	20.36	0	0.50
-944	40	3	120	18.4	35	24	1.25	29.26	19.61	0	0.50
-365	40	3	120	18.4	35	24	1.30	28.31	18.91	0	0.50
170	40	3	120	18.4	35	24	1.35	27.41	18.25	0	0.50
667	40	3	120	18.4	35	24	1.40	26.57	17.64	0	0.50
1128	40	3	120	18.4	35	24	1.45	25.78	17.07	0	0.50
1558	40	3	120	18.4	35	24	1.50	25.02	16.53	0	0.50
1960	40	3	120	18.4	35	24	1.55	24.31	16.03	0	0.50
2337	40	3	120	18.4	35	24	1.60	23.64	15.55	0	0.50
2690	40	3	120	18.4	35	24	1.65	22.99	15.10	0	0.50
3022	40	3	120	18.4	35	24	1.70	22.39	14.68	0	0.50
3335	40	3	120	18.4	35	24	1.75	21.81	14.27	0	0.50
3630	40	3	120	18.4	35	24	1.80	21.26	13.89	0	0.50
3909	40	3	120	18.4	35	24	1.85	20.73	13.53	0	0.50
4173	40	3	120	18.4	35	24	1.90	20.23	13.19	0	0.50
4423	40	3	120	18.4	35	24	1.95	19.75	12.86	0	0.50
4661	40	3	120	18.4	35	24	2.00	19.30	12.55	0	0.50
4887	40	3	120	18.4	35	24	2.05	18.86	12.25	0	0.50
5102	40	3	120	18.4	35	24	2.10	18.44	11.97	0	0.50
5307	40	3	120	18.4	35	24	2.15	18.04	11.70	0	0.50
5503	40	3	120	18.4	35	24	2.20	17.66	11.44	0	0.50
5690	40	3	120	18.4	35	24	2.25	17.29	11.19	0	0.50
5868	40	3	120	18.4	35	24	2.30	16.93	10.96	0	0.50
6039	40	3	120	18.4	35	24	2.35	16.59	10.73	0	0.50
6203	40	3	120	18.4	35	24	2.40	16.26	10.51	0	0.50
6360	40	3	120	18.4	35	24	2.45	15.95	10.30	0	0.50
6511	40	3	120	18.4	35	24	2.50	15.65	10.10	0	0.50
6655	40	3	120	18.4	35	24	2.55	15.35	9.90	0	0.50
6794	40	3	120	18.4	35	24	2.60	15.07	9.72	0	0.50
6928	40	3	120	18.4	35	24	2.65	14.80	9.54	0	0.50
7057	40	3	120	18.4	35	24	2.70	14.54	9.36	0	0.50
7181	40	3	120	18.4	35	24	2.75	14.29	9.20	0	0.50
7301	40	3	120	18.4	35	24	2.80	14.04	9.03	0	0.50
7416	40	3	120	18.4	35	24	2.85	13.80	8.88	0	0.50

INEEL CERCLA Disposal Facility
CELL 1 - Veneer Stability (Seismic)
Filename = CELL1-VENEER.XLS
Dead Load + Seismic Loading - No Equipment/No Seepage

CH2M HILL
Geotechnical Engineering
K. Sampaco/SEA

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)	A:	B:	C:	D:	E:	F:	G:	FORCE REQ'D (lb/ft)	EQ ACCEL. (% g)	SOIL WEIGHT (lb/ft)	EQ FORCE (lb/ft)
-7273	40	3	120	18.4	35	24	0.80	41.19	29.10	0	0.00	9.38E-13	0.972115	4.45E+08	0.586521	0	-383.005	-30.429	-7272.75	0.1	43817.35	4381.735
-5722	40	3	120	18.4	35	24	0.85	39.48	27.65	0	0.00	9.38E-13	0.914932	4.19E+08	0.55202	0	-326.999	-30.8968	-5721.51	0.1	43817.35	4381.735
-4350	40	3	120	18.4	35	24	0.90	37.88	26.32	0	0.00	9.38E-13	0.864103	3.96E+08	0.521352	0	-277.216	-31.4979	-4350.01	0.1	43817.35	4381.735
-3128	40	3	120	18.4	35	24	0.95	36.39	25.11	0	0.00	9.38E-13	0.818624	3.75E+08	0.493913	0	-232.674	-32.2776	-3128.41	0.1	43817.35	4381.735
-2033	40	3	120	18.4	35	24	1.00	35.00	24.00	0	0.00	9.38E-13	0.777692	3.56E+08	0.469217	0	-192.585	-33.3095	-2033.18	0.1	43817.35	4381.735
-1046	40	3	120	18.4	35	24	1.05	33.70	22.98	0	0.00	9.38E-13	0.740659	3.39E+08	0.446873	0	-156.315	-34.7202	-1045.55	0.1	43817.35	4381.735
-150	40	3	120	18.4	35	24	1.10	32.48	22.04	0	0.00	9.38E-13	0.706993	3.24E+08	0.426561	0	-123.342	-36.7437	-150.296	0.1	43817.35	4381.735
665	40	3	120	18.4	35	24	1.15	31.34	21.16	0	0.00	9.38E-13	0.676254	3.1E+08	0.408015	0	-93.2359	-39.8634	665.0369	0.1	43817.35	4381.735
1411	40	3	120	18.4	35	24	1.20	30.26	20.36	0	0.00	9.38E-13	0.648077	2.97E+08	0.391014	0	-65.6388	-45.2627	1410.747	0.1	43817.35	4381.735
2095	40	3	120	18.4	35	24	1.25	29.26	19.61	0	0.00	9.38E-13	0.622154	2.85E+08	0.375374	0	-40.2495	-56.8035	2095.425	0.1	43817.35	4381.735
2726	40	3	120	18.4	35	24	1.30	28.31	18.91	0	0.00	9.38E-13	0.598225	2.74E+08	0.360936	0	-16.8132	-68.4607	2726.301	0.1	43817.35	4381.735
3309	40	3	120	18.4	35	24	1.35	27.41	18.25	0	0.00	9.38E-13	0.576068	2.64E+08	0.347568	0	4.887127	219.4005	3309.498	0.1	43817.35	4381.735
3850	40	3	120	18.4	35	24	1.40	26.57	17.64	0	0.00	9.38E-13	0.555495	2.54E+08	0.335155	0	25.03739	21.22799	3850.242	0.1	43817.35	4381.735
4353	40	3	120	18.4	35	24	1.45	25.78	17.07	0	0.00	9.38E-13	0.53634	2.46E+08	0.323598	0	43.79797	0.655623	4353.021	0.1	43817.35	4381.735

INEEL CERCLA Disposal Facility
Final Cover - Veneer Stability (Static)
Filename = ICDF_FinalCover_Veneer.XLS
CASE 1 - Dead Load Only (Self-Weight)

CH2M HILL
Geotechnical Engineering
M. Reimbold/SEA

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-22943	28	5	135	21.8	40	38	1.00	40.00	38.00	0	0.00
-20888	28	5	135	21.8	40	38	1.05	38.63	36.65	0	0.00
-19038	28	5	135	21.8	40	38	1.10	37.34	35.38	0	0.00
-17364	28	5	135	21.8	40	38	1.15	36.12	34.19	0	0.00
-15841	28	5	135	21.8	40	38	1.20	34.96	33.07	0	0.00
-14449	28	5	135	21.8	40	38	1.25	33.87	32.01	0	0.00
-13172	28	5	135	21.8	40	38	1.30	32.84	31.01	0	0.00
-11995	28	5	135	21.8	40	38	1.35	31.86	30.06	0	0.00
-10907	28	5	135	21.8	40	38	1.40	30.94	29.16	0	0.00
-9899	28	5	135	21.8	40	38	1.45	30.06	28.32	0	0.00
-8961	28	5	135	21.8	40	38	1.50	29.22	27.51	0	0.00
-8087	28	5	135	21.8	40	38	1.55	28.43	26.75	0	0.00
-7271	28	5	135	21.8	40	38	1.60	27.67	26.03	0	0.00
-6506	28	5	135	21.8	40	38	1.65	26.96	25.34	0	0.00
-5787	28	5	135	21.8	40	38	1.70	26.27	24.68	0	0.00
-5112	28	5	135	21.8	40	38	1.75	25.62	24.06	0	0.00
-4476	28	5	135	21.8	40	38	1.80	24.99	23.46	0	0.00
-3875	28	5	135	21.8	40	38	1.85	24.40	22.90	0	0.00
-3307	28	5	135	21.8	40	38	1.90	23.83	22.35	0	0.00
-2769	28	5	135	21.8	40	38	1.95	23.28	21.83	0	0.00
-2259	28	5	135	21.8	40	38	2.00	22.76	21.34	0	0.00
-1774	28	5	135	21.8	40	38	2.05	22.26	20.86	0	0.00
-1314	28	5	135	21.8	40	38	2.10	21.78	20.41	0	0.00
-875	28	5	135	21.8	40	38	2.15	21.32	19.97	0	0.00
-457	28	5	135	21.8	40	38	2.20	20.88	19.55	0	0.00
-58	28	5	135	21.8	40	38	2.25	20.45	19.15	0	0.00
323	28	5	135	21.8	40	38	2.30	20.04	18.76	0	0.00
688	28	5	135	21.8	40	38	2.35	19.65	18.39	0	0.00
1037	28	5	135	21.8	40	38	2.40	19.27	18.03	0	0.00

INEEL CERCLA Disposal Facility CH2M HILL
Final Cover - Veneer Stability (Static w/seepage Geotechnical Engineering
Filename = ICDF_FinalCover_Veneer.XLS M. Reimbold/SEA
CASE 2 - Dead Load Only +Seepage (2.5' = 50 height)

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-14346	28	5	135	21.8	40	38	1.00	40.00	38.00	0	2.50
-12701	28	5	135	21.8	40	38	1.05	38.63	36.65	0	2.50
-11223	28	5	135	21.8	40	38	1.10	37.34	35.38	0	2.50
-9889	28	5	135	21.8	40	38	1.15	36.12	34.19	0	2
-8677	28	5	135	21.8	40	38	1.20	34.96	33.07	0	2
-7572	28	5	135	21.8	40	38	1.25	33.87	32.01	0	2.50
-6559	28	5	135	21.8	40	38	1.30	32.84	31.01	0	2.50
-5627	28	5	135	21.8	40	38	1.35	31.86	30.06	0	2.50
-4767	28	5	135	21.8	40	38	1.40	30.94	29.16	0	2.50
-3970	28	5	135	21.8	40	38	1.45	30.06	28.32	0	2.50
-3230	28	5	135	21.8	40	38	1.50	29.22	27.51	0	2.50
-2541	28	5	135	21.8	40	38	1.55	28.43	26.75	0	2.50
-1898	28	5	135	21.8	40	38	1.60	27.67	26.03	0	2.50
-1296	28	5	135	21.8	40	38	1.65	26.96	25.34	0	2.50
-731	28	5	135	21.8	40	38	1.70	26.27	24.68	0	2.50
-200	28	5	135	21.8	40	38	1.75	25.62	24.06	0	2.50
300	28	5	135	21.8	40	38	1.80	24.99	23.46	0	2.50
772	28	5	135	21.8	40	38	1.85	24.40	22.90	0	2.50
1218	28	5	135	21.8	40	38	1.90	23.83	22.35	0	2.50
1639	28	5	135	21.8	40	38	1.95	23.28	21.83	0	2.50
2039	28	5	135	21.8	40	38	2.00	22.76	21.34	0	2.50
2419	28	5	135	21.8	40	38	2.05	22.26	20.86	0	2.50
2780	28	5	135	21.8	40	38	2.10	21.78	20.41	0	2.50
3123	28	5	135	21.8	40	38	2.15	21.32	19.97	0	2.50
3450	28	5	135	21.8	40	38	2.20	20.88	19.55	0	2.50
3763	28	5	135	21.8	40	38	2.25	20.45	19.15	0	2.50
4061	28	5	135	21.8	40	38	2.30	20.04	18.76	0	2.50
4346	28	5	135	21.8	40	38	2.35	19.65	18.39	0	2.50
4619	28	5	135	21.8	40	38	2.40	19.27	18.03	0	2.50

INEEL CERCLA Disposal Facility — CH2M HILL
Final Cover - Veneer Stability (Seismic) — Geotechnical Engineering
Filename = ICDF_FinalCover_Veneer.XLS — M. Reimbold/SEA
Dead Load + Seismic Loading - No Equipment/No Seepage

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)	A:	B:	C:	D:	E:	F:	G:	FORCE REQ'D (lb/ft)	EQ ACCEL (% g)	SOIL WEIGHT (lb/ft)	EQ FORCE (lb/ft)
-20352	28	5	135	21.8	40	38	0.80	46.37	44.32	0	0.00	7.8E-11	1.216671	54689994	1.051828	0	-2620.24	-13.0339	-20352.2	0.3	45998.93	13799.68
-16973	28	5	135	21.8	40	38	0.85	44.63	42.59	0	0.00	7.8E-11	1.145102	51472935	0.989955	0	-2359.2	-13.0436	-16972.9	0.3	45998.93	13799.68
-14030	28	5	135	21.8	40	38	0.90	42.99	40.96	0	0.00	7.8E-11	1.081485	48613328	0.934958	0	-2127.16	-13.0831	-14030.2	0.3	45998.93	13799.68
-11441	28	5	135	21.8	40	38	0.95	41.45	39.43	0	0.00	7.8E-11	1.024565	46054732	0.88575	0	-1919.55	-13.1493	-11441.1	0.3	45998.93	13799.68
-9143	28	5	135	21.8	40	38	1.00	40.00	38.00	0	0.00	7.8E-11	0.973336	43751995	0.841462	0	-1732.7	-13.2411	-9143.07	0.3	45998.93	13799.68
-7088	28	5	135	21.8	40	38	1.05	38.63	36.65	0	0.00	7.8E-11	0.926987	41668567	0.801392	0	-1563.84	-13.3585	-7088.18	0.3	45998.93	13799.68
-5239	28	5	135	21.8	40	38	1.10	37.34	35.38	0	0.00	7.8E-11	0.884851	39774541	0.764966	0	-1409.95	-13.5028	-5238.69	0.3	45998.93	13799.68
-3565	28	5	135	21.8	40	38	1.15	36.12	34.19	0	0.00	7.8E-11	0.846379	38045213	0.731706	0	-1269.63	-13.6766	-3564.54	0.3	45998.93	13799.68
-2041	28	5	135	21.8	40	38	1.20	34.96	33.07	0	0.00	7.8E-11	0.811114	36459996	0.701218	0	-1141	-13.8835	-2041.4	0.3	45998.93	13799.68
-649	28	5	135	21.8	40	38	1.25	33.87	32.01	0	0.00	7.8E-11	0.778669	35001596	0.67317	0	-1022.86	-14.1288	-649.333	0.3	45998.93	13799.68
628	28	5	135	21.8	40	38	1.30	32.84	31.01	0	0.00	7.8E-11	0.74872	33655381	0.647279	0	-913.426	-14.4199	628.1613	0.3	45998.93	13799.68
1805	28	5	135	21.8	40	38	1.35	31.86	30.06	0	0.00	7.8E-11	0.72099	32408885	0.623305	0	-812.281	-14.7668	1804.88	0.3	45998.93	13799.68
2892	28	5	135	21.8	40	38	1.40	30.94	29.16	0	0.00	7.8E-11	0.69524	31251425	0.601044	0	-718.362	-15.1835	2892.457	0.3	45998.93	13799.68
3901	28	5	135	21.8	40	38	1.45	30.06	28.32	0	0.00	7.8E-11	0.671266	30173790	0.580319	0	-630.919	-15.6897	3900.774	0.3	45998.93	13799.68
4838	28	5	135	21.8	40	38	1.50	29.22	27.51	0	0.00	7.8E-11	0.648691	29167997	0.560975	0	-549.306	-16.314	4838.287	0.3	45998.93	13799.68
5712	28	5	135	21.8	40	38	1.55	28.43	26.75	0	0.00	7.8E-11	0.627959	28227094	0.542879	0	-472.958	-17.0996	5712.277	0.3	45998.93	13799.68
6529	28	5	135	21.8	40	38	1.60	27.67	26.03	0	0.00	7.8E-11	0.608335	27344997	0.525914	0	-401.382	-18.114	6529.048	0.3	45998.93	13799.68

INEEL CERCLA Disposal Facility
Evaporation Pond - Veneer Stability (Static)
Filename = POND-VENEER.XLS
CASE 1 - Dead Load Only (Self-Weight)

CH2M HILL
Geotechnical Engineering
K. Sampaco/SEA

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-4386	10	3	120	18.4	35	24	0.80	41.19	29.10	0	0.00
-3898	10	3	120	18.4	35	24	0.85	39.48	27.65	0	0.00
-3471	10	3	120	18.4	35	24	0.90	37.88	26.32	0	0.00
-3095	10	3	120	18.4	35	24	0.95	36.39	25.11	0	0.00
-2760	10	3	120	18.4	35	24	1.00	35.00	24.00	0	0.00
-2461	10	3	120	18.4	35	24	1.05	33.70	22.98	0	0.00
-2191	10	3	120	18.4	35	24	1.10	32.48	22.04	0	0.00
-1947	10	3	120	18.4	35	24	1.15	31.34	21.16	0	0.00
-1725	10	3	120	18.4	35	24	1.20	30.26	20.36	0	0.00
-1522	10	3	120	18.4	35	24	1.25	29.26	19.61	0	0.00
-1336	10	3	120	18.4	35	24	1.30	28.31	18.91	0	0.00
-1165	10	3	120	18.4	35	24	1.35	27.41	18.25	0	0.00
-1007	10	3	120	18.4	35	24	1.40	26.57	17.64	0	0.00
-860	10	3	120	18.4	35	24	1.45	25.78	17.07	0	0.00
-723	10	3	120	18.4	35	24	1.50	25.02	16.53	0	0.00
-596	10	3	120	18.4	35	24	1.55	24.31	16.03	0	0.00
-478	10	3	120	18.4	35	24	1.60	23.64	15.55	0	0.00
-367	10	3	120	18.4	35	24	1.65	22.99	15.10	0	0.00
-262	10	3	120	18.4	35	24	1.70	22.39	14.68	0	0.00
-164	10	3	120	18.4	35	24	1.75	21.81	14.27	0	0.00
-72	10	3	120	18.4	35	24	1.80	21.26	13.89	0	0.00
15	10	3	120	18.4	35	24	1.85	20.73	13.53	0	0.00
98	10	3	120	18.4	35	24	1.90	20.23	13.19	0	0.00
176	10	3	120	18.4	35	24	1.95	19.75	12.86	0	0.00
250	10	3	120	18.4	35	24	2.00	19.30	12.55	0	0.00
320	10	3	120	18.4	35	24	2.05	18.86	12.25	0	0.00
387	10	3	120	18.4	35	24	2.10	18.44	11.97	0	0.00

INEEL CERCLA Disposal Facility
Evaporation Pond - Veneer Stability (Static)
Filename = POND-VENEER.XLS
CASE 2 - Dead Load + Equip Load (D6H)

CH2M HILL
Geotechnical Engineering
K. Sampaco/SEA

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-4001	10	3	120	18.4	35	24	0.80	41.19	29.10	4400	0.00
-3376	10	3	120	18.4	35	24	0.85	39.48	27.65	4400	0.00
-2827	10	3	120	18.4	35	24	0.90	37.88	26.32	4400	0.00
-2342	10	3	120	18.4	35	24	0.95	36.39	25.11	4400	0.00
-1910	10	3	120	18.4	35	24	1.00	35.00	24.00	4400	0.00
-1522	10	3	120	18.4	35	24	1.05	33.70	22.98	4400	0.00
-1172	10	3	120	18.4	35	24	1.10	32.48	22.04	4400	0.00
-855	10	3	120	18.4	35	24	1.15	31.34	21.16	4400	0.00
-566	10	3	120	18.4	35	24	1.20	30.26	20.36	4400	0.00
-301	10	3	120	18.4	35	24	1.25	29.26	19.61	4400	0.00
-57	10	3	120	18.4	35	24	1.30	28.31	18.91	4400	0.00
167	10	3	120	18.4	35	24	1.35	27.41	18.25	4400	0.00
374	10	3	120	18.4	35	24	1.40	26.57	17.64	4400	0.00
567	10	3	120	18.4	35	24	1.45	25.78	17.07	4400	0.00
746	10	3	120	18.4	35	24	1.50	25.02	16.53	4400	0.00
913	10	3	120	18.4	35	24	1.55	24.31	16.03	4400	0.00
1069	10	3	120	18.4	35	24	1.60	23.64	15.55	4400	0.00
1216	10	3	120	18.4	35	24	1.65	22.99	15.10	4400	0.00
1353	10	3	120	18.4	35	24	1.70	22.39	14.68	4400	0.00
1483	10	3	120	18.4	35	24	1.75	21.81	14.27	4400	0.00
1604	10	3	120	18.4	35	24	1.80	21.26	13.89	4400	0.00
1719	10	3	120	18.4	35	24	1.85	20.73	13.53	4400	0.00
1828	10	3	120	18.4	35	24	1.90	20.23	13.19	4400	0.00
1931	10	3	120	18.4	35	24	1.95	19.75	12.86	4400	0.00
2029	10	3	120	18.4	35	24	2.00	19.30	12.55	4400	0.00
2122	10	3	120	18.4	35	24	2.05	18.86	12.25	4400	0.00
2210	10	3	120	18.4	35	24	2.10	18.44	11.97	4400	0.00

INEEL CERCLA Disposal Facility
Evaporation Pond - Veneer Stability (Static)
Filename = POND-VENEER.XLS
CASE 3A - Dead Load + 6" Seepage

CH2M HILL
Geotechnical Engineering
K. Sampaco/SEA

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-5312	10	3	120	18.4	35	24	0.70	45.01	32.46	0	0.25
-4670	10	3	120	18.4	35	24	0.75	43.03	30.69	0	0.25
-4123	10	3	120	18.4	35	24	0.80	41.19	29.10	0	0.25
-3650	10	3	120	18.4	35	24	0.85	39.48	27.65	0	0.25
-3237	10	3	120	18.4	35	24	0.90	37.88	26.32	0	0.25
-2873	10	3	120	18.4	35	24	0.95	36.39	25.11	0	0.25
-2550	10	3	120	18.4	35	24	1.00	35.00	24.00	0	0.25
-2260	10	3	120	18.4	35	24	1.05	33.70	22.98	0	0.25
-2000	10	3	120	18.4	35	24	1.10	32.48	22.04	0	0.25
-1764	10	3	120	18.4	35	24	1.15	31.34	21.16	0	0.25
-1550	10	3	120	18.4	35	24	1.20	30.26	20.36	0	0.25
-1354	10	3	120	18.4	35	24	1.25	29.26	19.61	0	0.25
-1174	10	3	120	18.4	35	24	1.30	28.31	18.91	0	0.25
-1009	10	3	120	18.4	35	24	1.35	27.41	18.25	0	0.25
-856	10	3	120	18.4	35	24	1.40	26.57	17.64	0	0.25
-715	10	3	120	18.4	35	24	1.45	25.78	17.07	0	0.25
-583	10	3	120	18.4	35	24	1.50	25.02	16.53	0	0.25
-461	10	3	120	18.4	35	24	1.55	24.31	16.03	0	0.25
-346	10	3	120	18.4	35	24	1.60	23.64	15.55	0	0.25
-239	10	3	120	18.4	35	24	1.65	22.99	15.10	0	0.25
-138	10	3	120	18.4	35	24	1.70	22.39	14.68	0	0.25
-44	10	3	120	18.4	35	24	1.75	21.81	14.27	0	0.25
45	10	3	120	18.4	35	24	1.80	21.26	13.89	0	0.25
129	10	3	120	18.4	35	24	1.85	20.73	13.53	0	0.25
209	10	3	120	18.4	35	24	1.90	20.23	13.19	0	0.25
284	10	3	120	18.4	35	24	1.95	19.75	12.86	0	0.25

INEEL CERCLA Disposal Facility
Evaporation Pond - Veneer Stability (Static)
Filename = POND-VENEER.XLS
CASE 3B - Dead Load + 12" Seepage

CH2M HILL
Geotechnical Engineering
K. Sampaco/SEA

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)
-4378	10	3	120	18.4	35	24	0.70	45.01	32.46	0	1.00
-3799	10	3	120	18.4	35	24	0.75	43.03	30.69	0	1.00
-3306	10	3	120	18.4	35	24	0.80	41.19	29.10	0	1.00
-2881	10	3	120	18.4	35	24	0.85	39.48	27.65	0	1.00
-2511	10	3	120	18.4	35	24	0.90	37.88	26.32	0	1.00
-2185	10	3	120	18.4	35	24	0.95	36.39	25.11	0	1.00
-1896	10	3	120	18.4	35	24	1.00	35.00	24.00	0	1.00
-1638	10	3	120	18.4	35	24	1.05	33.70	22.98	0	1.00
-1406	10	3	120	18.4	35	24	1.10	32.48	22.04	0	1.00
-1196	10	3	120	18.4	35	24	1.15	31.34	21.16	0	1.00
-1005	10	3	120	18.4	35	24	1.20	30.26	20.36	0	1.00
-831	10	3	120	18.4	35	24	1.25	29.26	19.61	0	1.00
-672	10	3	120	18.4	35	24	1.30	28.31	18.91	0	1.00
-525	10	3	120	18.4	35	24	1.35	27.41	18.25	0	1.00
-389	10	3	120	18.4	35	24	1.40	26.57	17.64	0	1.00
-264	10	3	120	18.4	35	24	1.45	25.78	17.07	0	1.00
-147	10	3	120	18.4	35	24	1.50	25.02	16.53	0	1.00
-39	10	3	120	18.4	35	24	1.55	24.31	16.03	0	1.00
62	10	3	120	18.4	35	24	1.60	23.64	15.55	0	1.00
157	10	3	120	18.4	35	24	1.65	22.99	15.10	0	1.00
246	10	3	120	18.4	35	24	1.70	22.39	14.68	0	1.00
330	10	3	120	18.4	35	24	1.75	21.81	14.27	0	1.00
408	10	3	120	18.4	35	24	1.80	21.26	13.89	0	1.00
482	10	3	120	18.4	35	24	1.85	20.73	13.53	0	1.00
553	10	3	120	18.4	35	24	1.90	20.23	13.19	0	1.00
619	10	3	120	18.4	35	24	1.95	19.75	12.86	0	1.00
682	10	3	120	18.4	35	24	2.00	19.30	12.55	0	1.00

Evaporation Pond - Veneer Stability (Seismic) Geotechnical Engineering
Filename = POND-VENEER.XLS K. Sampaco/SEA
Dead Load + Seismic (No Seepage)

Method Reference: **Copyright Stephen J. Druschel 1992.**
Druschel, S.J., and Underwood, E.R. (1993). "Design of Lining and Cover System Sideslopes," accepted for publication and presentation, Geosynthetics '93 Conference, Industrial Fabrics Association International, Vancouver, BC.
The purpose of this calculation is to evaluate the factor of safety for the proposed configuration. Edit data in columns B-H, K & L. Residual strength values will be reduced by the selected FS. The actual FS will be the one where the anchorage strength equals zero.

Required Variables:

H	Slope Height (ft.)	W_e	Equipment Weight (lb/ft.)
T_c	Cover Soil Thickness (ft.)	S_t	Seepage Thickness (ft.)
γ	Cover Soil Total Unit Weight (pcf)	γ_w	Unit Weight of Water (pcf) (assumed at 62.4pcf)
β	Slope Angle (degrees)	F_s	Factor of Safety (unitless)
ψ	Soil Shear Strength Angle (degrees)	F_a	Anchor Force (lb/ft)
δ	Interface Friction Angle (degrees)		

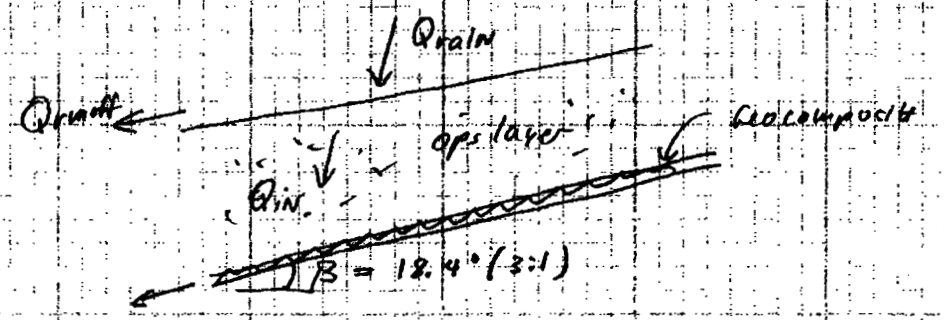
Required F_a (lb/ft)	H (feet)	T_c (feet)	γ (pcf)	β (deg)	ψ (deg)	δ (deg)	F_s (FS)	mobil. ψ (deg)	mobil. δ (deg)	W_e (lb/ft.)	S_t (feet)	A:	B:	C:	D:	E:	F:	G:	FORCE REQ'D (lb/ft)	EQ ACCEL (% g)	SOIL WEIGHT (lb/ft)	EQ FORCE (lb/ft)
-5434	10	3	120	18.4	35	24	0.60	49.41	36.58	0	0.00	9.38E-13	1.296154	1.48E+08	0.782028	0	-700.372	-10.5009	-5434.12	0.2	9602.138	1920.428
-4480	10	3	120	18.4	35	24	0.65	47.13	34.41	0	0.00	9.38E-13	1.19645	1.37E+08	0.721872	0	-602.721	-10.6185	-4479.53	0.2	9602.138	1920.428
-3692	10	3	120	18.4	35	24	0.70	45.01	32.46	0	0.00	9.38E-13	1.110989	1.27E+08	0.67031	0	-519.02	-10.814	-3692.27	0.2	9602.138	1920.428
-3030	10	3	120	18.4	35	24	0.75	43.03	30.69	0	0.00	9.38E-13	1.036923	1.19E+08	0.625623	0	-446.479	-11.0888	-3030.48	0.2	9602.138	1920.428
-2466	10	3	120	18.4	35	24	0.80	41.19	29.10	0	0.00	9.38E-13	0.972115	1.11E+08	0.586521	0	-383.005	-11.4515	-2465.56	0.2	9602.138	1920.428
-1977	10	3	120	18.4	35	24	0.85	39.48	27.65	0	0.00	9.38E-13	0.914932	1.05E+08	0.55202	0	-326.999	-11.9193	-1977.18	0.2	9602.138	1920.428
-1550	10	3	120	18.4	35	24	0.90	37.88	26.32	0	0.00	9.38E-13	0.864103	98939708	0.521352	0	-277.216	-12.5204	-1550.44	0.2	9602.138	1920.428
-1174	10	3	120	18.4	35	24	0.95	36.39	25.11	0	0.00	9.38E-13	0.818624	93732355	0.493913	0	-232.674	-13.3	-1174.14	0.2	9602.138	1920.428
-840	10	3	120	18.4	35	24	1.00	35.00	24.00	0	0.00	9.38E-13	0.777692	89045737	0.469217	0	-192.585	-14.332	-839.698	0.2	9602.138	1920.428
-540	10	3	120	18.4	35	24	1.05	33.70	22.98	0	0.00	9.38E-13	0.740659	84805464	0.446873	0	-156.315	-15.7427	-540.39	0.2	9602.138	1920.428
-271	10	3	120	18.4	35	24	1.10	32.48	22.04	0	0.00	9.38E-13	0.706993	80950670	0.426561	0	-123.342	-17.7662	-270.883	0.2	9602.138	1920.428
-27	10	3	120	18.4	35	24	1.15	31.34	21.16	0	0.00	9.38E-13	0.676254	77431076	0.408015	0	-93.2359	-20.8859	-26.8855	0.2	9602.138	1920.428
195	10	3	120	18.4	35	24	1.20	30.26	20.36	0	0.00	9.38E-13	0.648077	74204781	0.391014	0	-65.6388	-26.2852	195.0998	0.2	9602.138	1920.428
398	10	3	120	18.4	35	24	1.25	29.26	19.61	0	0.00	9.38E-13	0.622154	71236590	0.375374	0	-40.2495	-37.826	397.9519	0.2	9602.138	1920.428
584	10	3	120	18.4	35	24	1.30	28.31	18.91	0	0.00	9.38E-13	0.598225	68496721	0.360936	0	-16.8132	-79.4832	584.0645	0.2	9602.138	1920.428
755	10	3	120	18.4	35	24	1.35	27.41	18.25	0	0.00	9.38E-13	0.576068	65959805	0.347568	0	4.887127	238.378	755.4441	0.2	9602.138	1920.428
914	10	3	120	18.4	35	24	1.40	26.57	17.64	0	0.00	9.38E-13	0.555495	63604098	0.335155	0	25.03739	40.20551	913.7868	0.2	9602.138	1920.428
1061	10	3	120	18.4	35	24	1.45	25.78	17.07	0	0.00	9.38E-13	0.53634	61410853	0.323598	0	43.79797	19.63314	1060.536	0.2	9602.138	1920.428

(ref ICOF-2468)

GIVEN: Slope stability determined that for veneer stability equipment could not operate directly on sideslope ops layer if seepage height build up in ops layer

∴ w/ equip loading = 4460 lb/ft $h_s \cong \phi$

Recommendation that equipment stay off ops layer slope after rainfall slope needs to quantified.



Simplified Approach: Darcy's Law ($Q = kiA$) assumes saturated conditions in ops layer which is conservative as ops layer will likely not be saturated prior to a rainfall event

→ under saturated conditions: $Q_{IN} = k_{ops} \times i \times A$

$k_{ops} = 5 \times 10^{-2}$ cm/sec based on lab tests

$i = 1.0$ for vertical flow

$A = L_h$ (slope length) $\times 1$ (unit width)

$$Q_{IN} = k_{ops} \times L_h$$

→ $Q_{OUT} = k_{geocomp} \times i \times A = k_{comp} \times \sin\beta \times (t \times 1) = \theta \sin\beta$

$i = \sin\beta$

$A = t$ (thickness)

θ - transmissivity $= kt$

→ For no seepage head buildup

$Q_{IN} = Q_{OUT}$

$k_{ops} L_h = \theta \sin\beta$

$\theta_{req'd} = \dfrac{k_{ops} L_h}{\sin\beta}$

$$\theta_{req'd} = \frac{K_{ops} h_h}{\sin\beta} = \frac{5\times10^{-2}\,cm/sec \times 130\,ft}{\sin 18.4^\circ} \times \frac{1\,m}{100\,cm} \times \frac{1\,m}{3.281\,ft}$$

From Dwgs $h_h = 130'$

$= \underline{6.3\times10^{-3}\,m^2/s}$ req'd geocomposite (CON) transmissivity to maintain Ø seep height

$\theta_{act} = \underline{3\times10^{-4}\,m^2/s}$ (specified value for 1000 psf normal load)

⇒ under saturated conditions th ops layer with additional rainfall geocomposite cannot discharge flow without seepage height buildup because flow moves through ops layer faster than geocomposite can discharge. Recommendation to keep equipment off ops layer on sideslopes during rainfall event that saturates ops layer is appropriate

⇒ Determine how long to keep equipment off slopes after rainfall?? ⇒ How long after Q_{IN} ends to reduce seep height to Ø ??

Q_{IN} can be discharged downslope through both ops layer and geocomposite after rainfall event:

- $Q_{ops} = K_{ops}\, \underbrace{i\,(\text{downslope})}_{\sin\beta}\, \underbrace{A}_{1'\text{ gravel height} \times \text{unit width}}$ ⇒ Area for flow through ops downslope is limited by discharge @ toe. Assume = unit width x Leachate drain gravel (1') height = A

$$= 5\times10^{-2}\,cm/sec \times \sin 18.4^\circ \times 1\,ft \times \frac{1\,ft}{ft\ \text{unit width}} \times \frac{1\,ft}{30.48\,cm} \times \frac{60\,sec}{min} \times \frac{7.48\,gal}{ft^3}$$

$= \underline{0.23\,gpm/ft\ width}$

- $Q_{CON} = \overset{K_t \times i}{\theta \sin\beta} \times \text{unit width}$

$$= 3\times10^{-4}\,\frac{m^2}{sec} \times \frac{60\,sec}{min} \times \frac{(3.281\,ft)^2}{m^2} \times 7.48\,\frac{gal}{ft^3} \times \sin 18.4^\circ \times \frac{1\,ft}{ft\ \text{unit width}}$$

$= \underline{0.46\,gpm/ft\ width}$

$Q_{ops} + Q_{CON} = 30.6\,gpm/ft\ width$

⇒ In first portion of calcs it was assumed layer would be saturated resulting in conservative approach. For ops layer to saturate intensity of rain event would have to exceed the Q_{TOT} for ops layer and CON.

$$Q = I \cdot A \Rightarrow I = \frac{Q_{TOT}}{A} = \frac{0.70\ gpm/ft\ width}{130\ ft \times unit\ width} \times \frac{1\ ft^3}{7.48\ gal} \times \frac{60\ min}{hr} \times \frac{12\ in}{1\ ft}$$

$= 0.52$ in/hour ⇒ a significant rainfall intensity given that 25-year/24-hour event ≈ 1.8 in

→ check just Q_{CON} alone:

$$I = \frac{Q_{CON}}{A} = \frac{0.46\ gpm/ft}{130\ ft \times 1\ ft} \times \frac{1\ ft^3}{7.48\ gal} \times \frac{60\ min}{hr} \times \frac{12\ in}{1\ ft}$$

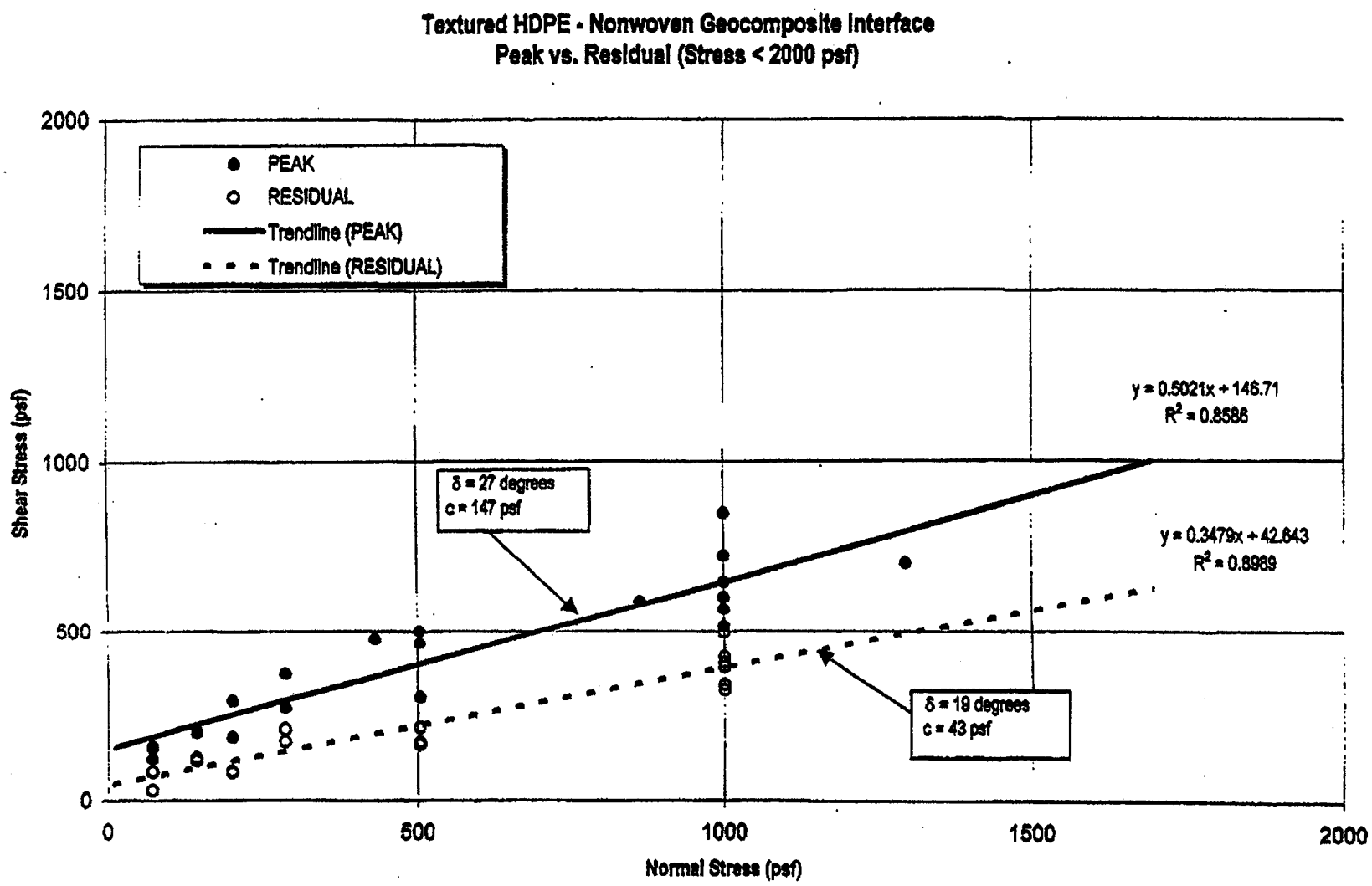
$I = 0.34$ in/hour ⇒ still a large intense rainfall event

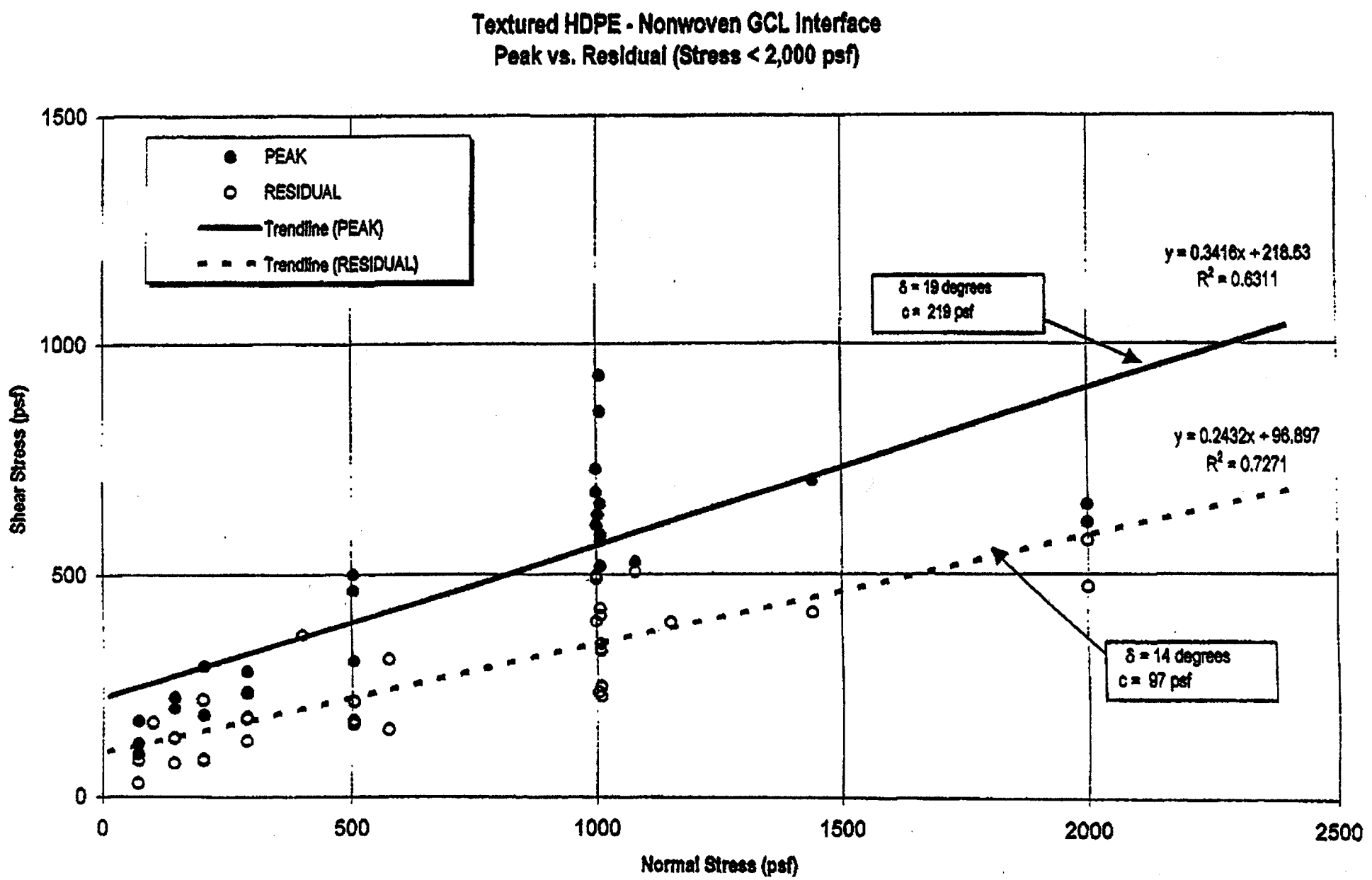
Conclusion: Free-draining nature of ops layer indicates it is unlikely to saturate and Q_{CON} alone can handle a storm event ≈ 0.3 in/hour. Seepage height would build up if ops layer were saturated and rainfall continued since $Q_{req'd} > Q_{CON}$ (see p.2). However it takes a significant rainfall to saturate the ops layer as shown above. The limiting factor will be discharge @ toe of slope - given this it is appropriate and conservative to look @ Q_{CON} as limiting storm event for saturation and potential seep head build-up. Apply FS=2 to Q_{CON} for limiting $I = \frac{0.34}{2} = 0.17$ in/hour (with ground pressure ≈ 4400 lb/ft²)

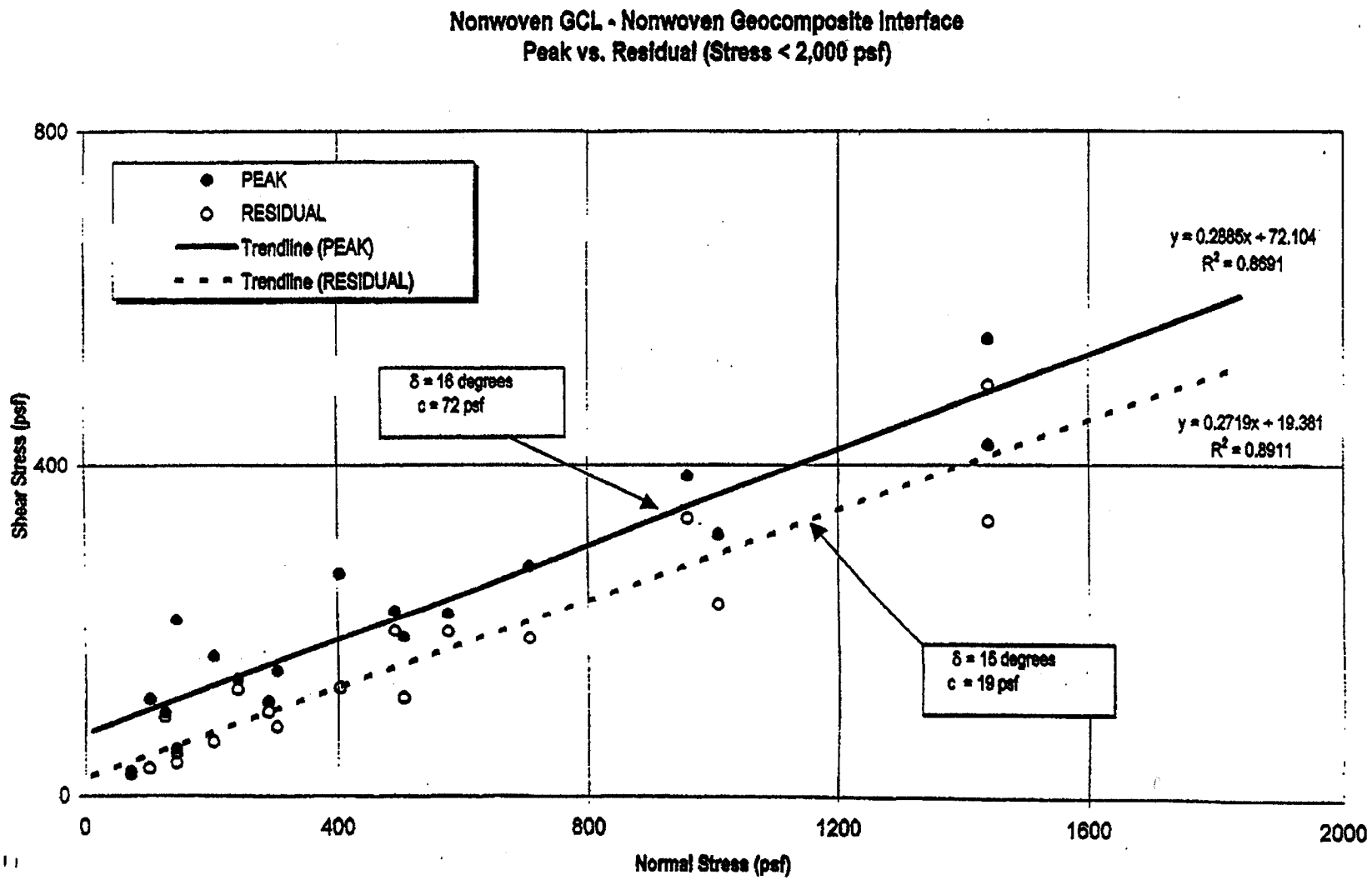
Recommendation: Install a rain gage on site, equipment may operate on slopes until a rain event in excess of 0.15 in/hour occurs. In that event equipment should be kept off slopes (directly on ops layer) and should not be permitted to operate on slopes until 1 hour after end of rainfall event.

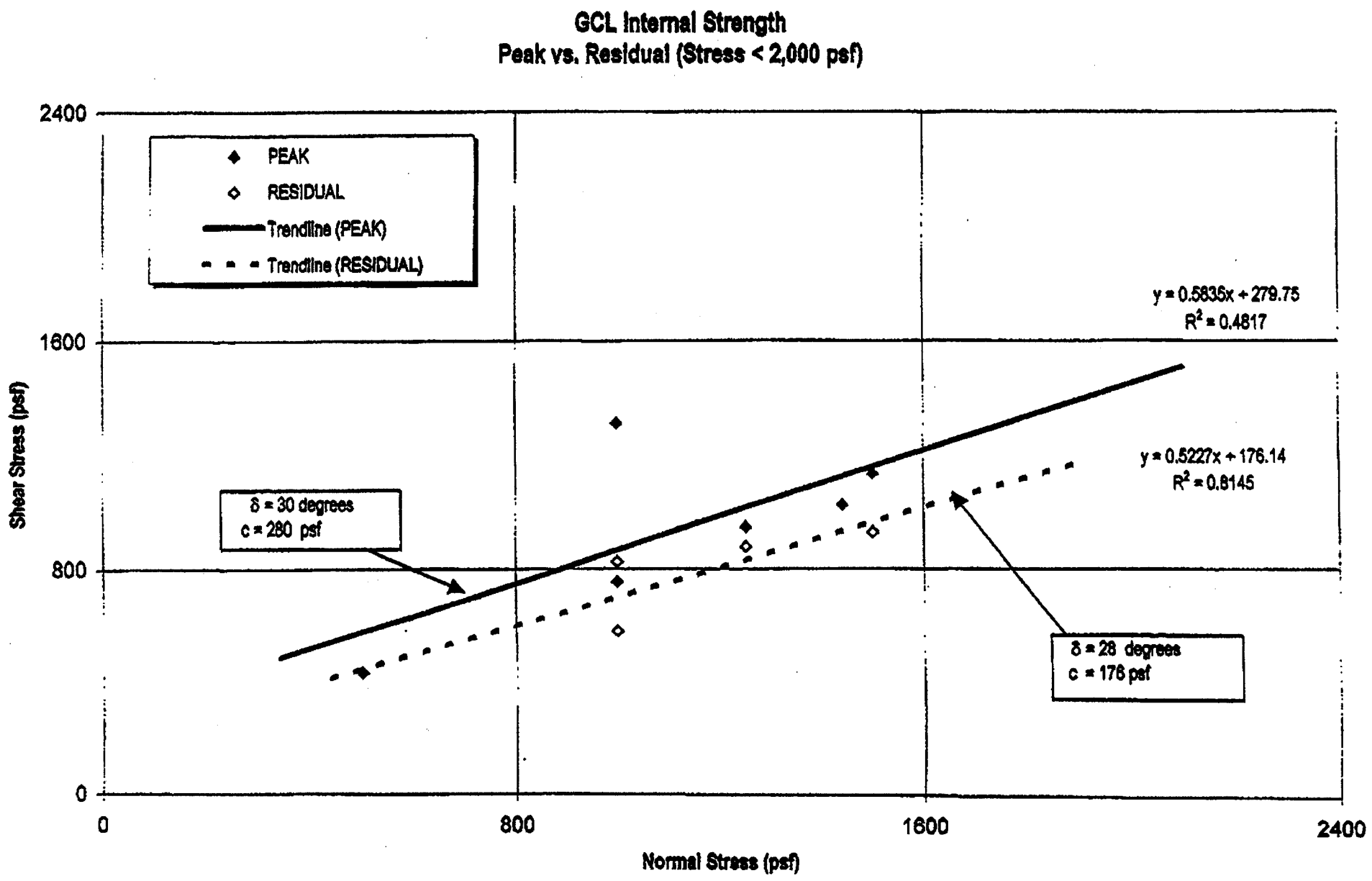
Appendix B

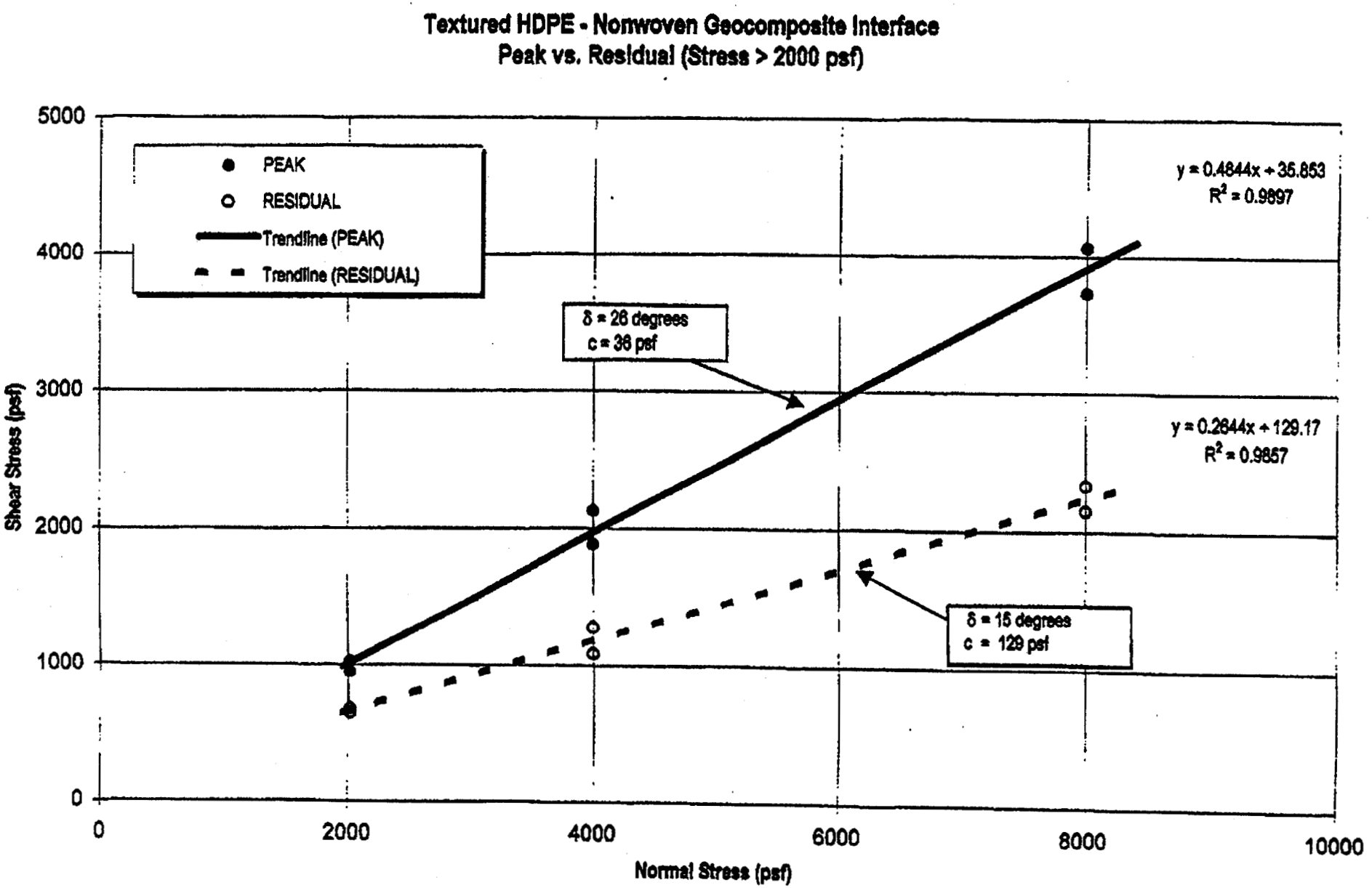
Global Stability Calculations and Plots

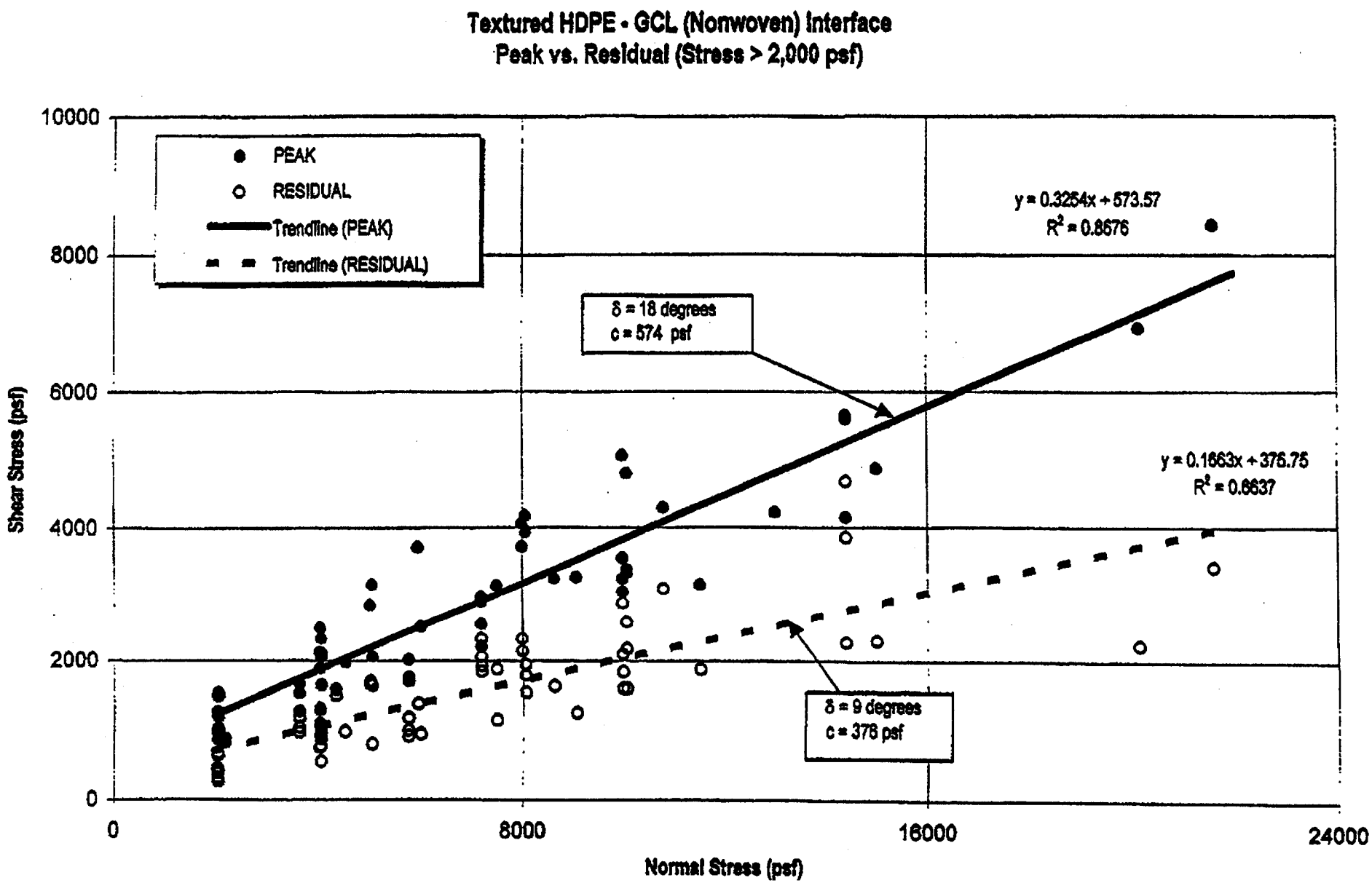

Textured HDPE - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress < 2000 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.5021x + 146.71
R² = 0.8586
y = 0.3479x + 42.643
R² = 0.8989
δ = 27 degrees
c = 147 psf
δ = 19 degrees
c = 43 psf
Shear Stress (psf)
Normal Stress (psf)
0
500
1000
1500
2000

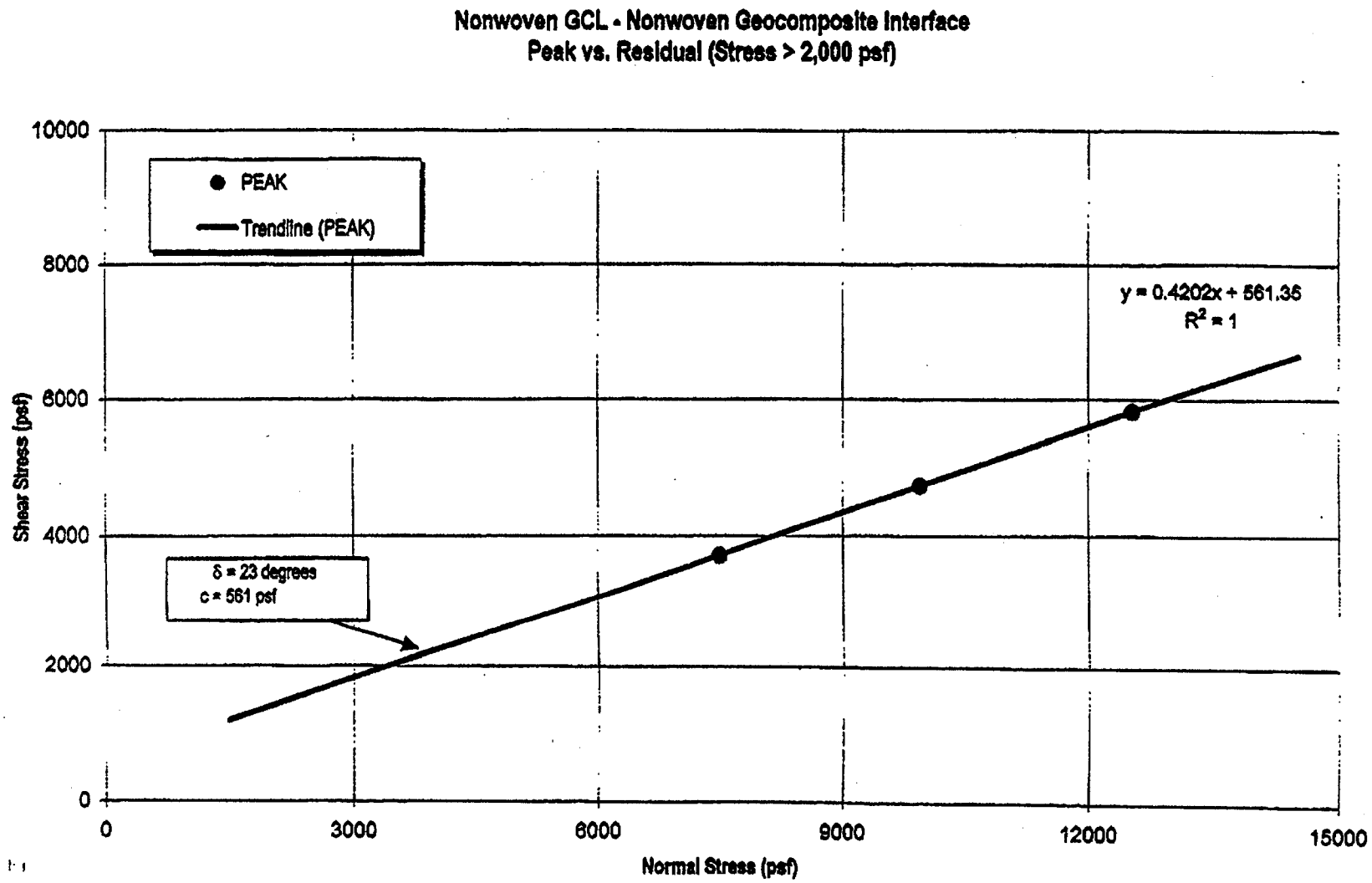

Textured HDPE - Nonwoven GCL Interface
Peak vs. Residual (Stress < 2,000 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.3416x + 218.53
R² = 0.6311
δ = 19 degrees
c = 219 psf
y = 0.2432x + 96.897
R² = 0.7271
δ = 14 degrees
c = 97 psf
Shear Stress (psf)
Normal Stress (psf)
0
500
1000
1500
2000
2500

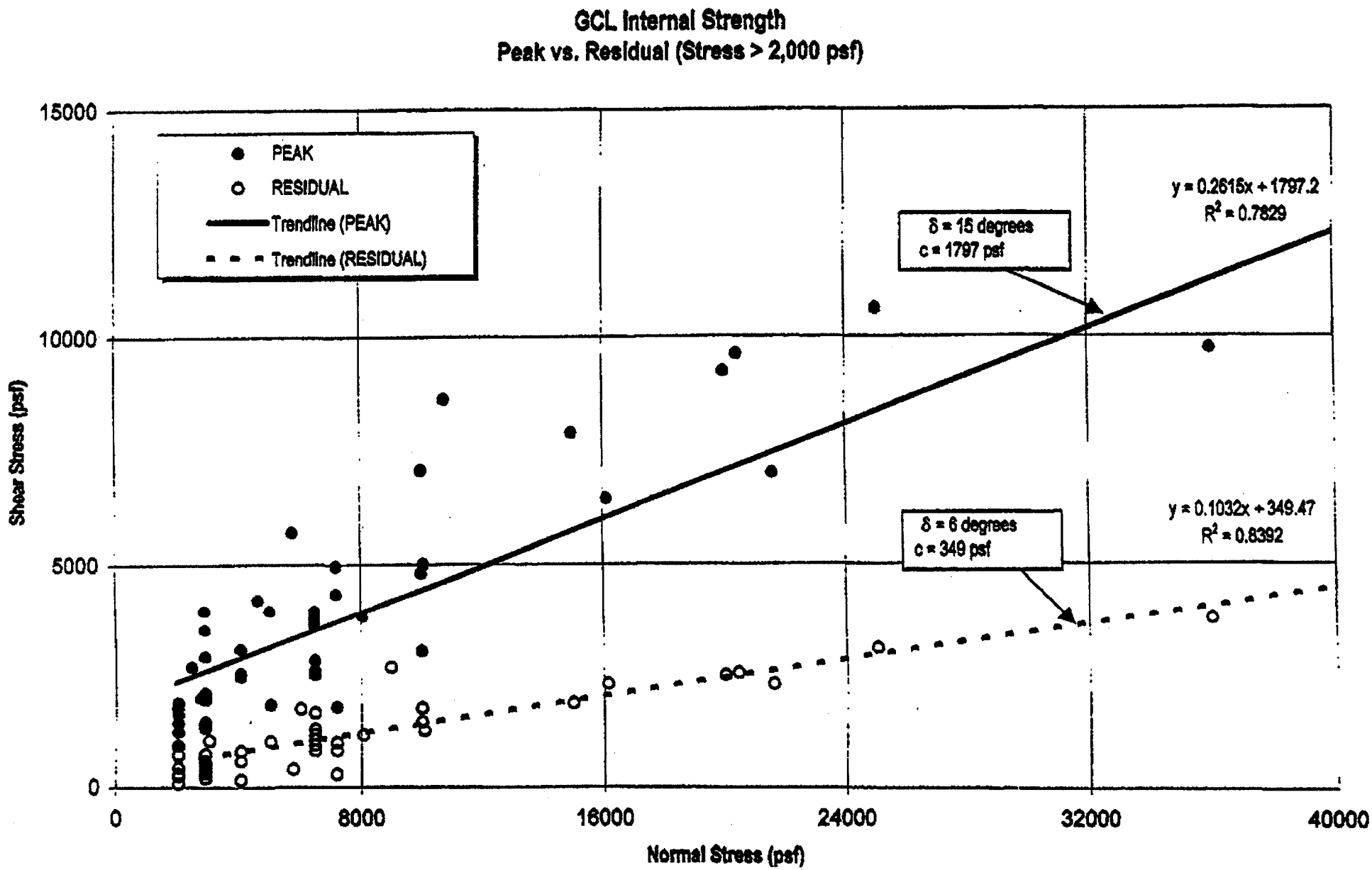

Nonwoven GCL - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress < 2,000 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.2885x + 72.104
R² = 0.8691
y = 0.2719x + 19.381
R² = 0.8911
δ = 16 degrees
c = 72 psf
δ = 15 degrees
c = 19 psf
Shear Stress (psf)
Normal Stress (psf)
0
400
800
1200
1600
2000


GCL Internal Strength
Peak vs. Residual (Stress < 2,000 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.5835x + 279.75
R² = 0.4817
y = 0.5227x + 176.14
R² = 0.8145
δ = 30 degrees
c = 280 psf
δ = 28 degrees
c = 176 psf
Shear Stress (psf)
Normal Stress (psf)
0
800
1600
2400


Textured HDPE - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress > 2000 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.4844x + 35.853
R² = 0.9897
y = 0.2644x + 129.17
R² = 0.9857
δ = 26 degrees
c = 36 psf
δ = 15 degrees
c = 129 psf
Shear Stress (psf)
Normal Stress (psf)
0
1000
2000
3000
4000
5000
0
2000
4000
6000
8000
10000


Textured HDPE - GCL (Nonwoven) Interface
Peak vs. Residual (Stress > 2,000 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
y = 0.3254x + 573.57
R² = 0.8676
δ = 18 degrees
c = 574 psf
y = 0.1663x + 376.75
R² = 0.6637
δ = 9 degrees
c = 376 psf
Shear Stress (psf)
Normal Stress (psf)
0
2000
4000
6000
8000
10000
0
8000
16000
24000


Nonwoven GCL - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress > 2,000 psf)
PEAK
Trendline (PEAK)
y = 0.4202x + 561.36
R² = 1
δ = 23 degrees
c = 561 psf
Shear Stress (psf)
Normal Stress (psf)
0
2000
4000
6000
8000
10000
0
3000
6000
9000
12000
15000


GCL Internal Strength
Peak vs. Residual (Stress > 2,000 psf)
PEAK
RESIDUAL
Trendline (PEAK)
Trendline (RESIDUAL)
δ = 15 degrees
c = 1797 psf
y = 0.2615x + 1797.2
R² = 0.7829
δ = 6 degrees
c = 349 psf
y = 0.1032x + 349.47
R² = 0.8392
Shear Stress (psf)
Normal Stress (psf)
0
5000
10000
15000
0
8000
16000
24000
32000
40000

NON-WOVEN GCL/NON-WOVEN GEOCOMPOSITE INTERFACE DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level (SL < 600 psf)					
	125	98	78.4	93	MW (2000)
	240	138	110.4	126	MW (2000)
	490	224	179.2	199	MW (2000)
	72	28	22.4	25	Koutsourais et al (1990)
	144	55	44	50	Bentomat (STS, 1996)
	288	111	88.8	99	Bentomat (STS, 1996)
	576	221	176.8	198	Bentomat (STS, 1996)
	504	191	152.8	116	Bentomat (CETCO, 1996)
	144	213	170.4	39	Bentomat (CETCO, 1996)
	302	148	118.4	81	Bentomat (CETCO, 1996)
	101	114	91.2	32	Bentomat (AGP, 1996)
	202	166	132.8	64	Bentomat (AGP, 1996)
	403	271	216.8	128	Bentomat (STS, 1999)
600 < SL < 2,000 psf					
	960	386		335	MW Data - Woven GCL
	1440	553		496	Bentomat (GA, 1992)
	1008	316		233	Bentomat (GSC, 1998)
	1440	424		332	Bentomat (GSC, 1998)
	706	279		189	Bentomat (VE, 1998)
High Normal Stress Level (> 2,000 psf)					
	7488	3708			Bentomat (SL, 1996)
	9936	4737			Bentomat (SL, 1996)
	12528	5826			Bentomat (SL, 1996)

TEXTURED HDPE/ NON-WOVEN GEOCOMPOSITE INTERFACE DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level < 2,000 psf					
SL < 600 psf	72	151	120.8	82	NW Lining - Unsaturated
	144	202	161.6	115	NW Lining - Unsaturated
	288	271	216.8	171	NW Lining - Unsaturated
	72	156	124.8	84	NW Lining - Saturated
	144	196	156.8	124	NW Lining - Saturated
	288	372	297.6	206	NW Lining - Saturated
	432	476	380.8		Koutsourais et al (1990)
	202	289	231.2	84.5	Bentomat (AGP, 1996)
	504	499	399.2	211	Bentomat (AGP, 1996)
	72	120	96	28.9	CETCO (1998)
	202	182	145.6	81.2	CETCO (1998)
	504	464	371.2	169.6	Bentomat (TRI, 199
	504	301	240.8	162	Bentomat (TRI, 1997)
600<SL<2000 psf	1296	707			Koutsourais et al (1990)
	1000	651		339	Bentomat (TRI, 1997)
	1000	570		405.2	CETCO (1998)
	1000	850		422	Bentomat (AGP, 1996)
	864	592			Koutsourais et al (1990)
	1000	517		324	Bentomat (TRI, 1997)
	1000	728		496	SERROT Intl. (2000)
	1000	605		392	SERROT Intl. (2000)
High Normal Stress Level (SL>2,000 psf)					
	2016	1024		678.5	Bentomat (TRI, 1997)
	2016	949		647.3	Bentomat (TRI, 1997)
	4000	2131		1286	SERROT Intl. (2000)
	8000	3732		2152	SERROT Intl. (2000)
	4000	1893		1085	SERROT Intl. (2000)
	8000	4064		2337	SERROT Intl. (2000)

TEXTURED HDPE/NON-WOVEN GCL INTERFACE DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level (SL < 2,000 psf)					
SL < 600 psf					
	144			75	Geosyntec (?)
	288			125	
	288			230	Geosyntec (?)
	100			165	CH2M HILL (6/93) Mica
	200			215	Nonwoven up
	400			360	
	576			150	
	576			305	Bentofix
	72	99	79.2	81	NW Lining - Saturated
	144	197	157.6	132	NW Lining - Saturated
	288	233	186.4	173	NW Lining - Saturated
	72	168	134.4	95	NW Lining - Unsaturated
	144	220	176	130	NW Lining - Unsaturated
	288	278	222.4	177	NW Lining - Unsaturated
	72	120	96	29	Bentomat (CETCO, 1988)
	202	182	145.6	81	Bentomat (CETCO, 1988)
	202	289	231.2	84	Bentomat (AGP, 1996)
	504	499	399.2	211	Bentomat (AGP, 1996)
	504	464	371.2	170	Bentomat (TRI, 1997)
	504	301	240.8	162	Bentomat (TRI, 1997)
600<SL< 2,000 psf					
	1003	627	501.6	232	Stark et al (1996)
	1008	570	456	405	Bentomat (CETCO, 1998)
	1008	850	680	422	Bentomat (AGP, 1996)
	1008	651	520.8	339	Bentomat (TRI, 1997)
	1008	517	413.6	324	Bentomat (TRI, 1997)
	1000	728	582.4	496	Serrot Intl. (Oakridge Project)
	1000	605	484	392	Serrot Intl. (Oakridge Project)
	1152			390	
	1080	525	420	505	Geosyntec (11/94)
	2000	650	520	473	AGP (7/95)
	2000	611	488.8	572	Geosyntec (1/97)
	1000	677	541.6	490	CH2M HILL (7/98) CHLF
7	1008	652		223	Bentomat (PL, 1999)
7	1008	584		244	Bentomat (PL, 1999)
10	1440	703		413	Bentomat (GSC, 1999)
7	1008	929		328	Bentomat (GSC, 2000)
High Normal Stress Level (SL > 2000 psf)					
	2005	1253	1002.4	463	Stark et al (1996)
	4010	2506	2004.8	926	Stark et al (1996)
	5952	3719	2975.2	1374	Stark et al (1996)
	2016	1024	819.2	678	Bentomat (TRI, 1997)
	2016	949	759.2	647	Bentomat (TRI, 1997)
	4000	2131	1704.8	1286	Serrot Intl. (Oakridge Project)
	8000	3732	2985.6	2152	Serrot Intl. (Oakridge Project)

	4000	1893	1514.4	1085	Serrot Intl. (Oakridge Project)
	8000	4064	3251.2	2337	Serrot Intl. (Oakridge Project)
	5000			1700	STS (10/93)
	7500			1880	Woven up
	10000			2100	
	4500	1980	1584	970	CETCO (8/94)
	6000	2520	2016	940	Woven up
	7500	3150	2520	1140	
	5760	1705	1364	993	TRI (5/93)
	8640	3263	2610.4	1632	Woven up
	11520	3163	2530.4	1881	
	2160	877	701.6	835	Woven up
	4320	1579	1263.2	1495	
	4000	1300	1040	754	Woven up
	10000	3250	2600	1597	
	15000	4875	3900	2300	
	7200	2905	2324		CETCO (7/96)
	10000	3557	2845.6		Woven up
	13000	4225	3380		
	5760	1760	1408	1167	Nonwoven up
	10000	3057	2445.6	1839	
	5000	2850	2280	1656	
	10000	5069	4055.2	2880	
14	2016	871		319	Bentomat (GSC, 1997)
40	5760	2016		912	Bentomat (GSC, 1997)
70	10080	3337		1597	Bentomat (GSC, 1997)
14	2016	1532		385	Bentomat (TRI, 1997)
28	4032	2343		769	Bentomat (TRI, 1997)
56	8064	3964		1538	Bentomat (TRI, 1997)
14	2016	1192		436	Bentomat (Emcon 1997)
28	4032	2094		872	Bentomat (Emcon, 1997)
70	10080	4799		2179	Bentomat (Emcon, 1997)
28	4032	1646		1035	Bentomat (CETCO, 1998)
50	7200	2560		1849	Bentomat (CETCO, 1998)
70	10080	3391		2588	Bentomat (CETCO, 1998)
25	3600	1260		965	Bentomat (GSC, 1998)
50	7200	2224		1929	Bentomat (GSC, 1998)
100	14400	4153		3858	Bentomat (GSC, 1998)
25	3600	1670		1170	Bentomat (GSC, 1998)
50	7200	2981		2339	Bentomat (GSC, 1998)
100	14400	5601		4679	Bentomat (GSC, 1998)
14	2016	995		276	Bentomat (TRI, 1998)
28	4032	1646		552	Bentomat (TRI, 1998)
63	9072	3274		1243	Bentomat (TRI, 1998)
28	4032	2062		894	Bentomat (PL, 1999)
56	8064	3942		1788	Bentomat (PL, 1999)
28	4032	2124		975	Bentomat (PL, 1999)
56	8064	4179		1951	Bentomat (PL, 1999)
25	3600	1532		1032	Bentomat (GSC, 1999)
50	7200	2914		2065	Bentomat (GSC, 1999)
75	10800	4296		3097	Bentomat (GSC, 1999)
14	2016	1487		655	Bentomat (GSC, 2000)
35	5040	3164		1638	Bentomat (GSC, 2000)
35	5040	2065		798	Bentomat (GSC, 2000)
100	14400	5658		2281	Bentomat (GSC, 2000)
150	21600	8421		3421	Bentomat (GSC, 2000)
	20160	6940	5552	2240	Geosyntec (5/96); Nonwoven up

GCL INTERNAL STRENGTH DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level					
< 2000 psf	200	274		215	James Clem 2/94
	1440	1020			Needlepunched GCL
	500	425		425	CH2M HILL 4/94, KFLF
	1000	765		824	Geosyntec, 8/96
	1250	942		875	ST
	1500	1130		925	
	1000	1310		576	CH2M HILL 7/98, CHLF
High Normal Stress Level					
>= 2,000 psf	3000			1015	Emcon 12/93
	6000			1710	
	9000			2640	
	2000	1740		705	Geosyntec, 2/94
	10000	4820		1720	
	7200	1745		965	
	2000	900		900	Native Soil/Internal, Bentomat ST
	5000	1800		1800	
	10000	3010		3010	
	2016	1215		705	CETCO 7/95
	4032	2425		780	
	7200	4325		792	
	5000	3945		994	
	10000	7056		1425	
20	2880	2881			Bentomat (GRI, 1991)
14	2016	1602			Bentomat (UTA, 1991)
19	2736	1953			Bentomat (UTA, 1991)
14	2016	1413		248	Bentomat (GSC, 1994)
70	10080	5003		1238	Bentomat (GSC, 1994)
142	20448	9619		2511	Bentomat (GSC, 1994)
14	2016	1837		77	Bentomat (CETCO, 1995)
28	4032	3049		155	Bentomat (CETCO, 1995)
50	7200	4952		277	Bentomat (CETCO, 1995)
20	2880	3948		196	Bentomat (PUWL, 1997)
40	5760	5706		393	Bentomat (PUWL, 1997)
20	2880	3502		293	Bentomat (PUWL, 1997)
14	2016	918		417	Bentomat (TRI, 1997)
20	2880	1937		405	Bentomat (PL, 1998)
45	6480	3851		911	Bentomat (PL, 1998)
20	2880	1943		405	Bentomat (PL, 1998)
45	6480	3939		911	Bentomat (PL, 1998)
20	2880	1906		456	Bentomat (PL, 1998)
45	6480	3585		1026	Bentomat (PL, 1998)
20	2880	2056		456	Bentomat (PL, 1998)
45	6480	3735		1026	Bentomat (PL, 1998)
20	2880	1926		354	Bentomat (PL, 1998)
45	6480	3682		796	Bentomat (PL, 1998)
20	2880	2002		560	Bentomat (PL, 1998)
45	6480	3758		1260	Bentomat (PL, 1998)
20	2880	1964		405	Bentomat (PL, 1998)
45	6480	3720		911	Bentomat (PL, 1998)
17	2448	2652			Bentomat (TRI, 1998)
32	4608	4198			Bentomat (TRI, 1998)
75	10800	8631			Bentomat (TRI, 1998)
104	14976	7893		1839	Bentomat (GSC, 1999)
139	20016	9243		2458	Bentomat (GSC, 1999)
174	25056	10594		3076	Bentomat (GSC, 1999)
20	2880	1422		718	Bentomat (PL, 1999)
45	6480	2803		1616	Bentomat (PL, 1999)
20	2880	1293		560	Bentomat (PL, 1999)
45	6480	2462		1260	Bentomat (PL, 1999)
20	2880	1349		508	Bentomat (PL, 1999)
45	6480	2588		1143	Bentomat (PL, 1999)
14	2016	1845		283	Bentomat (GSC, 1999)
28	4032	2500		567	Bentomat (GSC, 1999)
56	8064	3810		1133	Bentomat (GSC, 1999)
112	16128	6430		2267	Bentomat (GSC, 1999)
150	21600	7000		2270	Bentomat (GSC, 2000)
250	36000	9747		3784	Bentomat (GSC, 2000)
400	57600	13868		6054	Bentomat (GSC, 2000)

SOIL TO NON-WOVEN GEOCOMPOSITE INTERFACE DATA

	Normal Stress (psf)	Peak Shear Stress (psf)	80 % of Peak Shear Stress (psf)	Residual Shear Stress (psf)	Source of Data
Low Normal Stress Level					
	125	174	139.2	138	MW (2000)
	240	248	198.4	208	MW (2000)
	490	410	328	361	MW (2000)
	432	363	290.4		Koutsourais et al (1990)
	101	276	220.8		Bentomat (STS, 1996)
	288	375	300		Bentomat (STS, 1996)
	504	490	392		Bentomat (STS, 1996)
	101	324	259.2		Bentomat (CETCO, 1996)
	288	483	386.4		Bentomat (CETCO, 1996)
	504	667	533.6		Bentomat (CETCO, 1996)
	202	293	234.4		Bentomat (AGP, 1996)
	504	452	361.6		Bentomat (AGP, 1996)
	144	256	204.8		Bentomat (STS, 1999)
	288	370	296		Bentomat (STS, 1999)
	576	599	479.2		Bentomat (STS, 1999)
High Normal Stress Level					

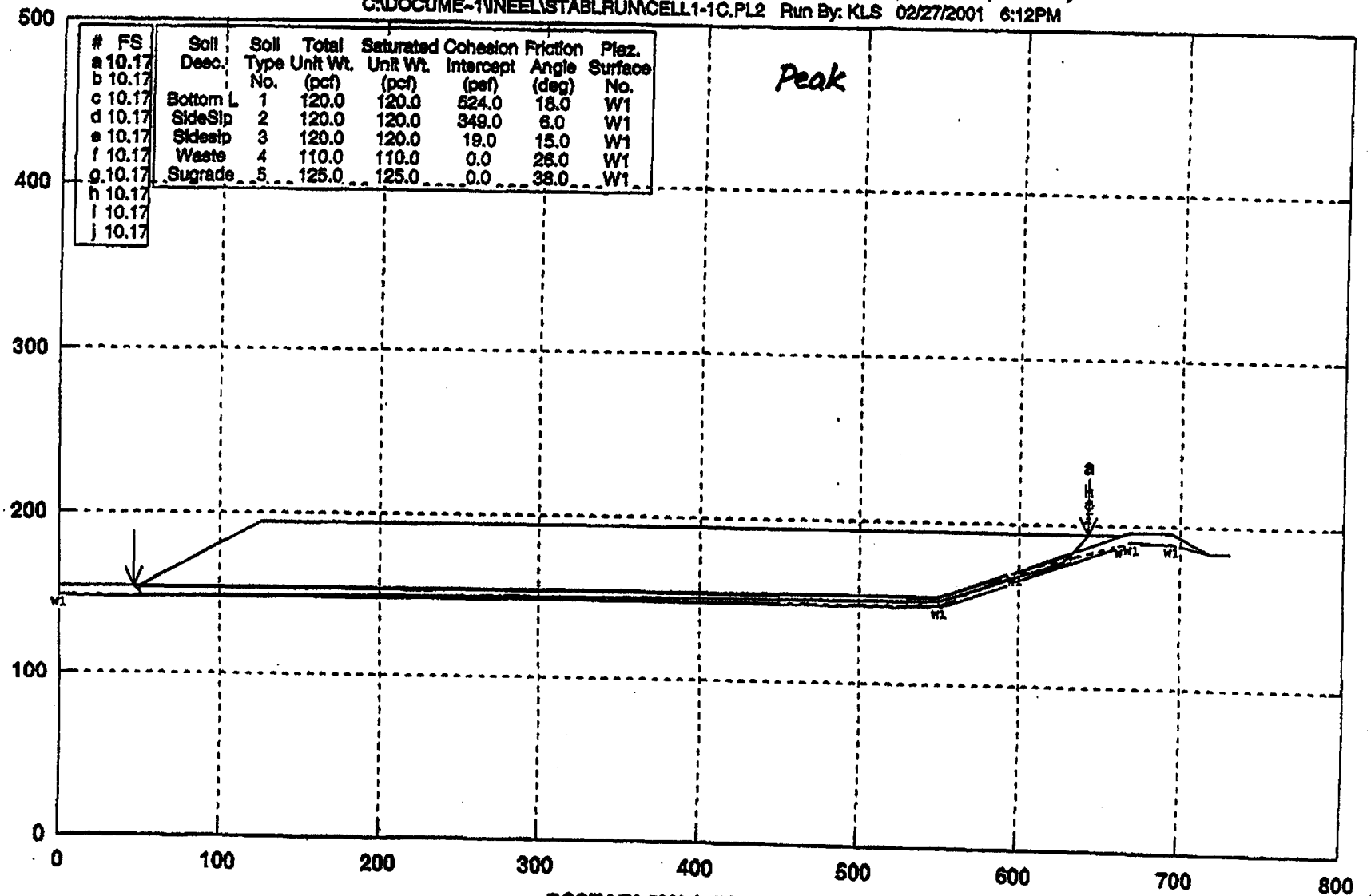
INEEL Landfill - Cell #1 - Interim Filling - Case A (Static)

C:\DOCUME~1\INEEL\STABLRUN\CELL1-1C.PL2 Run By: KLS 02/27/2001 6:12PM

#	FS
a	10.17
b	10.17
c	10.17
d	10.17
e	10.17
f	10.17
g	10.17
h	10.17
i	10.17
j	10.17

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	524.0	18.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1

Peak



PCSTABL5M/si FSmin=10.17

Safety Factors Are Calculated By The Modified Janbu Method

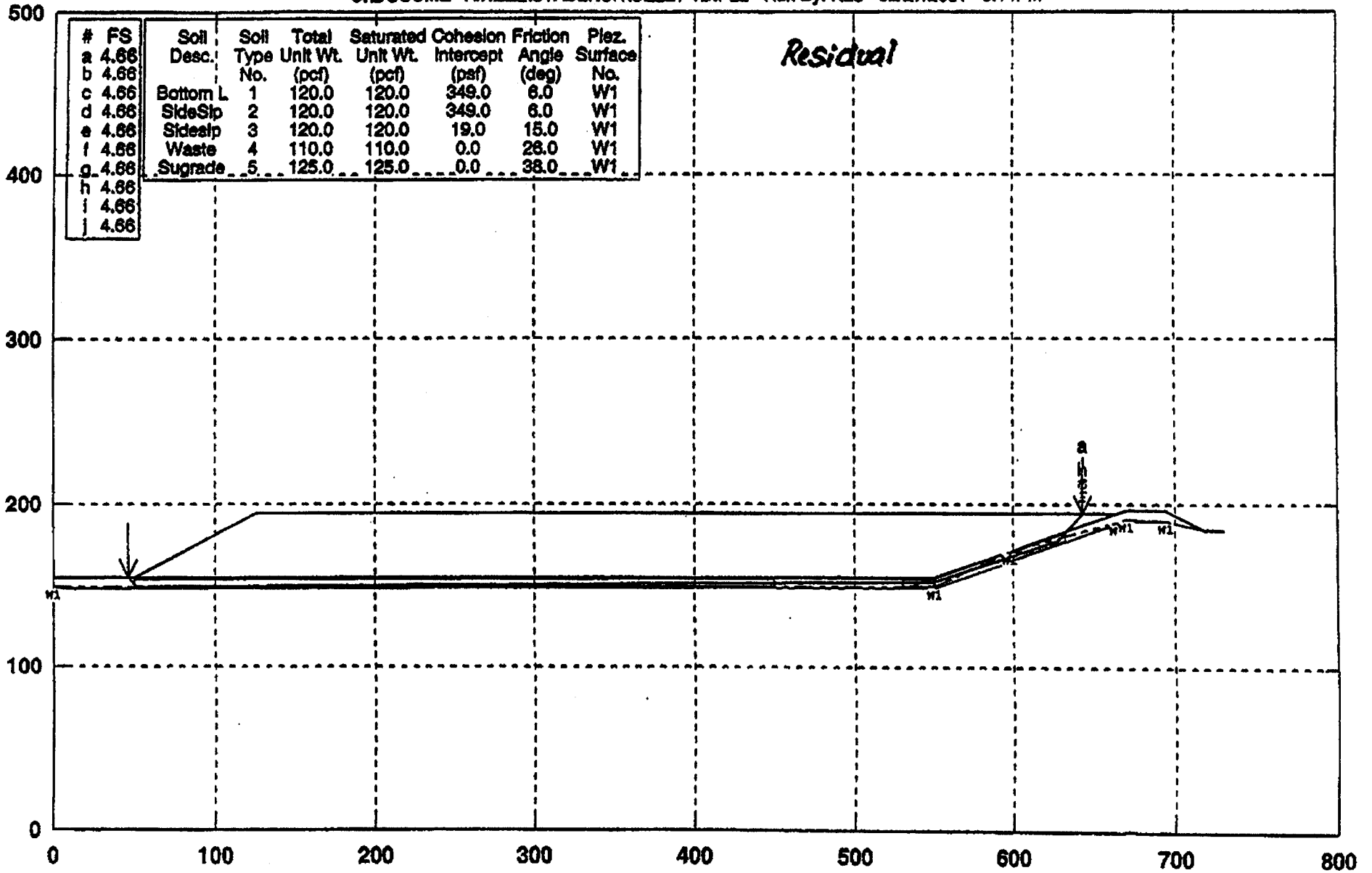
STED

INEEL Landfill - Cell #1 - Interim Filling - Case A (Static)

C:\DOCUME~1\INEEL\STABLRUN\CELL1-1D.PL2 Run By: KLS 02/27/2001 6:14PM

#	FS
a	4.66
b	4.66
c	4.66
d	4.66
e	4.66
f	4.66
g	4.66
h	4.66
i	4.66
j	4.66

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	349.0	6.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1



PCSTABL5M/si FSmin=4.66

Safety Factors Are Calculated By The Modified Janbu Method

STED

INEEL Landfill - Cell #1 - Interim Filling - Case A (Seismic)

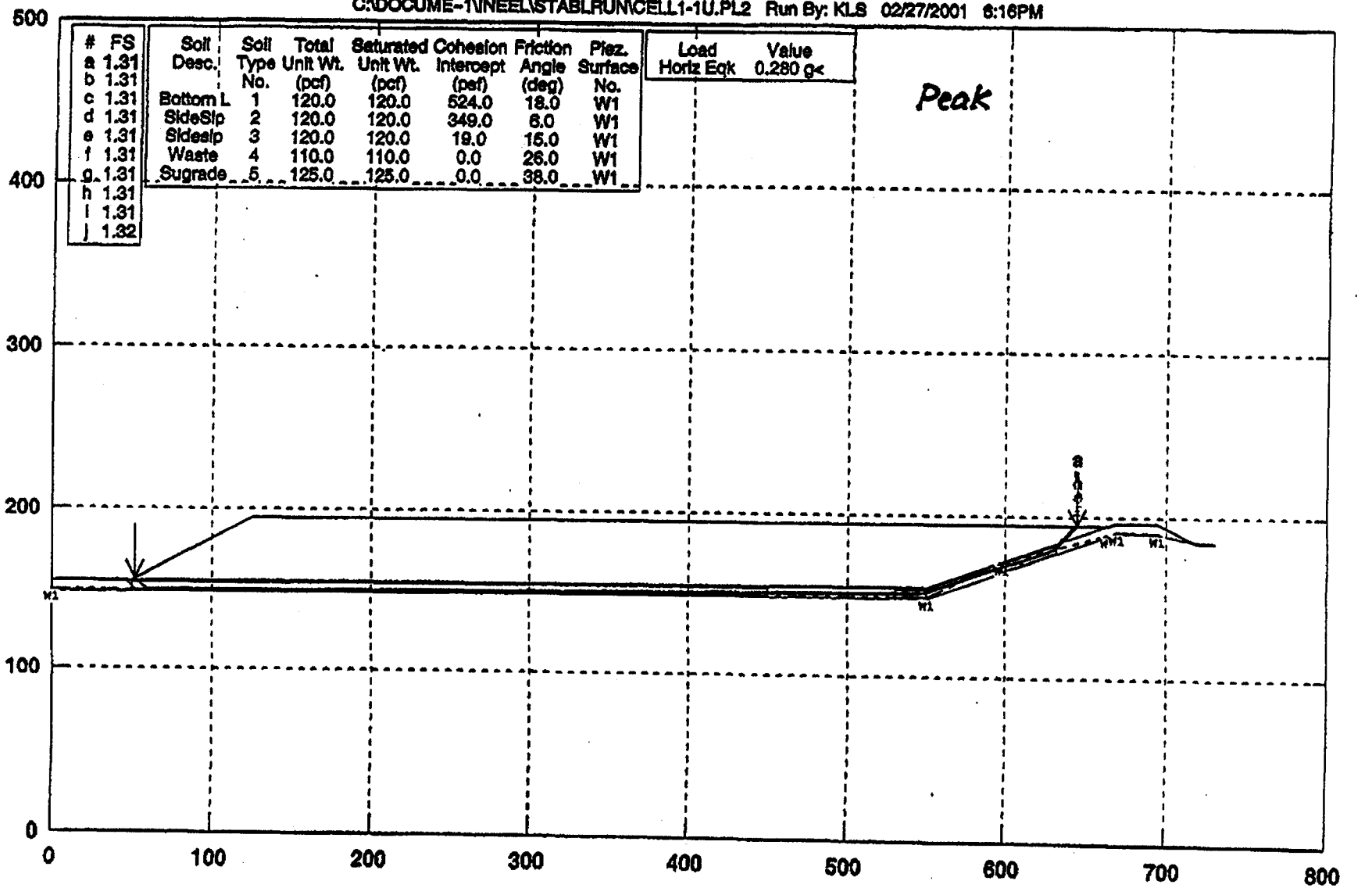
C:\DOCUME~1\INEEL\STABLRUN\CELL1-1U.PL2 Run By: KLS 02/27/2001 6:16PM

#	FS
a	1.31
b	1.31
c	1.31
d	1.31
e	1.31
f	1.31
g	1.31
h	1.31
i	1.31
j	1.32

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	524.0	18.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1

Load	Value
Horiz Eqk	0.280 g<

Peak



PCSTABL5M/si FSmin=1.31

Safety Factors Are Calculated By The Modified Janbu Method

STED

INEEL Landfill - Cell #1 - Interim Filling - Case A (Seismic)

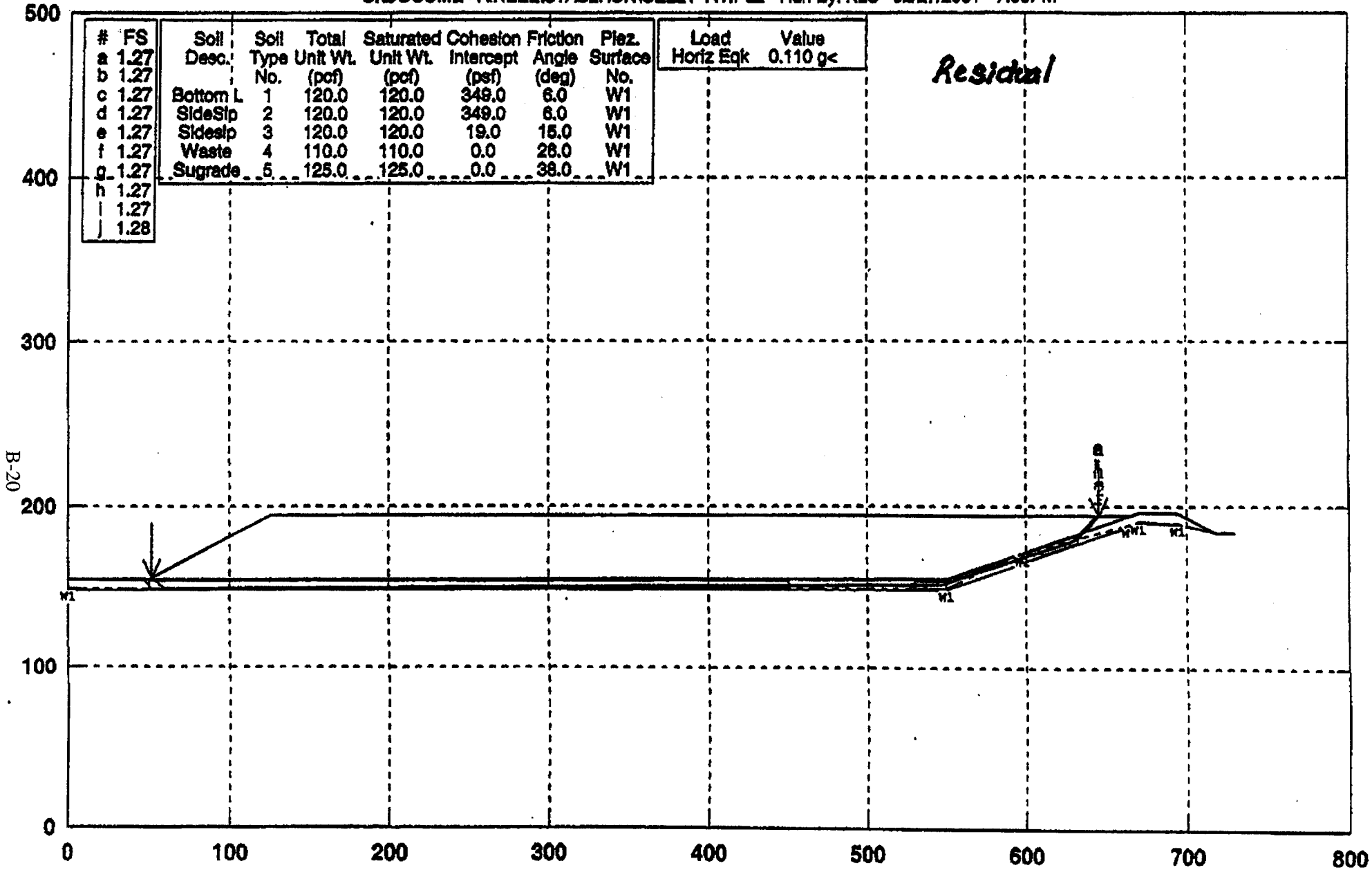
C:\DOCUME~1\NEEL\STABLRUN\CELL1-1W.PL2 Run By: KLS 02/27/2001 7:06PM

#	FS
a	1.27
b	1.27
c	1.27
d	1.27
e	1.27
f	1.27
g	1.27
h	1.27
i	1.27
j	1.28

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	349.0	6.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1

Load	Value
Horiz Eqk	0.110 g<

Residual



PCSTABL5M/si FSmin=1.27

Safety Factors Are Calculated By The Modified Janbu Method

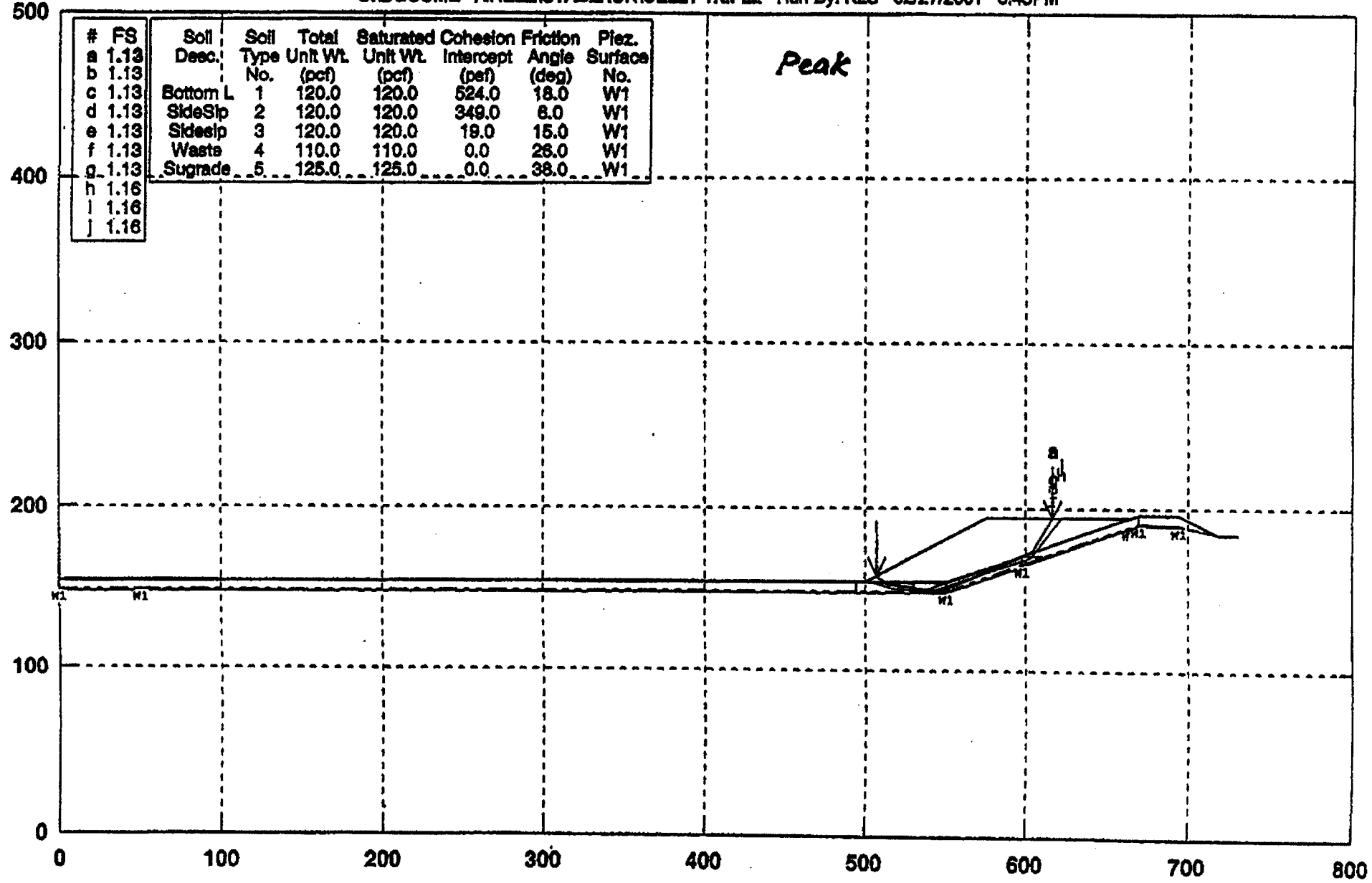
STED

ICDF Landfill - Cell #1- Inte) Filling- Case B (Static), L = 50 ft.

C:\DOCUME~1\NEEL\STABLRUN\CELL1-1K.PL2 Run By: KLS 02/27/2001 6:43PM

#	FS
a	1.13
b	1.13
c	1.13
d	1.13
e	1.13
f	1.13
g	1.13
h	1.16
i	1.16
j	1.16

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	524.0	18.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1



PCSTABL5M/si FSmin=1.13

Safety Factors Are Calculated By The Modified Janbu Method

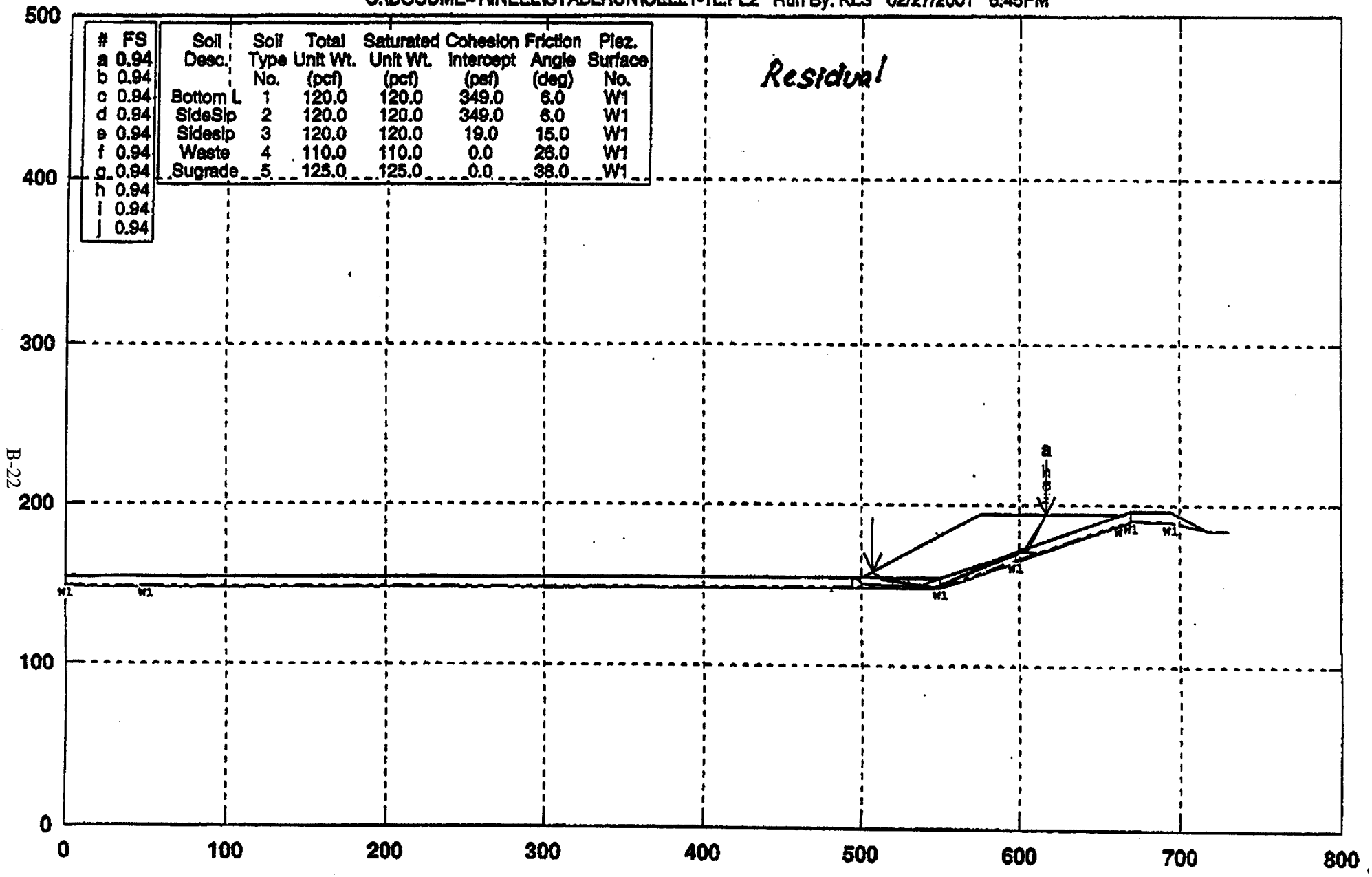
STED

ICDF Landfill - Cell #1- Interim Filling- Case B (Static), L = 50 ft.

C:\DOCUME~1\NEEL\STABLRUN\CELL1-1L.PL2 Run By: KLS 02/27/2001 6:45PM

#	FS
a	0.94
b	0.94
c	0.94
d	0.94
e	0.94
f	0.94
g	0.94
h	0.94
i	0.94
j	0.94

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	349.0	6.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1



PCSTABL5M/si FSmin=0.94

Safety Factors Are Calculated By The Modified Janbu Method

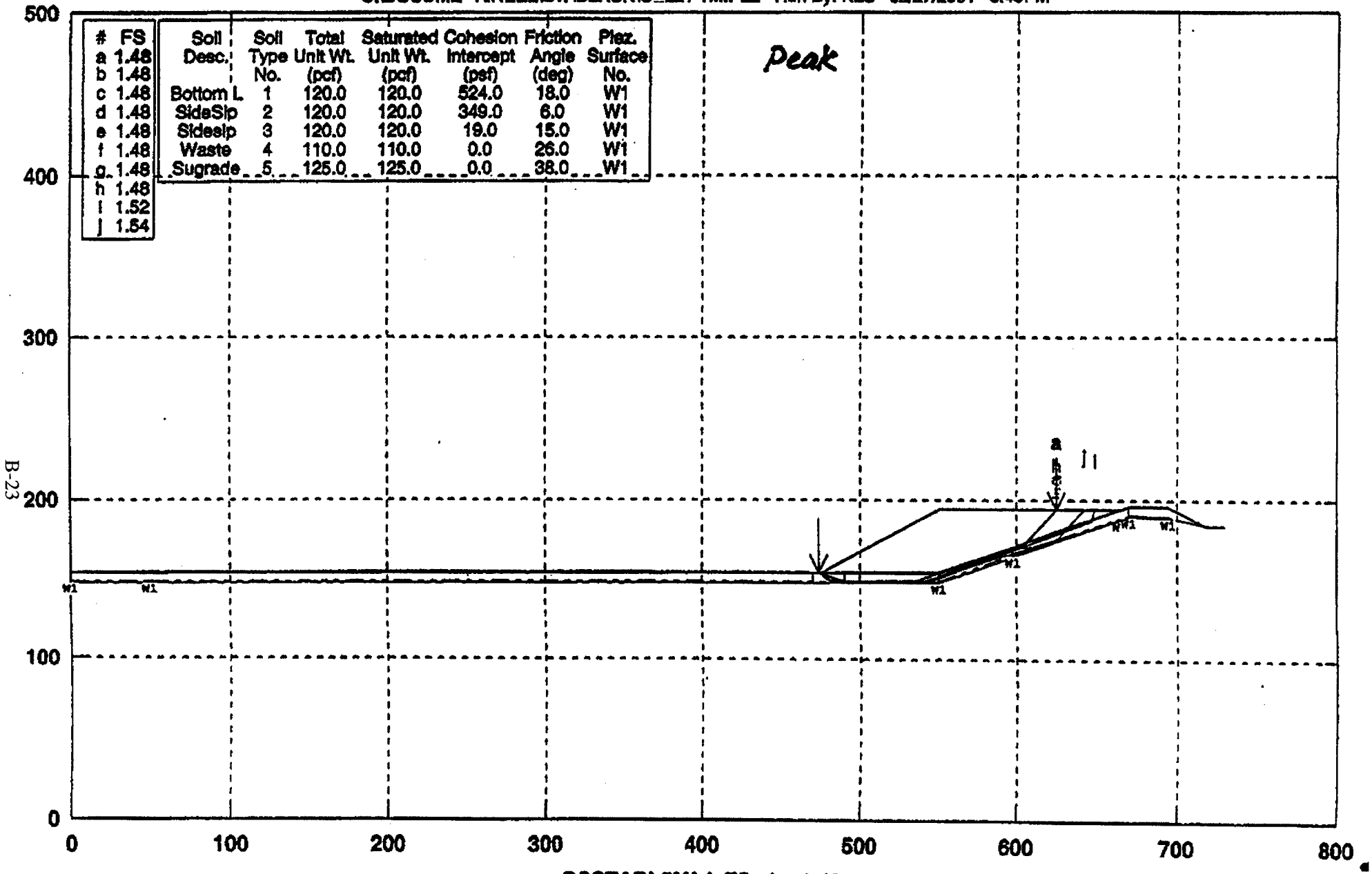
STED

ICDF Landfill - Cell #1- Inte[illegible]n Filling- Case B (Static), L = 75 ft.

C:\DOCUME~1\NEEL\STABLRUN\[illegible]1-1M.PL2 Run By: KLS 02/27/2001 6:49PM

#	FS
a	1.48
b	1.48
c	1.48
d	1.48
e	1.48
f	1.48
g	1.48
h	1.48
i	1.52
j	1.54

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	524.0	18.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1



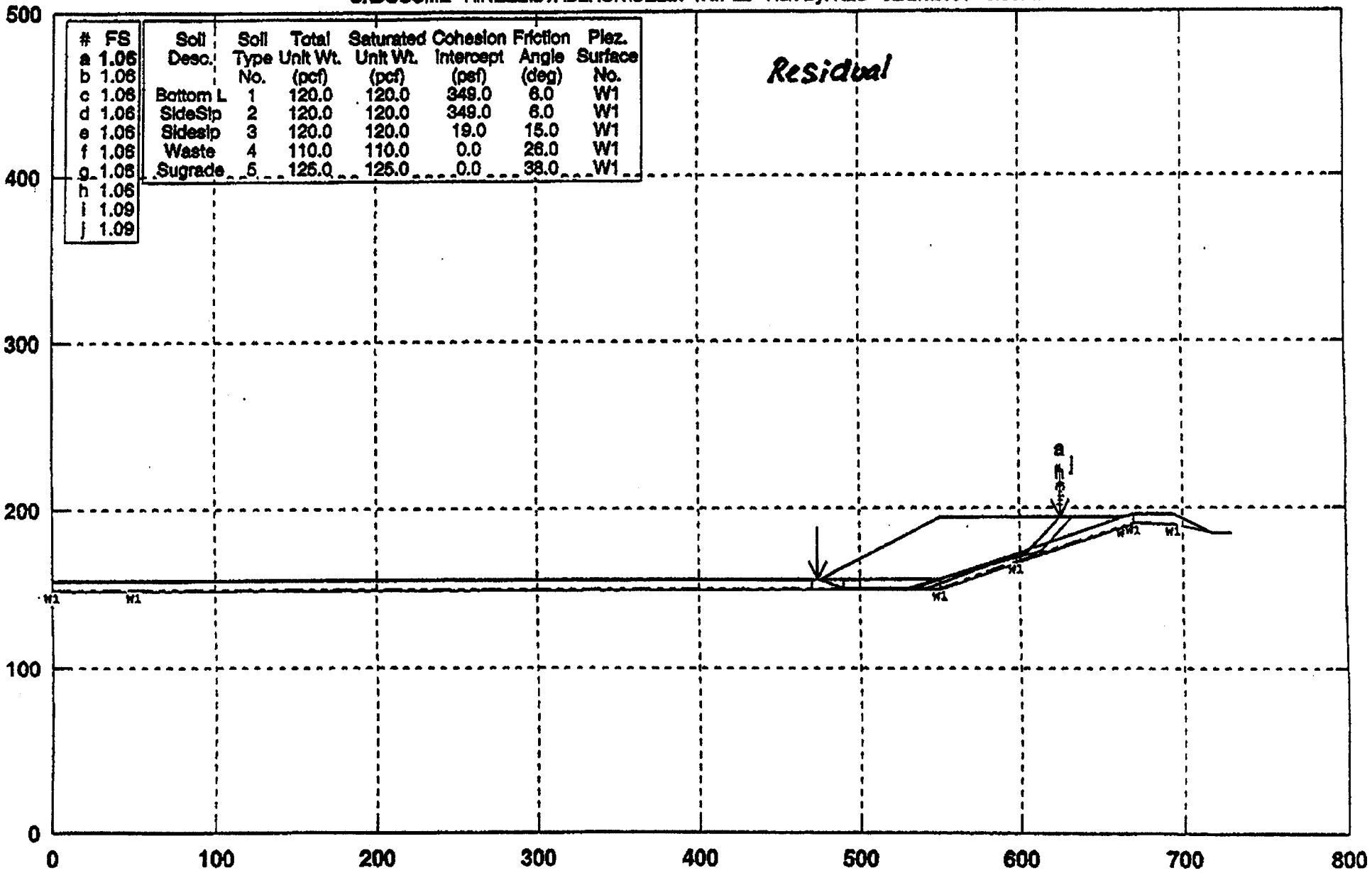
PCSTABL5M/si FSmin=1.48

Safety Factors Are Calculated By The Modified Janbu Method

STED

ICDF Landfill - Cell #1- Interim Filling- Case B (Static), L = 75 ft.

C:\DOCUME~1\INEEL\STABLRUN\CELL1-1N.PL2 Run By: KLS 02/27/2001 6:50PM



#	FS
a	1.06
b	1.06
c	1.06
d	1.06
e	1.06
f	1.06
g	1.06
h	1.06
i	1.09
j	1.09

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	349.0	6.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1

PCSTABL5M/si FSmin=1.06

Safety Factors Are Calculated By The Modified Janbu Method

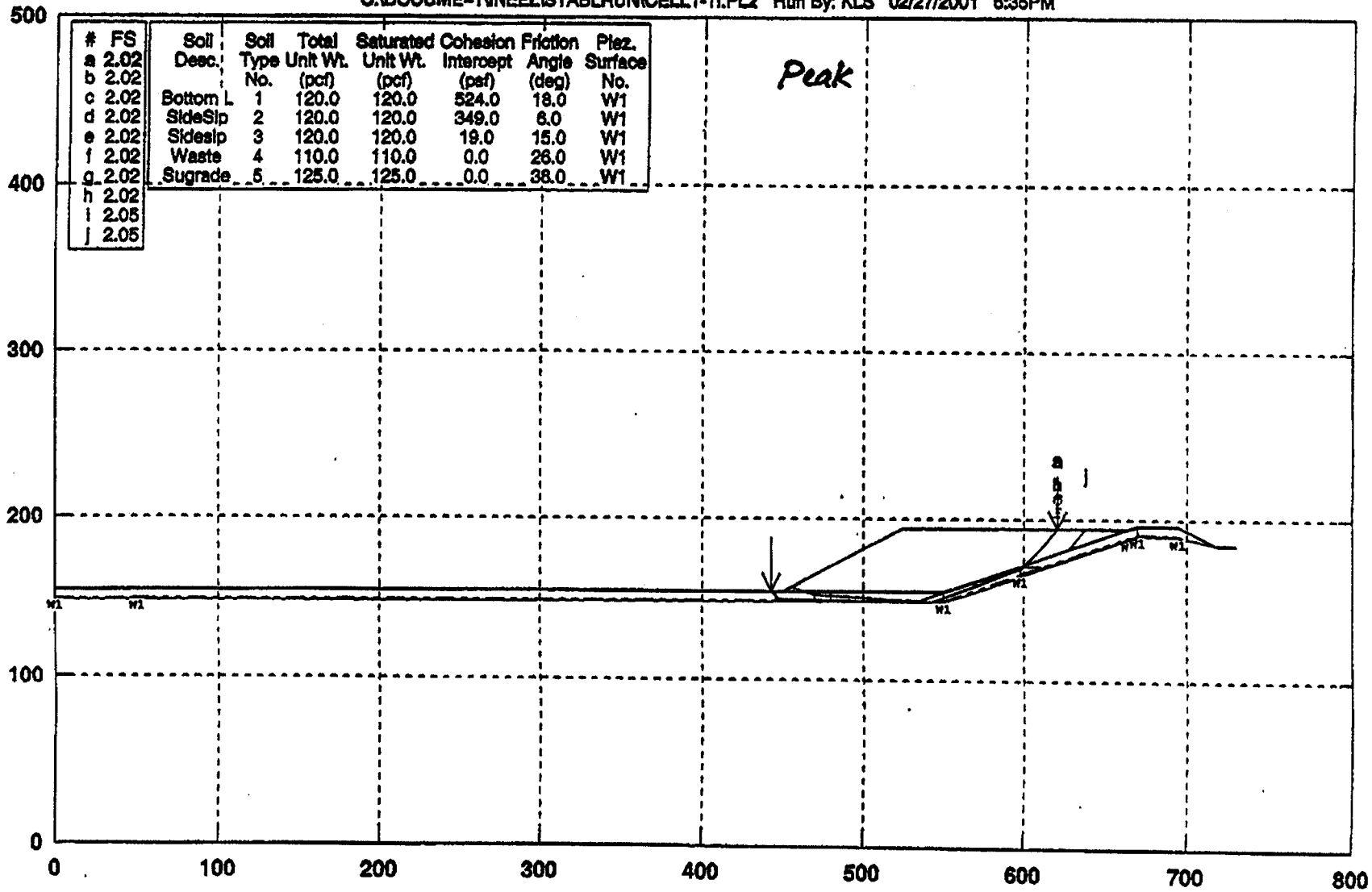
STED

ICDF Landfill - Cell #1- Interim Filling- Case B (Static), L = 100 ft.

C:\DOCUME~1\NEEL\STABLRUN\CELL1-1I.PL2 Run By: KLS 02/27/2001 6:35PM

#	FS
a	2.02
b	2.02
c	2.02
d	2.02
e	2.02
f	2.02
g	2.02
h	2.02
i	2.05
j	2.05

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	524.0	18.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1



PCSTABL5M/si FSmin=2.02

Safety Factors Are Calculated By The Modified Janbu Method

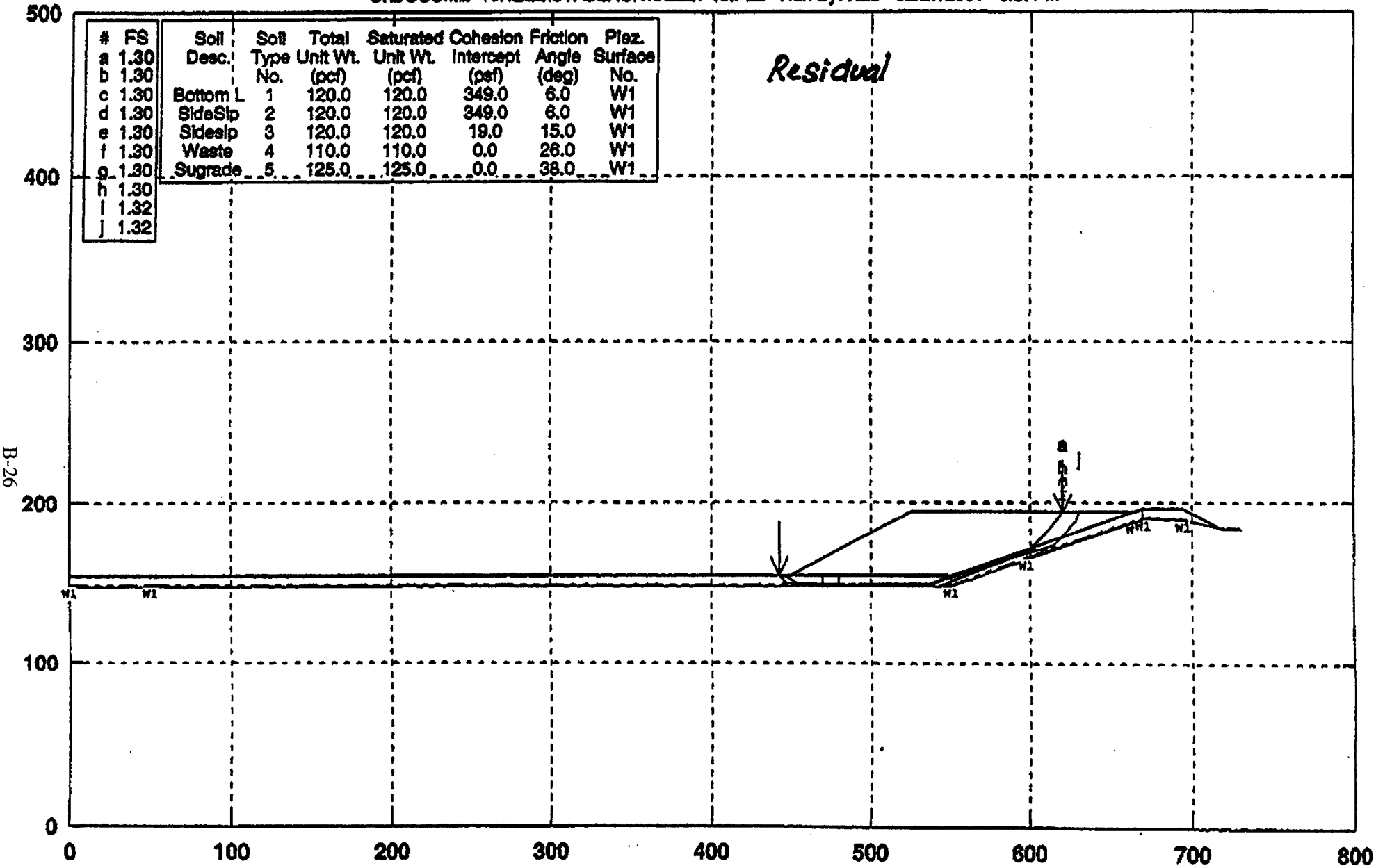
STED

ICDF Landfill - Cell #1- Interim Filling- Case B (Static), L = 100 ft.

C:\DOCUME~1\NEEL\STABLRUN\CELL1-1J.PL2 Run By: KLS 02/27/2001 6:37PM

#	FS
a	1.30
b	1.30
c	1.30
d	1.30
e	1.30
f	1.30
g	1.30
h	1.30
i	1.32
j	1.32

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Bottom L	1	120.0	120.0	349.0	6.0	W1
SideSlp	2	120.0	120.0	349.0	6.0	W1
Sideslp	3	120.0	120.0	19.0	15.0	W1
Waste	4	110.0	110.0	0.0	26.0	W1
Sugrade	5	125.0	125.0	0.0	38.0	W1



PCSTABL5M/si FSmin=1.30

Safety Factors Are Calculated By The Modified Janbu Method

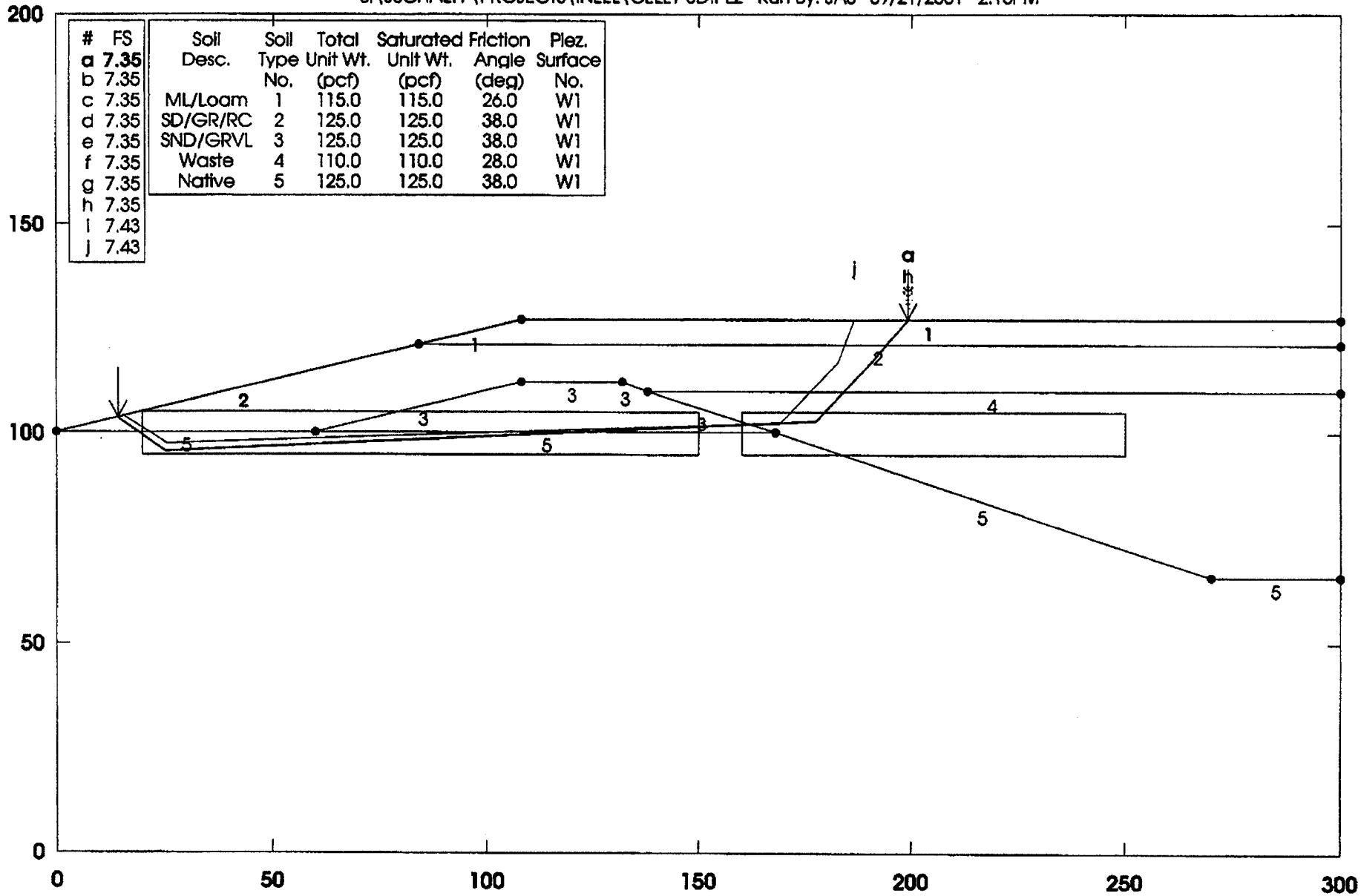
STED

INEEL Landfill - Cell #1 - Final Configuration Stability (Static)

S:\JSCHAEFF\PROJECTS\INEEL\CELL1-3D.PL2 Run By: JAS 09/21/2001 2:16PM

#	FS
a	7.35
b	7.35
c	7.35
d	7.35
e	7.35
f	7.35
g	7.35
h	7.35
i	7.43
j	7.43

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Plez. Surface No.
ML/Loam	1	115.0	115.0	26.0	W1
SD/GR/RC	2	125.0	125.0	38.0	W1
SND/GRVL	3	125.0	125.0	38.0	W1
Waste	4	110.0	110.0	28.0	W1
Native	5	125.0	125.0	38.0	W1



PCSTABL5M/si FSmin=7.35

Safety Factors Are Calculated By The Modified Janbu Method

STED

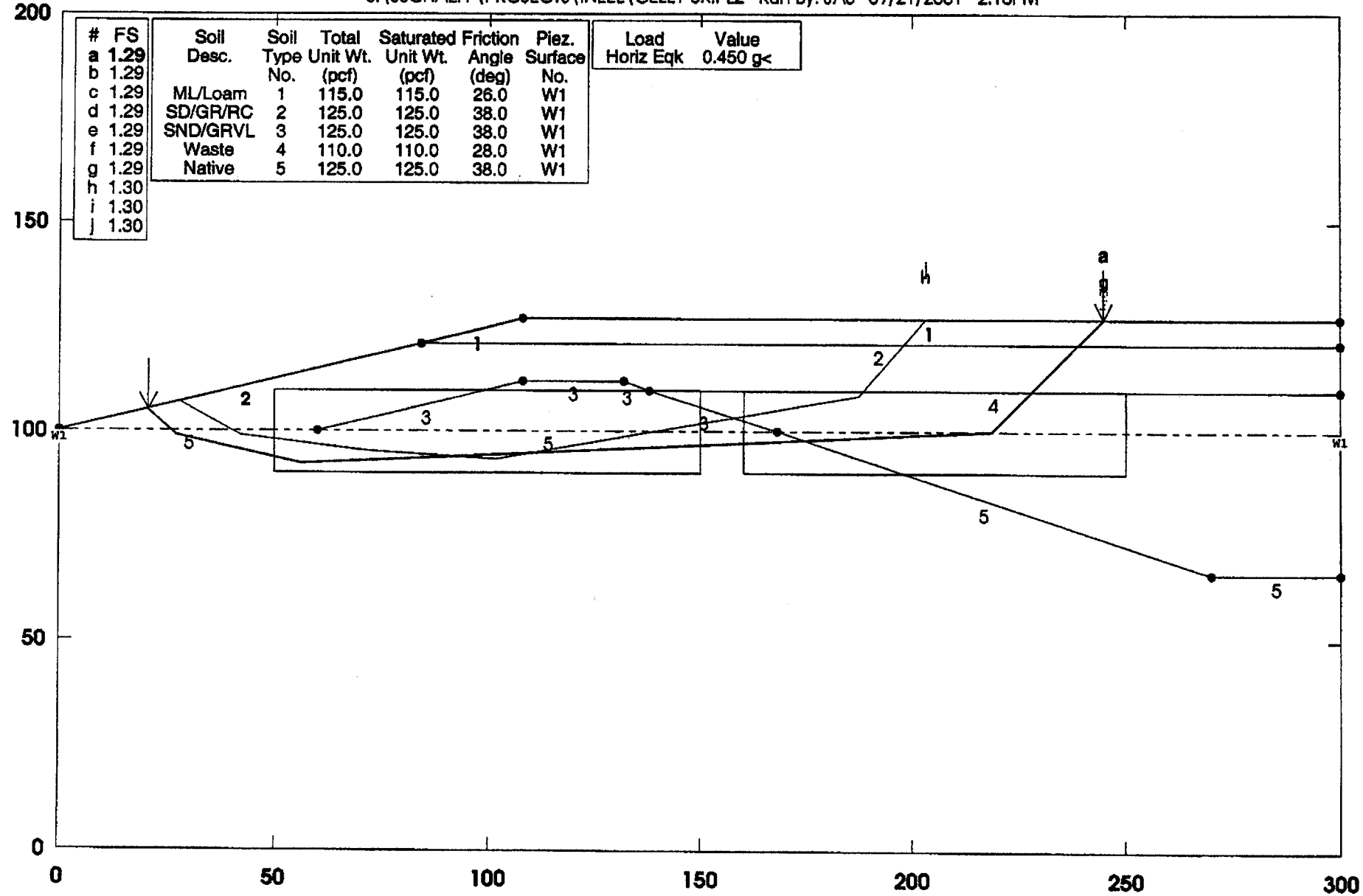
INEEL Landfill - Cell #1 - Final Configuration Stability (Seismic)

S:\JSCHAEFF\PROJECTS\INEEL\CELL1-3K.PL2 Run By: JAS 09/21/2001 2:18PM

#	FS
a	1.29
b	1.29
c	1.29
d	1.29
e	1.29
f	1.29
g	1.29
h	1.30
i	1.30
j	1.30

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
ML/Loam	1	115.0	115.0	26.0	W1
SD/GR/RC	2	125.0	125.0	38.0	W1
SND/GRVL	3	125.0	125.0	38.0	W1
Waste	4	110.0	110.0	28.0	W1
Native	5	125.0	125.0	38.0	W1

Load	Value
Horiz Eqk	0.450 g<



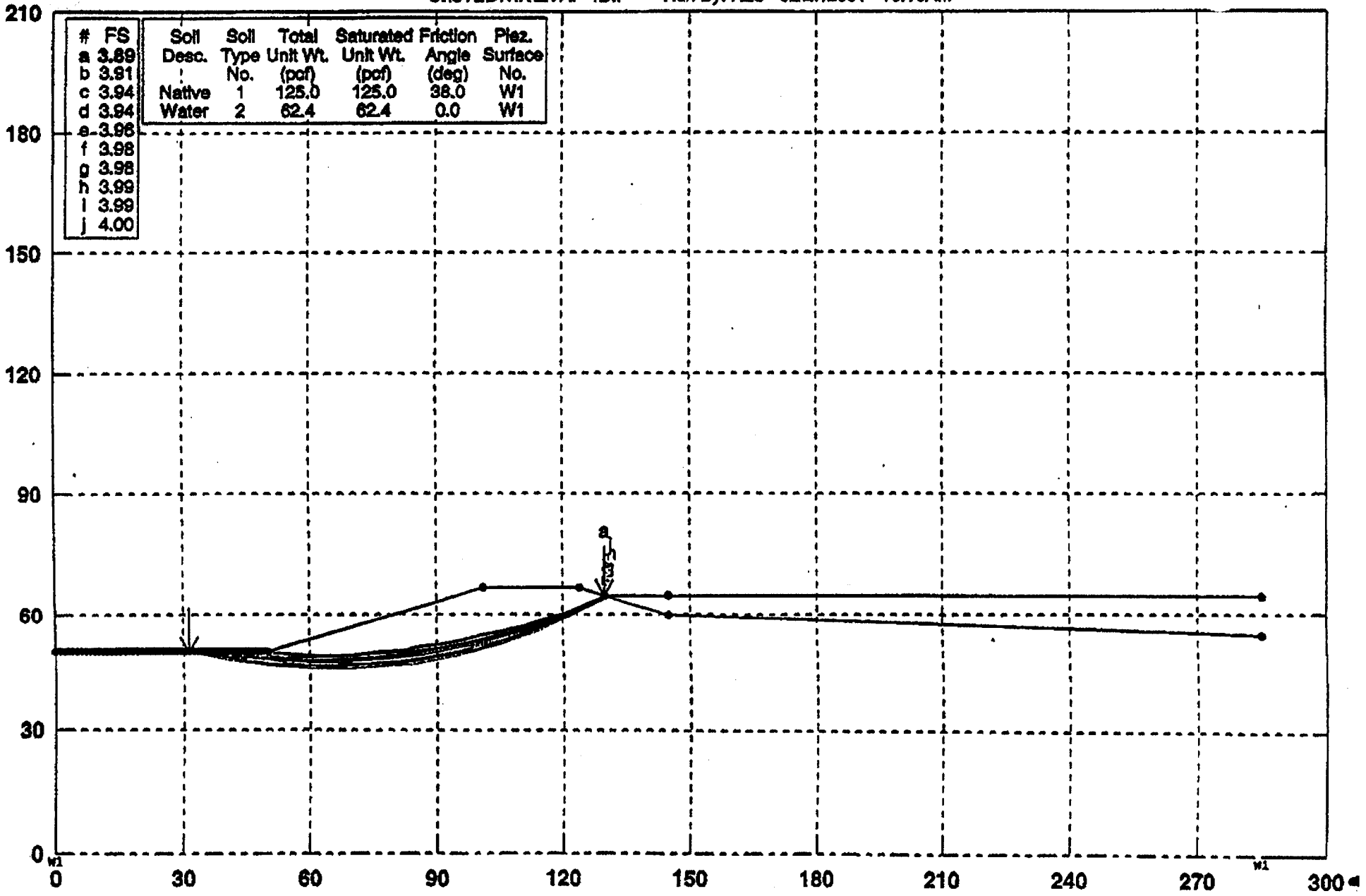
PCSTABL5M/si FSmin=1.29

Safety Factors Are Calculated By The Modified Janbu Method

STED

ICDF Evaporation Pond - Global Stability- Static Loading

C:\STEDWIN\EVAP-4D.I Run By: KLS 02/27/2001 10:10AM



#	FS
a	3.89
b	3.91
c	3.94
d	3.94
e	3.96
f	3.98
g	3.98
h	3.99
i	3.99
j	4.00

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
Native	1	125.0	125.0	38.0	W1
Water	2	62.4	62.4	0.0	W1

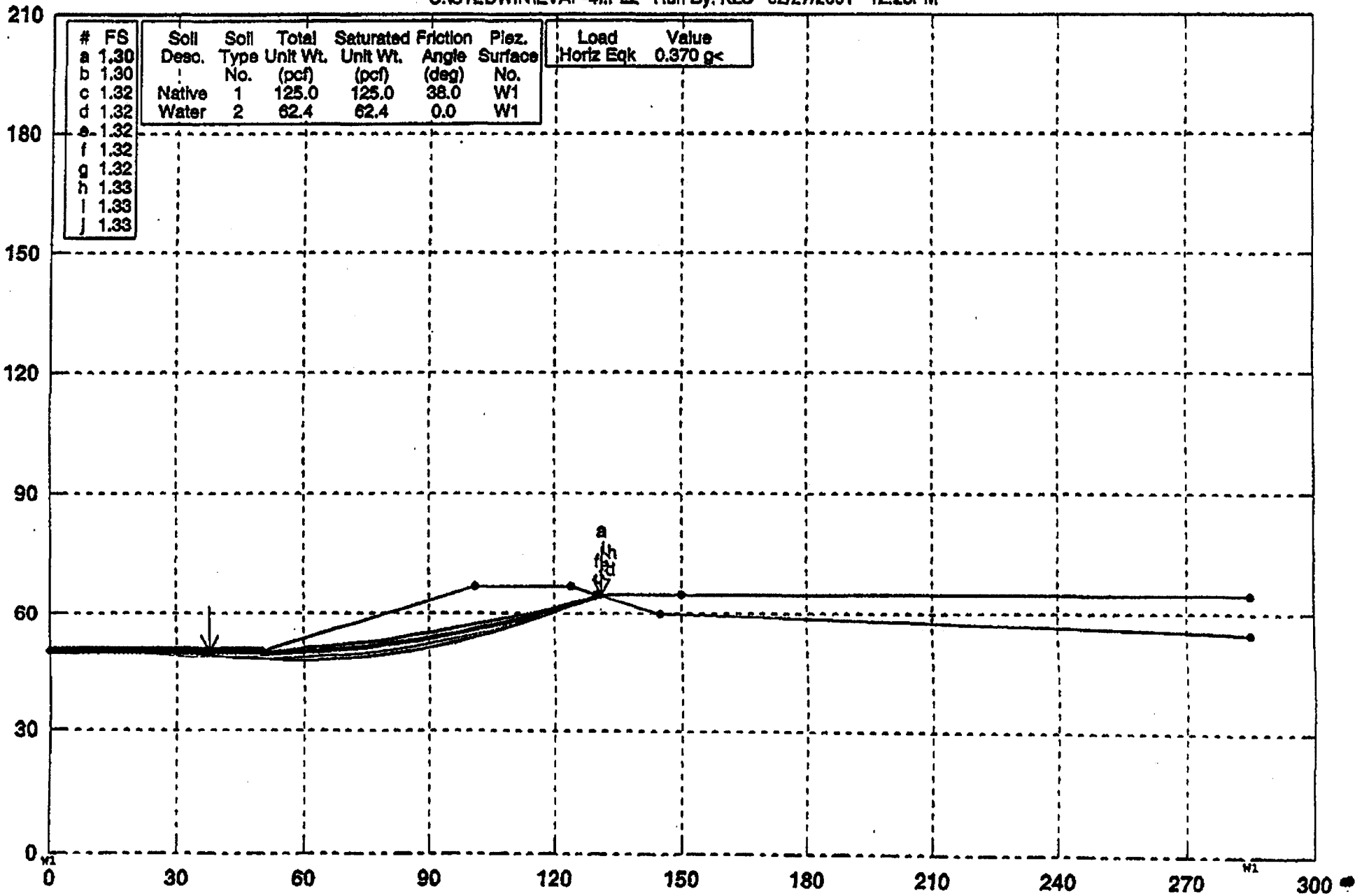
PCSTABL5M/si FSmin=3.89

Safety Factors Are Calculated By The Modified Bishop Method

STED

ICDF Evaporation Pond - Global Stability- ~~Static~~ Seismic Loading

C:\STEDWIN\EVAP-4I.PL2 Run By: KLS 02/27/2001 12:23PM



#	FS
a	1.30
b	1.30
c	1.32
d	1.32
e	1.32
f	1.32
g	1.32
h	1.33
i	1.33
j	1.33

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
Native	1	125.0	125.0	38.0	W1
Water	2	62.4	62.4	0.0	W1

Load	Value
Horiz Eqk	0.370 g<

PCSTABL5M/si FSmin=1.30

Safety Factors Are Calculated By The Modified Bishop Method

STED

Appendix C

Site-Specific Interface Shear Strength Data and Plots

Precision Geosynthetic Laboratories

ISO 9002

June 8, 2001

Mr. Mike Reimbold
CH2M HILL
777 108th Avenue NE
Bellevue, WA 98004-5118

Dear Mr. Reimbold: **RE: INEEL CDF**

Thank you for consulting Precision Geosynthetic Laboratories for your material testing needs.

It should be noted that the test specimen and test sample used for this report was believed to be representative of the material produced under the designation herein stated. However, these results are indicative of only the specimens that were actually tested. The testing herein is based upon accepted industry practice as well as the test method listed. Precision Geosynthetic Laboratories neither accepts responsibility for nor makes claims to the final use and purpose of the material.

By accepting the data and results represented on this report, Client agrees to limit the liability of Precision Geosynthetic Laboratories from Client and all other parties for claims arising out of the use of this data to the cost for the respective test(s) represented in this report, and Client agrees to indemnify and hold harmless Precision Geosynthetic Laboratories from and against all liability in excess of the aforementioned limit.

The test data and all associated project information provided shall be held in confidence and disclosed to other parties only with the authorization of Client or Precision Geosynthetic Laboratories.

It is a company policy to keep the physical records of each job for 2 years since the receipt of the samples and keep the electronic file for 7 years. We will dispose the samples two weeks after the final report is faxed to you. Should you want us to keep them for some period of time, please advise us immediately.

If you have any questions or if we may be of further service, please do not hesitate to call at 800-522-4599.

Sincerely,

PRECISION GEOSYNTHETIC LABORATORIES

Edith Pintor
Quality Assurance

Cora B. Queja
Vice President

Enclosure: (Job No. 010449)

1160 North Gilbert Street, Anaheim, CA 92801, Tel # 714-520-9631, Fax # 714-520-9637

Precision Geosynthetic Laboratories

ISO 9002

CLIENT: CH2M HILL
PROJECT: INEEL CDF

INTERFACE SHEAR TEST RESULTS
(PGL Job No. 010449)

SAMPLE IDENTIFICATIONS:

SAMPLE ID	PRECISION CONTROL NUMBER	DATE RECEIVED	ORIGIN OF MATERIAL
Operations Layer	70671/70672	5/24/01	
HDPE Textured Liner	70692	5/25/01	GSE
HDPE Textured Liner	70693	5/25/01	GSE
HDPE Textured Liner	70694	5/25/01	GSE
Soil Bentonite	70707	5/29/01	Soil Tech Inc.
GCL Roll 1257 Lot 2001191O	70751	5/30/01	Cetco
D/S Geocomposite	70809	6/1/01	GSE

Friction Flex

TESTS REQUIRED:

TEST METHOD	DESCRIPTION
ASTM D6243	Interface Shear
ASTM D5321	Interface Shear

TEST CONDITIONS: The samples were conditioned for a minimum one hour in the laboratory at 22 ± 2°C (71.6 ± 3.6°F) and at 60 ± 10% relative humidity prior to test.

TEST RESULTS:

The test results is summarized in Tables 1 through 11 . The units in which the data are reported are included on the tables.

PRECISION GEOSYNTHETIC LABORATORIES

CAL-LAB
Initials: EP #: 013
Date: 6/22/01

Edith Pintor
Quality Assurance

Cora B. Queja
Vice President

1160 North Gilbert Street, Anaheim, CA 92801, Tel # 714-520-9631, Fax # 714-520-9637

REC'D CH_2M SEA MAR 1 9 2002

Precision Geosynthetic Laboratories

ISO 9002

March 11, 2002

Mr. Mike Reimbold
CH2MHILL
777 108th Avenue NE
Bellevue, WA 98004-5118

Dear Mr. Reimbold: **RE: Ineel CDF**

Thank you for consulting Precision Geosynthetic Laboratories for your material testing needs.

It should be noted that the test specimen and test sample used for this report was believed to be representative of the material produced under the designation herein stated. However, these results are indicative of only the specimens that were actually tested. The testing herein is based upon accepted industry practice as well as the test method listed. Precision Geosynthetic Laboratories neither accepts responsibility for nor makes claims to the final use and purpose of the material.

By accepting the data and results represented on this report, Client agrees to limit the liability of Precision Geosynthetic Laboratories from Client and all other parties for claims arising out of the use of this data to the cost for the respective test(s) represented in this report, and Client agrees to indemnify and hold harmless Precision Geosynthetic Laboratories from and against all liability in excess of the aforementioned limit.

The test data and all associated project information provided shall be held in confidence and disclosed to other parties only with the authorization of Client or Precision Geosynthetic Laboratories.

It is a company policy to keep the physical records of each job for 2 years since the receipt of the samples and keep the electronic file for 7 years. We will dispose the samples two weeks after the final report is faxed to you. Should you want us to keep them for some period of time, please advise us immediately.

If you have any questions or if we may be of further service, please do not hesitate to call at 800-522-4599.

Sincerely,

PRECISION GEOSYNTHETIC LABORATORIES

Edith Pintor
Quality Assurance

Cora B. Queja
Vice President

Enclosure: (Job No.020106)

1160 North Gilbert Street, Anaheim, CA 92801. Tel # 714-520-9631. Fax # 714-520-9637

Precision Geosynthetic Laboratories

ISO 9002

CLIENT: CH2MHILL
PROJECT: Inael CDF
INTERFACE SHEAR TEST RESULTS
(PGL Job No. 020106)

SAMPLE IDENTIFICATIONS:

SAMPLE ID	PRECISION CONTROL NUMBER	DATE RECEIVED	ORIGIN OF MATERIAL
Bentomat DN R#7096 L#200146LO	74355	3/4/02	CH2MHILL
HDPE Textured — HDT replaces	74356	3/4/02	CH2MHILL
Geocomposite Precision Flex in tests #3, 4, 5 6, 10, 11	74356	3/4/02	CH2MHILL

TESTS REQUIRED:

TEST METHOD	DESCRIPTION
ASTM D5321	Interface Shear
ASTM D6243	Interface Shear

TEST CONDITIONS: The samples were conditioned for a minimum one hour in the laboratory at 22 ± 2°C (71.6 ± 3.6°F) and at 60 ± 10% relative humidity prior to test.

TEST RESULTS:

The test results are summarized in Tables 1 through 4. The units in which the data are reported are included on the tables.

PRECISION GEOSYNTHETIC LABORATORIES

CAL-LAB
Initials: [illegible] 013
Date: 3/11/02

Edith Pintor
Quality Assurance

Cora B. Queja
Vice President

1160 North Gilbert Street. Anaheim. CA 92801. Tel # 714-520-9631. Fax # 714-520-9637

TABLE 1.

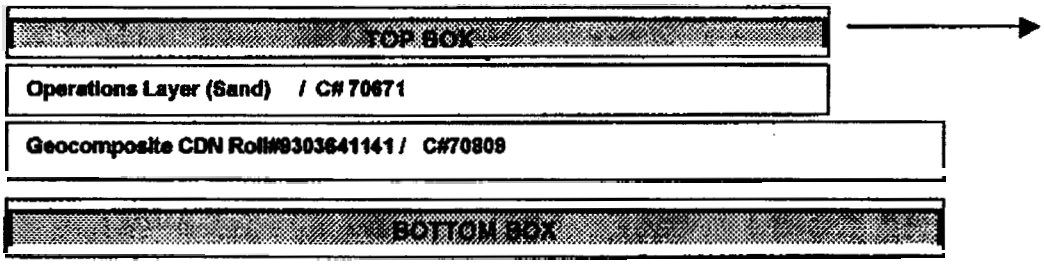
CLIENT: CH2M HILL
PROJECT: INEEL CDF

INTERFACE SHEAR TEST RESULT (ASTM D5321)

(PGL Job No. 010449)

QC'd by: _____
June 6, 2001

TEST CONFIGURATION #1



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 20" x 20".
2. Operations Layer (Sand) was lightly tamped into the top box at 5.04% moisture content.

CONSOLIDATION:

1. Each set of specimen was consolidated under drained condition for 15 min at normal load before shearing.

SHEAR TEST:

1. Shear test was conducted at 0.04 in/ min.
2. Sheared at minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in drained condition.

Tests were performed in general accordance with ASTM D5321-92
using Brainard- Kilman LG-112 Direct Shear machine with effective area of 12 in x 12 in.

TEST RESULTS:

NORMAL STRESS (psi)	NORMAL STRESS (psf)	PEAK STRENGTH: SHEAR STRESS (psf)	PEAK STRENGTH: PEAK SECANT ANGLE	2.0" DISPLACEMENT STRENGTH: SHEAR STRESS (psf)	2.0" DISPLACEMENT STRENGTH: 2.0" DISPLACEMENT SECANT ANGLE
0.69	100	197	63	177	61
1.74	250	294	50	268	47
3.47	500	574	49	492	45
	COHESION (psf):		**83**		**86**
	FRICTION ANGLE (degrees):		**43.8**		**38.6**
	COEFFICIENT OF FRICTION:		**0.96**		**0.80**

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

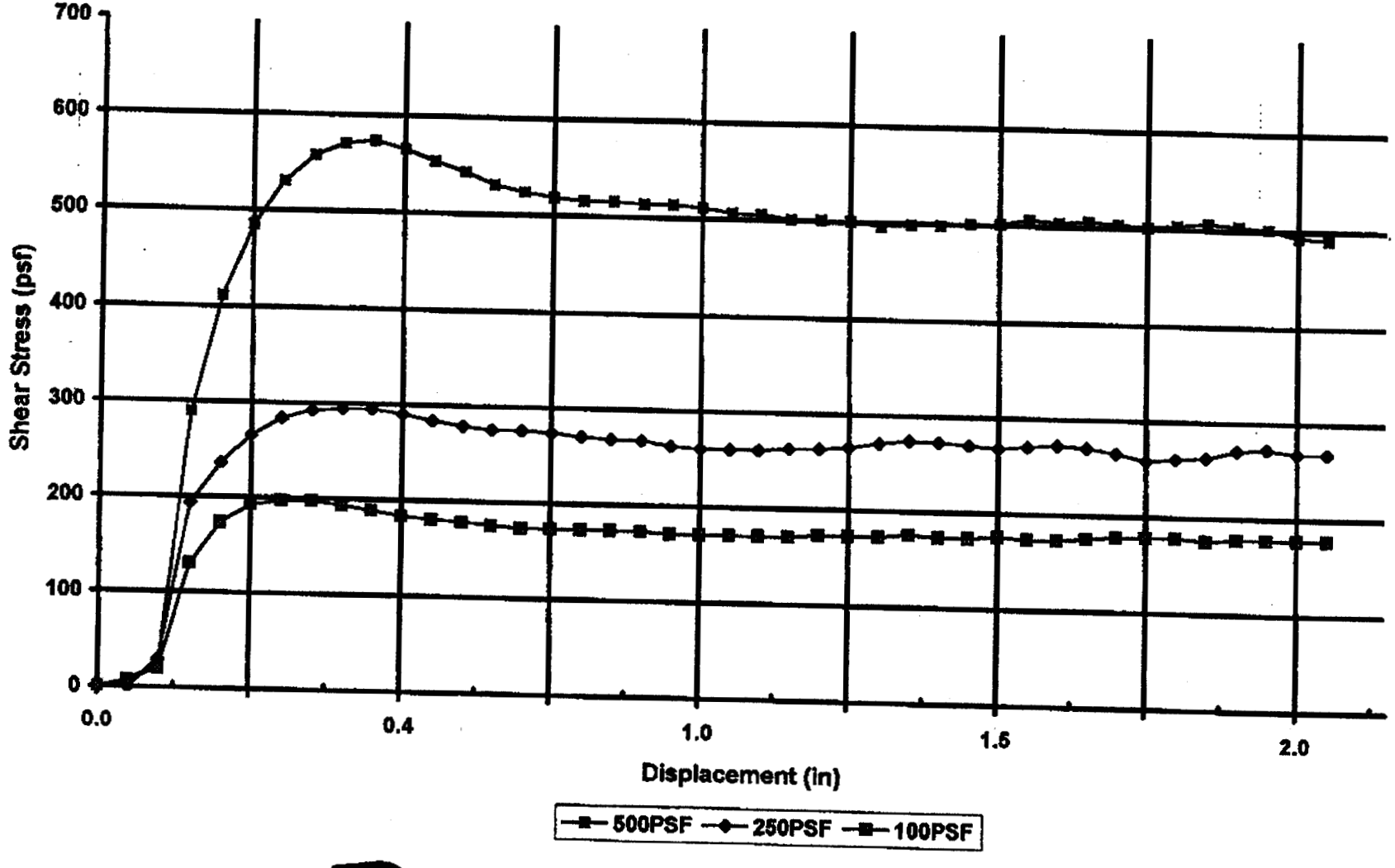
OBSERVATIONS:

Failure occurred along the interface. **See Figure #1 and #2**
No stretching, abrasion, or tearing was observed on the Geocomposite specimens.

Precision Geosynthetic Laboratories

ISO 9002

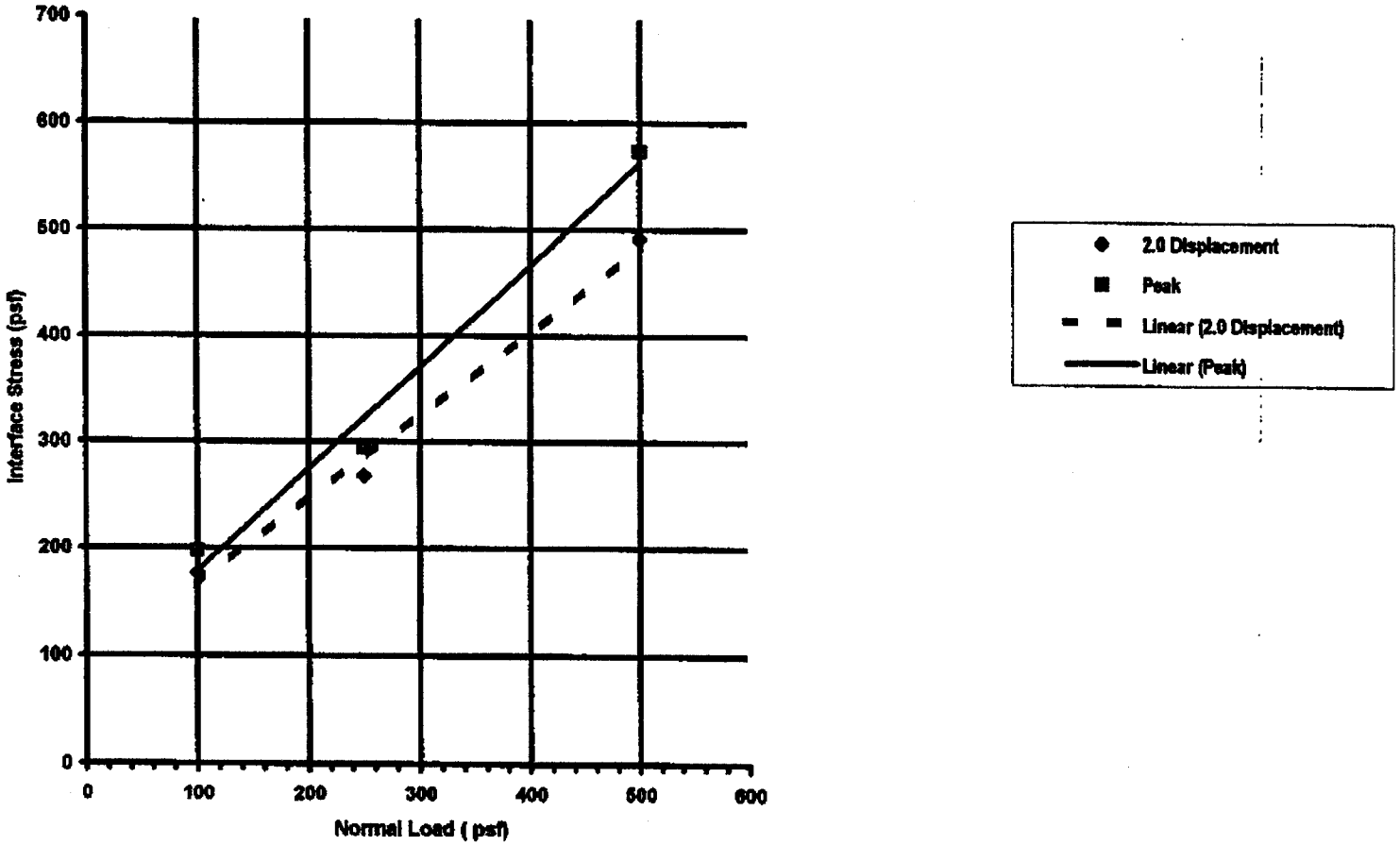
Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 010449_1
Operations Layer (Sand), C#70671 / Geocomposite CDN Roll#9303641141, C#70809



Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 010449_1
Operations Layer (Sand), C# 70671 / Geocomposite CDN Roll#9303641141, C#70809



Precision Geosynthetic Laboratories

ISO 9002

TABLE 2.

CLIENT: CH2M HILL
PROJECT: INEEL CDF

INTERFACE SHEAR TEST RESULT (ASTM D5321)
(PGL Job No. 010449)

QC'd by: _____
June 12, 2001

TEST CONFIGURATION #2

TOP BOX

Operations Layer (Sand) / C# 70671

Geocomposite CDN Roll#0303641141 / C#70809

BOTTOM BOX

TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 20" x 20".
2. Operations Layer (Sand) was lightly tamped into the top box at 5.04% moisture content.

CONSOLIDATION:

1. Each set of specimen was consolidated under drained condition for 15 min at normal load before shearing.

SHEAR TEST:

1. Shear test was conducted at 0.04 in/ min.
2. Sheared at minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in drained condition.
4. Tests were performed in general accordance with ASTM D5321-92 using Brainard- Kilman LG-112 Direct Shear machine with effective area of 12 in x 12 in.

TEST RESULTS:

NORMAL STRESS (psi)	NORMAL STRESS (psf)	PEAK STRENGTH: SHEAR STRESS (psf)	PEAK STRENGTH: PEAK SECANT ANGLE	2.0" DISPLACEMENT STRENGTH: SHEAR STRESS (psf)	2.0" DISPLACEMENT STRENGTH: 2.0" DISPLACEMENT SECANT ANGLE
6.94	1000	789	36	721	36
27.8	4000	2791	35	2776	35
55.6	8000	5169	33	4392	29

	PEAK STRENGTH	2.0" DISPLACEMENT STRENGTH
COHESION (psf):	212	385
FRICTION ANGLE (degrees):	32.0	27.4
COEFFICIENT OF FRICTION:	0.62	0.52

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

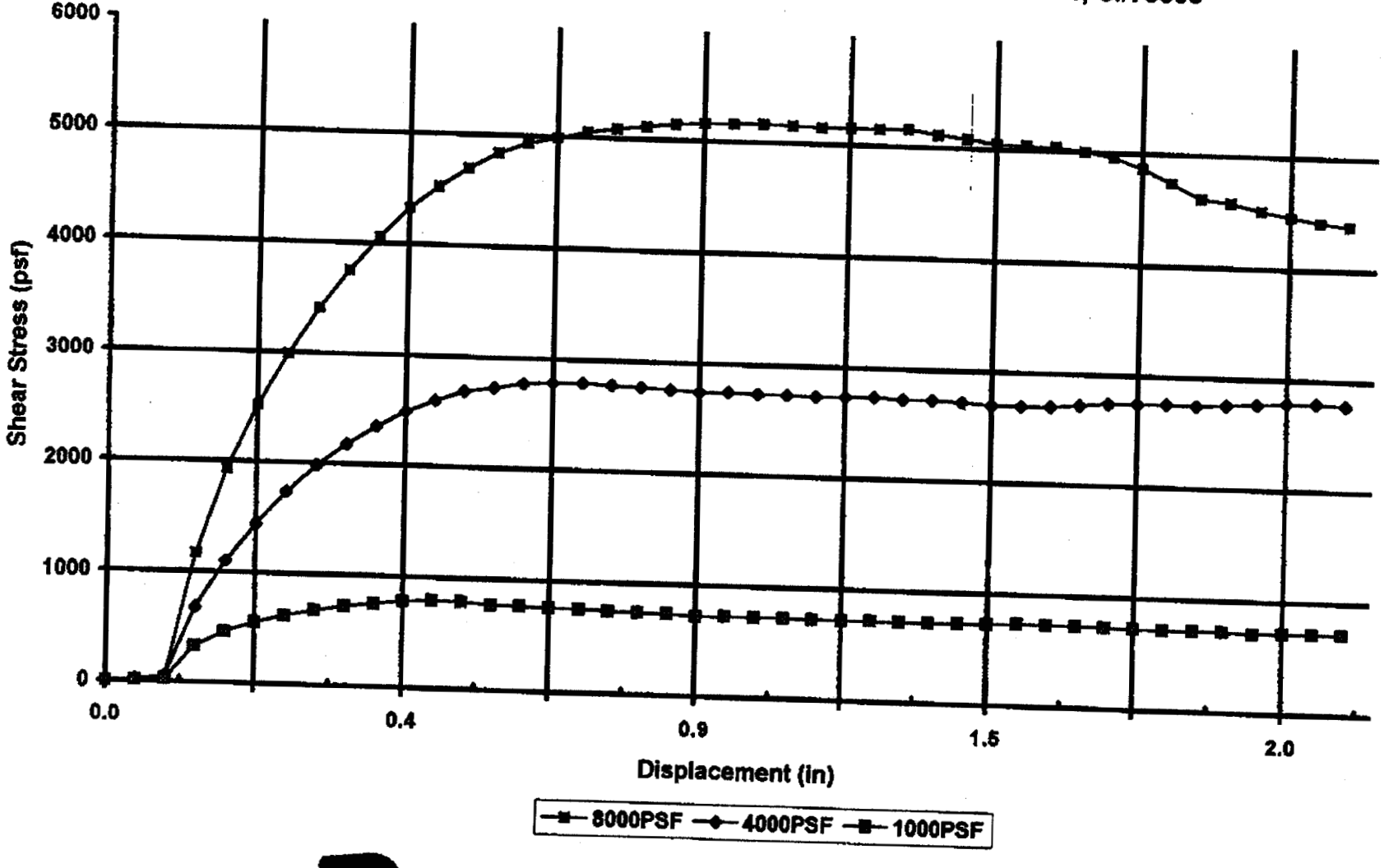
Failure occurred along the interface. See Figure #1 and #2

No stretching, abrasion, or tearing was observed on the Geocomposite specimens.

Precision Geosynthetic Laboratories

ISO 9002

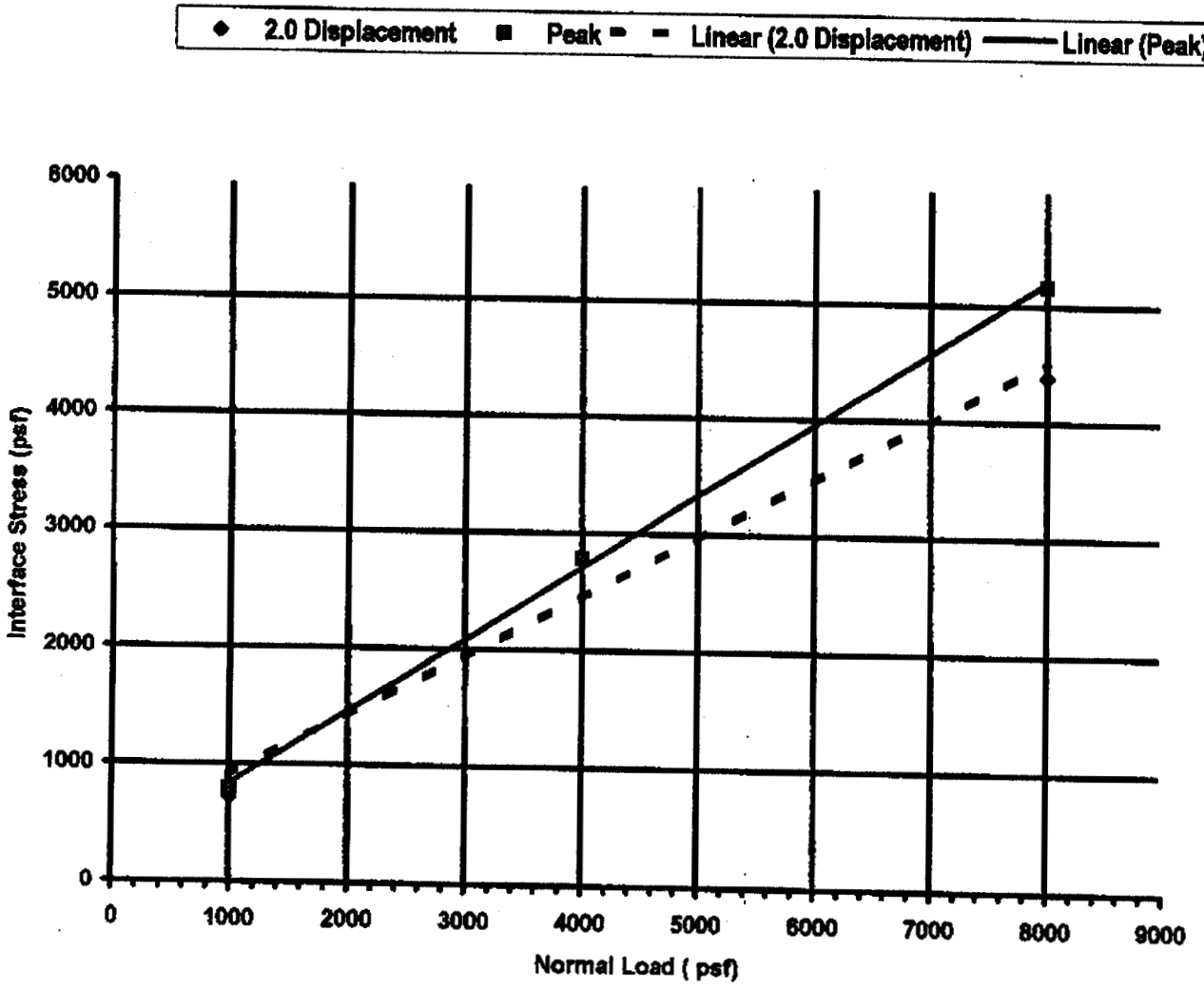
Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 010449_2
Operations Layer, C#70672 / Geocomposite CDN Roll#9303641141, C#70809



Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 010449_2
Operations Layer, C# 70672 / Geocomposite CDN Roll#9303641141, C#70809



Precision Geosynthetic Laboratories

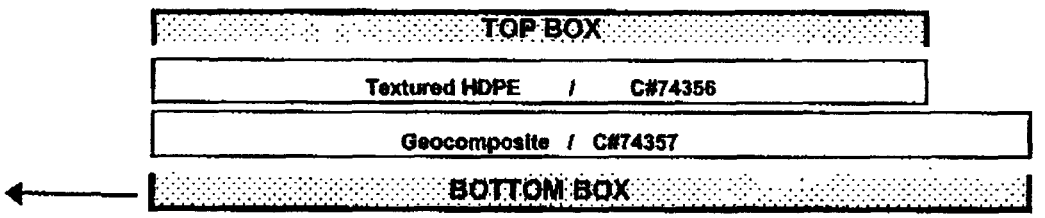
ISO 9002

TABLE 3R
CLIENT: CH2MHILL
PROJECT: Ineel CDF

INTERFACE SHEAR TEST RESULT (ASTM D 5321)
PGL Job No. G020106

QC'd by: _____
8-Mar-02

TEST CONFIGURATION # 3R



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimen were cut along machine direction to 14" x 18".

CONSOLIDATION:

1. Each set of specimen was consolidated under dry condition for 1hour @ normal load before shearing.

SHEAR TEST:

1. Shear test was conducted @ 0.2 in/ min.
2. Sheared @ minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in dry condition.
4. Test were performed in general accordance with ASTM D5321-92 using Brainard-Kilman LG-112 Direct Shear machine with effective area of 12 in X 12 in.

TEST RESULTS:

Normal Stress (psi)	Normal Stress (psf)	PEAK STRENGTH SHEAR STRESS (psf)	PEAK STRENGTH PEAK SECANT ANGLE (degrees)	2.0 " DISPLACEMENT STRENGTH SHEAR STRESS (psf)	2.0 " DISPLACEMENT STRENGTH 2.0 " DISPLACEMENT SECANT ANGLE (degrees)
0.69	100	295	71	198	63
1.74	250	450	61	261	46
3.47	500	606	50	351	35

COHESION (psf):	**234.5**	**162.28**
COEFFICIENT OF FRICTION:	**0.76**	**0.38**
FRICTION ANGLE(degrees):	**37.3**	**20.8**

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

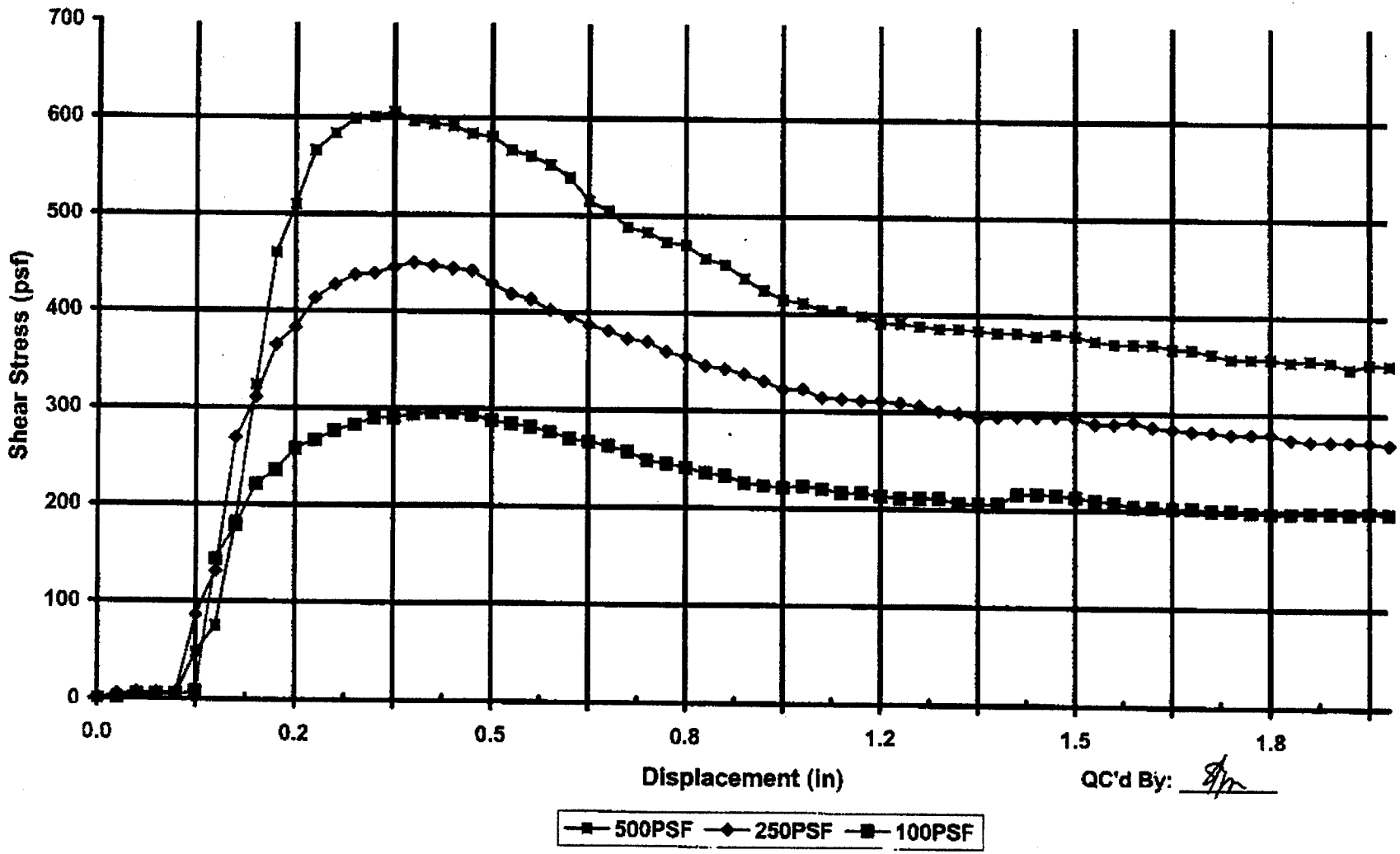
See Figure #1 and #2

No stretching or tearing was observed with the HDPE or geocomposite specimens.

Precision Geosynthetic Laboratories

ISO 9002

Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 020106_3R
Textured HDPE, C#74356 / Geocomposite, C#74357

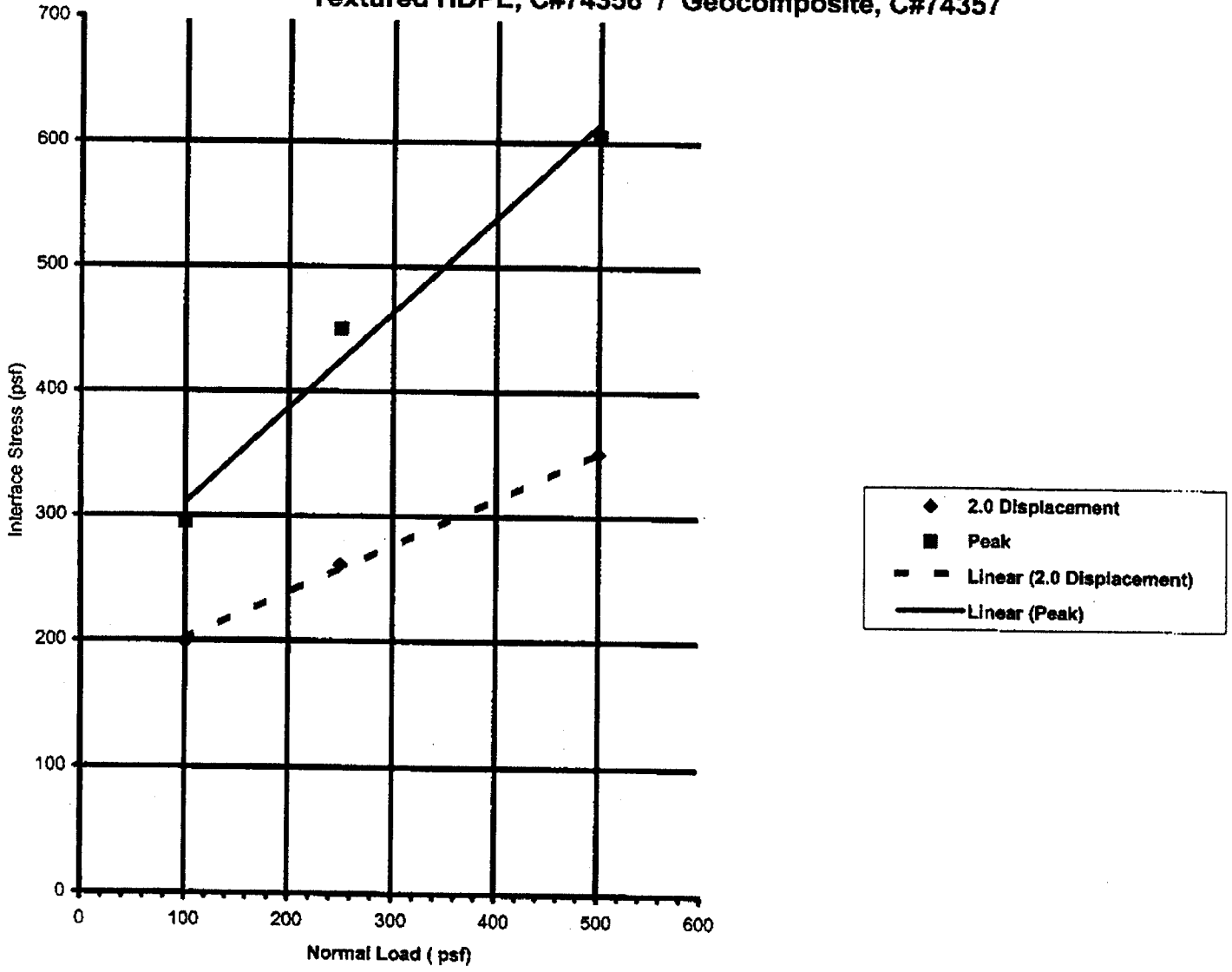


QC'd By: _____

Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 020106_3R
Textured HDPE, C#74356 / Geocomposite, C#74357



QC'd By: tm

Precision Geosynthetic Laboratories

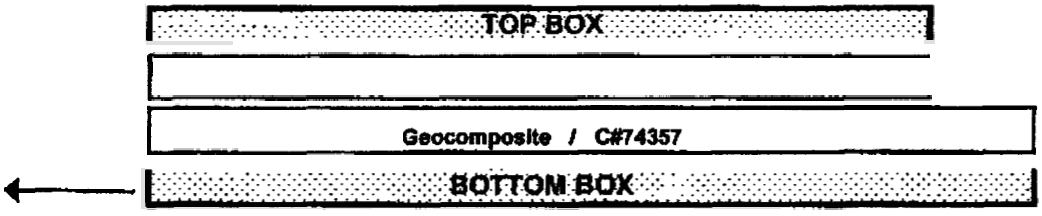
ISO 9002

TABLE 4R
CLIENT: CH2MHILL
PROJECT: Ineel CDF

INTERFACE SHEAR TEST RESULT (ASTM D 5321)
PGL Job No. G020106

QC'd by: _____ 11-Mar-02

TEST CONFIGURATION # 4R



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimen were cut along machine direction to 14" x 18".

CONSOLIDATION:

1. Each set of specimen was consolidated under dry condition for 1hour @ normal load before shearing.

SHEAR TEST:

1. Shear test was conducted @ 0.2 in/ min.
2. Sheared @ minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in dry condition.
4. Test were performed in general accordance with ASTM D5321-92 using Brainard-Kilman LG-112 Direct Shear machine with effective area of 12 in X 12 in.

TEST RESULTS:

Normal Stress (psi)	Normal Stress (psf)	PEAK STRENGTH SHEAR STRESS (psf)	PEAK STRENGTH PEAK SECANT ANGLE (degrees)	2.0 " DISPLACEMENT STRENGTH SHEAR STRESS (psf)	2.0 " DISPLACEMENT SECANT ANGLE (degrees)
6.94	1000	737	36	458	25
27.78	4000	2242	29	1102	15
55.56	8000	4174	28	2054	14

COHESION (psf):	**258.5**	**214.32**
COEFFICIENT OF FRICTION:	**0.49**	**0.23**
FRICTION ANGLE(degrees):	**26.1**	**12.9**

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

See Figure #1 and #2

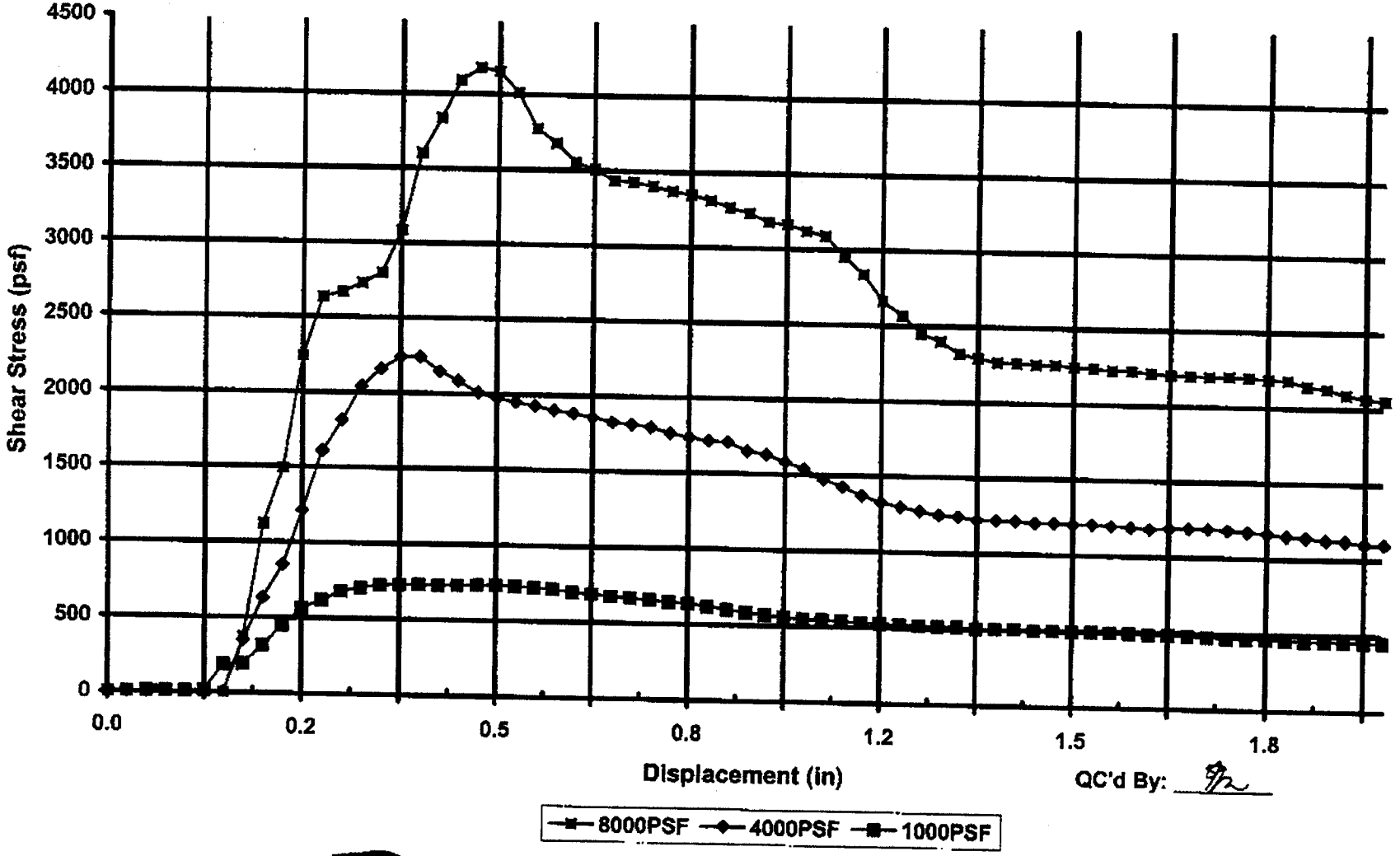
No stretching or tearing was observed with the HDPE or geocomposite specimens at all normal loads.

Slight pull out of threads of the Geotextile was observed at 4000psf, and 8000psf.

Precision Geosynthetic Laboratories

ISO 9002

Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 020106_4R
Textured HDPE, C#74356 / Geocomposite, C#74357

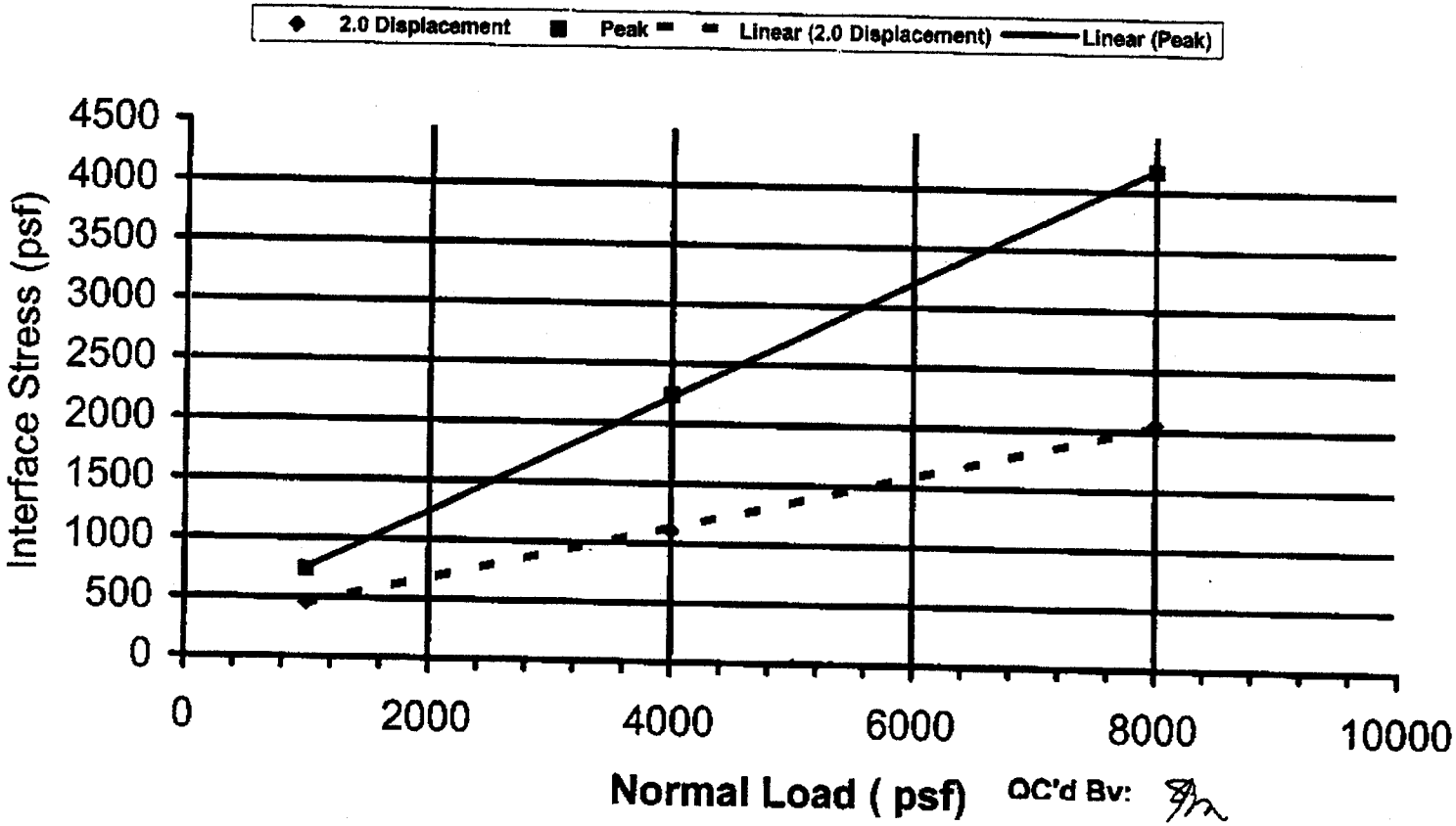


QC'd By: _____

Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 020106_4R
Textured HDPE, C#74356 / Geocomposite, C#74357



QC'd By:

Precision Geosynthetic Laboratories

ISO 9002

TABLE 5R
CLIENT: CH2MHILL
PROJECT: Ineel CDF

INTERFACE SHEAR TEST RESULT (ASTM D 6243)
PGL Job No. G020106

QC'd by: _____
11-Mar-02

TEST CONFIGURATION # 5R

TOP BOX

GCL Bentomat DN R#7096 L#200146LO (Non- Woven) / C#74355

Textured HDPE / C#74356

← BOTTOM BOX

TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimen were cut along machine direction to 14" x 18".
2. Initial moisture content of the GCL is 14.97%.

HYDRATION / CONSOLIDATION:

1. Each set of specimen was hydrated and consolidated for 24hrs @ normal load before shearing.

SHEAR TEST:

1. Shear test was conducted @ 0.04 in/ min.
2. Sheared @ minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in drained condition.
4. Test were performed in general accordance with ASTM D6243-98 using Brainard-Kilman LG-112 Direct Shear machine with effective area of 12 in X 12 in.

TEST RESULTS:

Normal Stress (psi)	Normal Stress (psf)	FINAL MC GCL %	PEAK STRENGTH SHEAR STRESS (psf)	PEAK STRENGTH PEAK SECANT ANGLE (degrees)	2.0 " DISPLACEMENT STRENGTH SHEAR STRESS (psf)	2.0 " DISPLACEMENT SECANT ANGLE (degrees)
0.69	100	102.02	221	66	171	60
1.74	250	83.18	366	56	277	48
3.47	500	82.51	554	48	389	38

	PEAK	2.0 " DISPLACEMENT
COHESION (psf):	146.8	127.39
COEFFICIENT OF FRICTION:	0.82	0.54
FRICTION ANGLE(degrees):	39.5	28.2

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

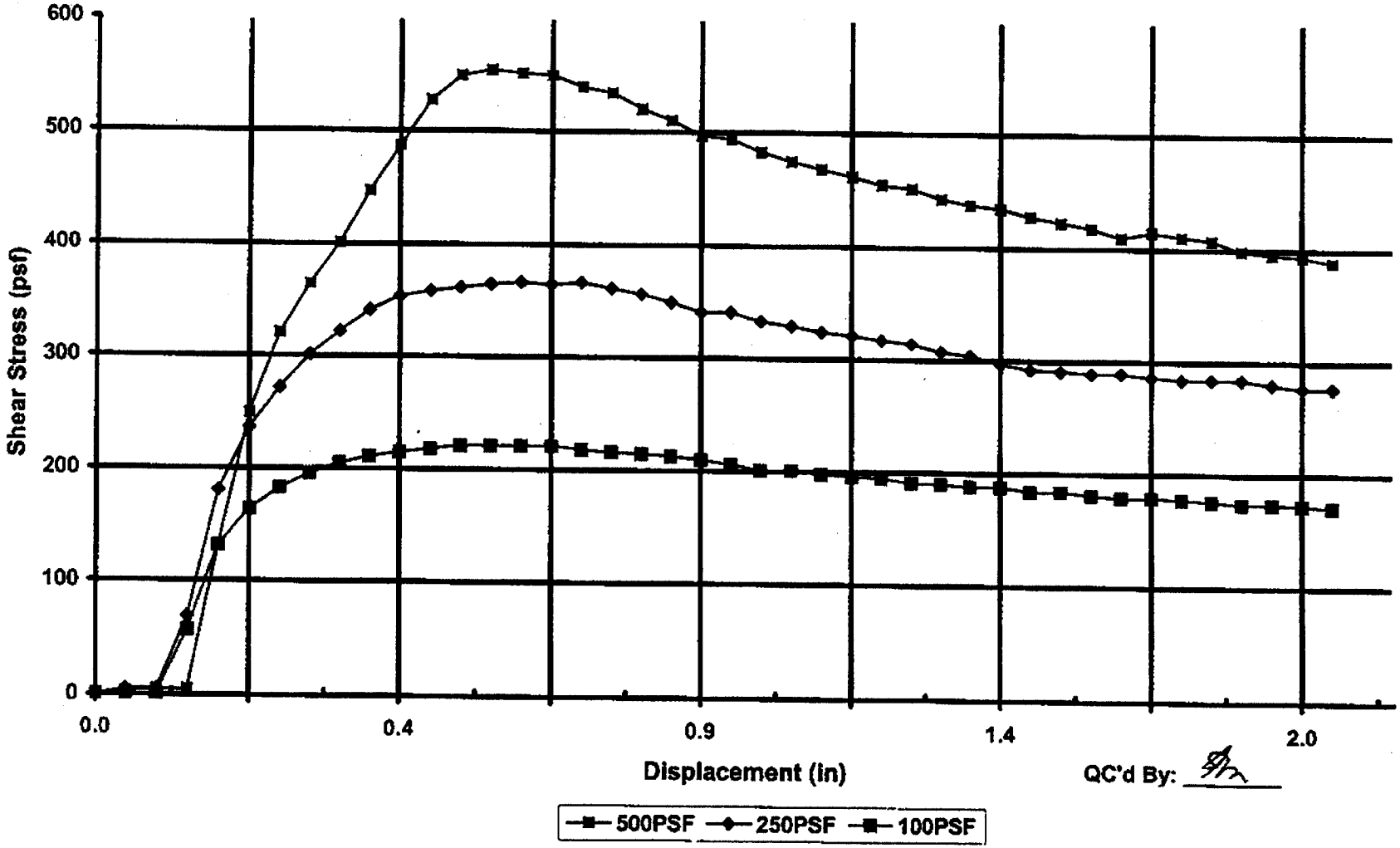
See Figure #1 and #2

No stretching or tearing was observed with either the GCL or HDPE specimens at all normal loads.

Precision Geosynthetic Laboratories

ISO 9002

Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 020106_5R
GCL Bentomat DN R#7096 L#200146LO (Non-Woven), C#74355 / Textured HDPE, C#74356

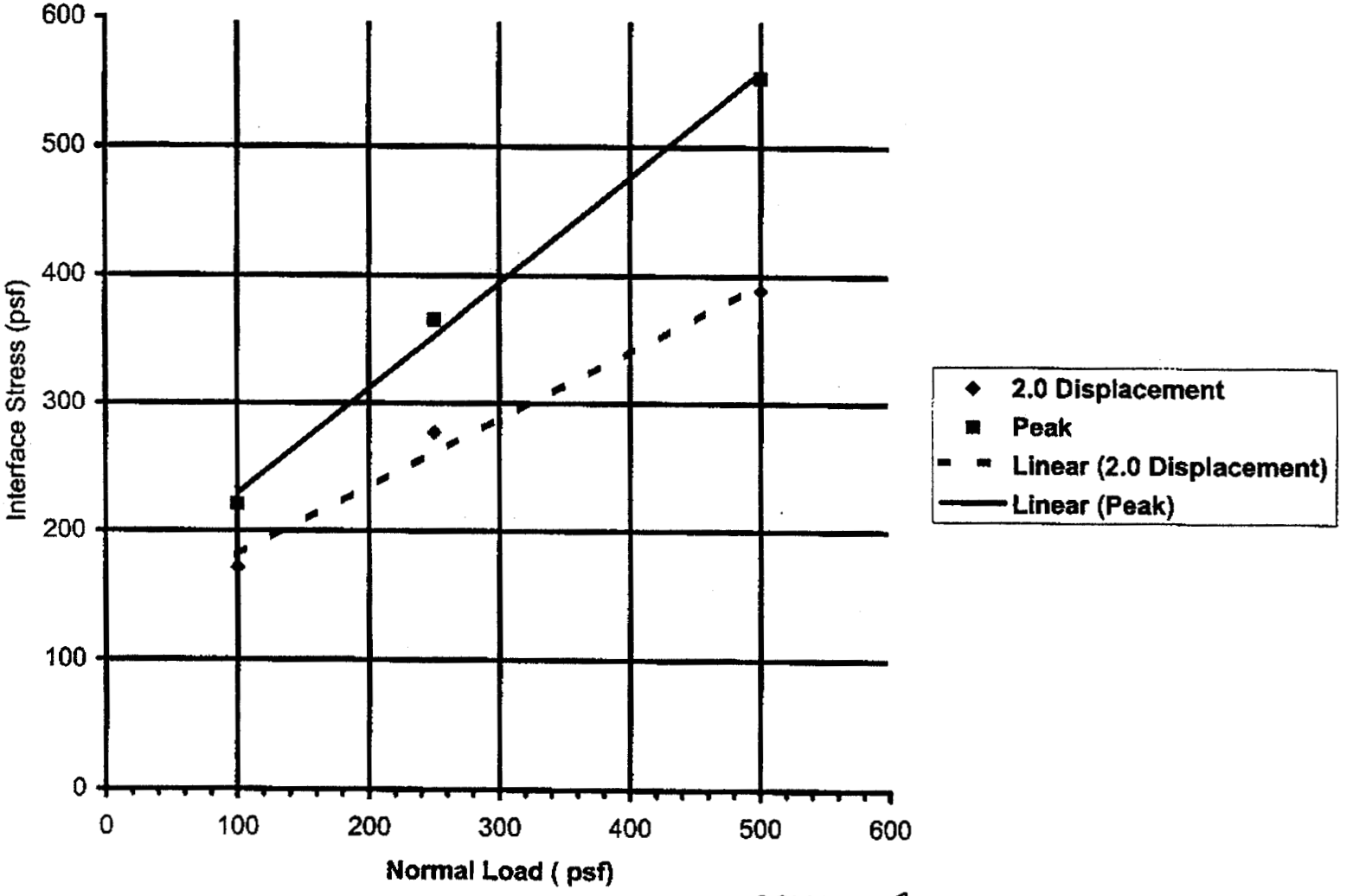


QC'd By: _____

Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 020106_5R
GCL Bentomat DN R#7096 L#200146LO (Non- Woven), C#74355 / Textured HDPE, C#74356



QC'd By:

Precision Geosynthetic Laboratories

ISO 9002

TABLE 6R
CLIENT: CH2MHILL
PROJECT: Ineel CDF

INTERFACE SHEAR TEST RESULT (ASTM D 6243)
PGL Job No. G020106

QC'd by: _____
11-Mar-02

TEST CONFIGURATION # 6R

TOP BOX

GCL Bentomat DN R#7096 L#200146LO (Non- Woven) / C#74355

Textured HDPE / C#74356

BOTTOM BOX

TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimen were cut along machine direction to 14" x 18".
2. Initial moisture content of the GCL is 14.97%.

HYDRATION / CONSOLIDATION:

1. Each set of specimen was hydrated and consolidated for 24hrs @ normal load before shearing.

SHEAR TEST:

1. Shear test was conducted @ 0.04 in/ min.
2. Sheared @ minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in drained condition.
4. Test were performed in general accordance with ASTM D6243-98 using Brainard-Kilman LG-112 Direct Shear machine with effective area of 12 in X 12 in.

TEST RESULTS:

Normal Stress (psi)	Normal Stress (psf)	FINAL MC GCL %	PEAK STRENGTH SHEAR STRESS (psf)	PEAK STRENGTH PEAK SECANT ANGLE (degrees)	2.0 " DISPLACEMENT STRENGTH SHEAR STRESS (psf)	2.0 " DISPLACEMENT SECANT ANGLE (degrees)
6.94	1000	78.25	1053	46	687	34
27.78	4000	52.44	2452	32	1587	22
55.56	8000	61.19	4513	29	2267	16

COHESION (psf):	525.9	548.62
COEFFICIENT OF FRICTION:	0.50	0.22
FRICTION ANGLE(degrees):	26.4	12.6

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

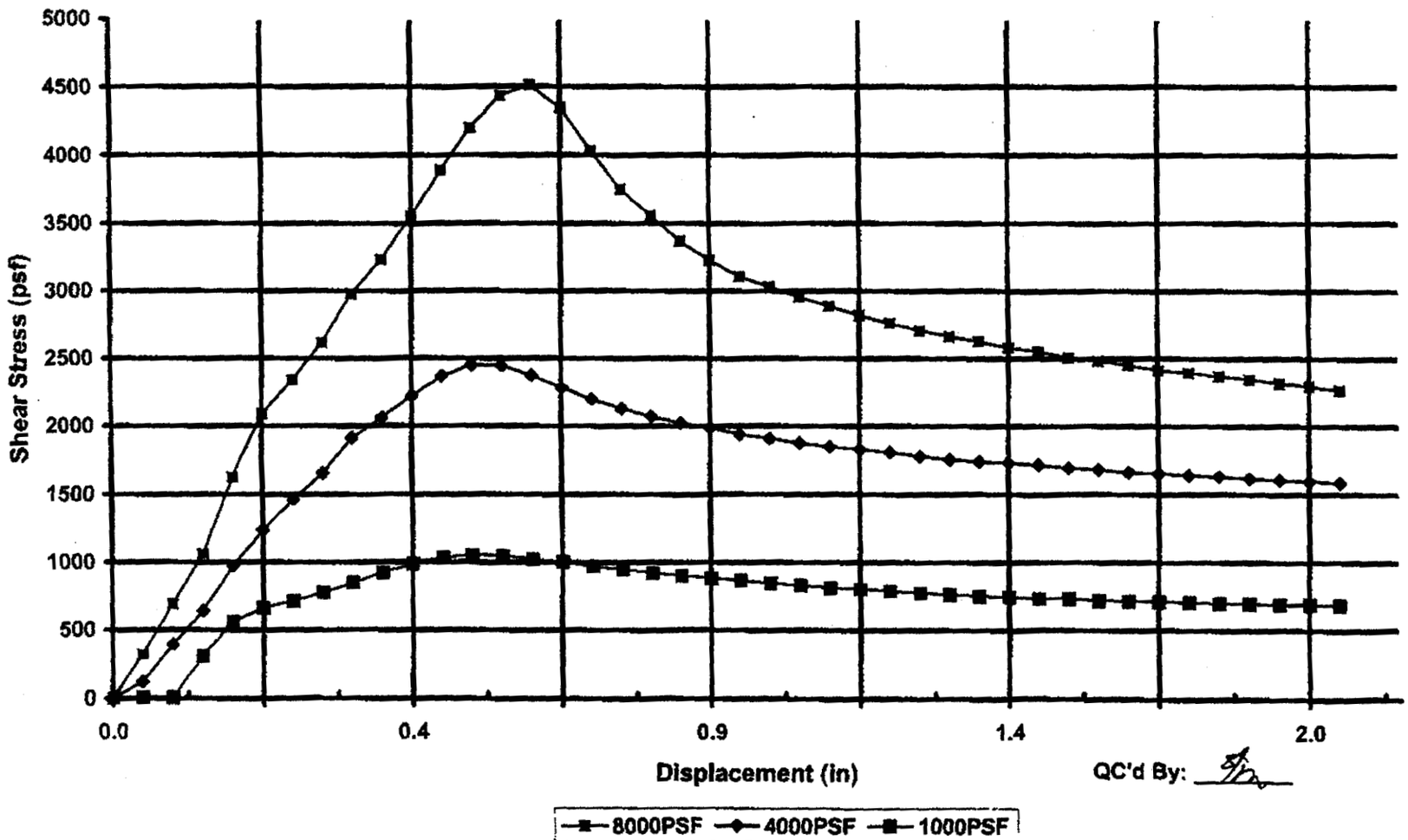
See Figure #1 and #2

No stretching or tearing was observed with either the GCL or HDPE specimens at all normal loads.

Precision Geosynthetic Laboratories

ISO 9002

Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 020106_6R
GCL Bentomat DN R#7096 L#200146LO(Non- Woven), C#74355 / Textured HDPE, C#74356

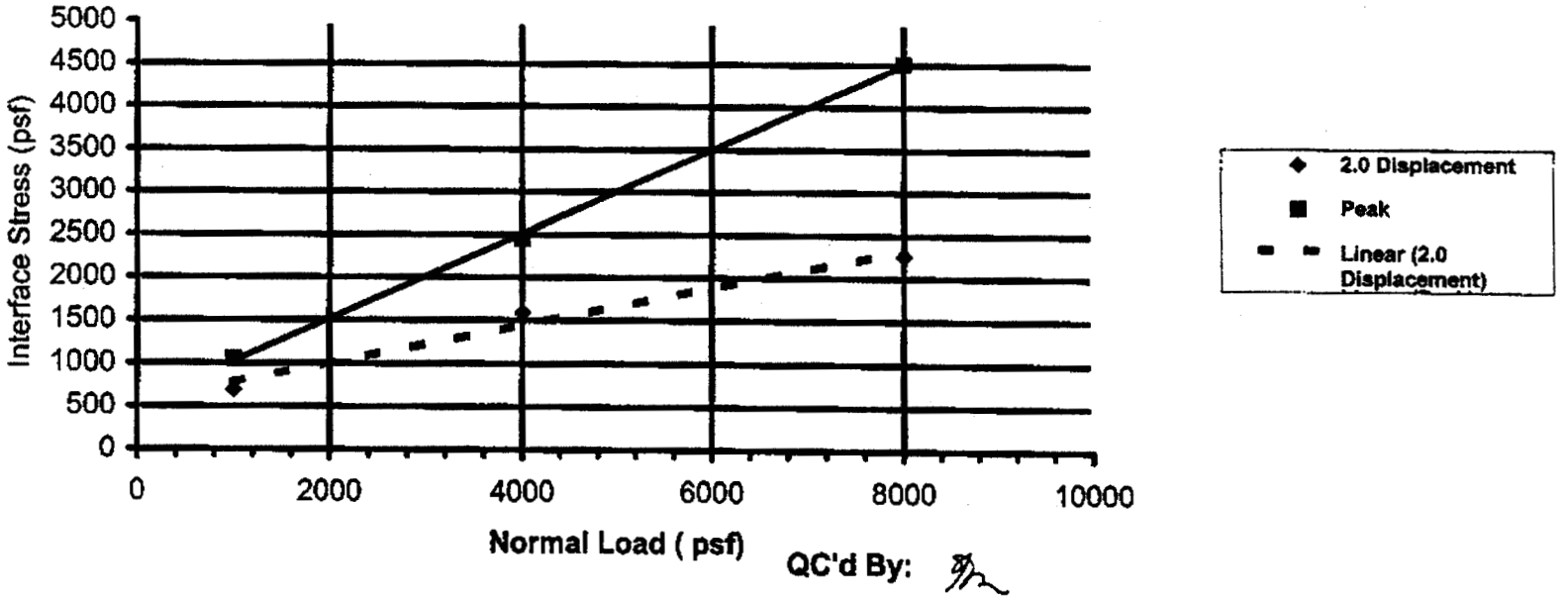


QC'd By: _____

Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 020106_6R
GCL Bentomat DN R#7096 L#200146LO(Non- Woven), C#74355 / Textured HDPE, C#74356



QC'd By:

Precision Geosynthetic Laboratories

ISO 9002

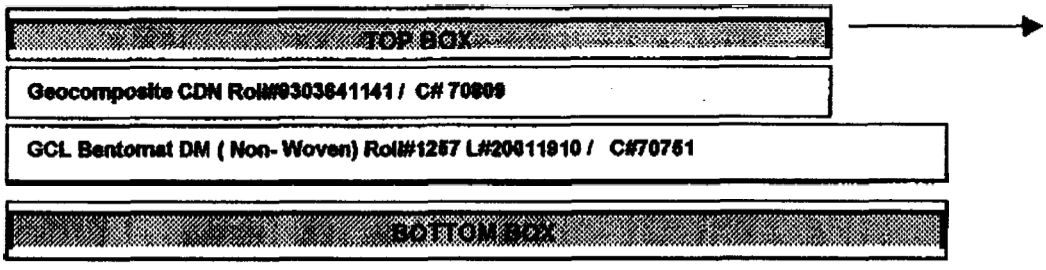
TABLE 7.

CLIENT: CH2M HILL
PROJECT: INEEL CDF

INTERFACE SHEAR TEST RESULT (ASTM D6243)
(PGL Job No. 010449)

QC'd by: _____
June 8, 2001

TEST CONFIGURATION #7



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 20" x 20".

HYDRATION:

1. GCL specimens were hydrated for 24hours at normal load.

CONSOLIDATION:

1. Each set of specimen was consolidated under drained condition for 15 min at normal load before shearing.

SHEAR TEST:

1. Shear test was conducted at 0.04 in/ min.
2. Sheared at minimum 2.0 inch horizontal displacement.
   The test specimens were sheared in drained condition.
   Initial moisture content of the GCL was 17.6%, and the final were 65.3%, 62.2%, and 62.0% at normal loads of 100psf, 250psf, and 500psf respectively.
5. Tests were performed in general accordance with ASTM D6243-98
   using Brainard- Kilman LG-112 Direct Shear machine with effective area of 12 in x 12 in.

TEST RESULTS:

NORMAL STRESS (psi)	NORMAL STRESS (psf)	PEAK STRENGTH: SHEAR STRESS (psf)	PEAK STRENGTH: PEAK SECANT ANGLE	2.0" DISPLACEMENT STRENGTH: SHEAR STRESS (psf)	2.0" DISPLACEMENT STRENGTH: 2.0" DISPLACEMENT SECANT ANGLE
0.69	100	69	35	34	19
1.74	250	167	34	128	27
3.47	500	326	33	260	27
	COHESION (psf):		5.5	0	
	FRICTION ANGLE (degrees):		32.7	~~29.3~~ 27.5 corrected to 0 cohesion	
	COEFFICIENT OF FRICTION:		0.64	0.56	

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

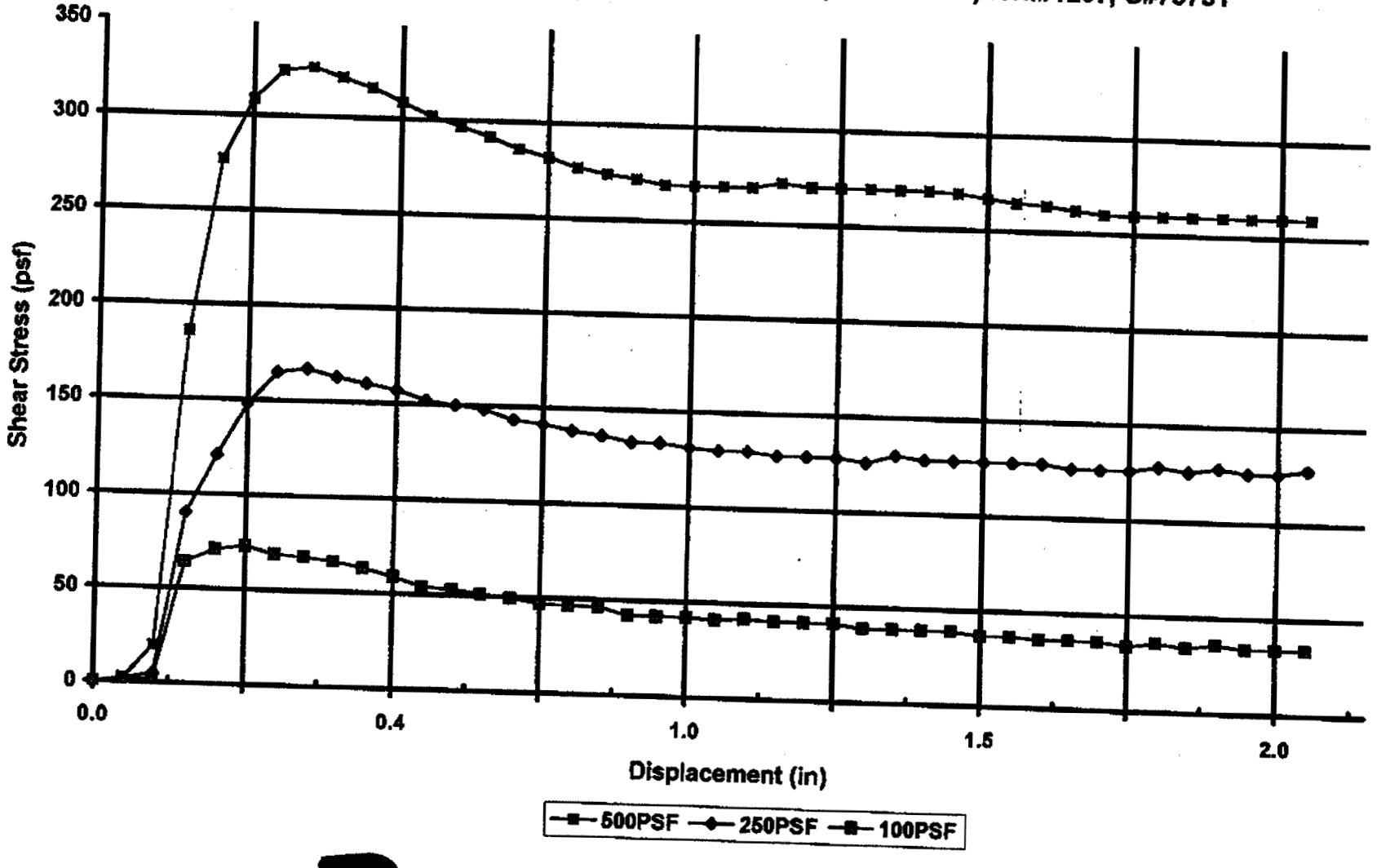
Failure occurred along the interface. See Figure #1 and #2
No stretching, [illegible]r tearing was observed on either the geocomposite, or the GCL specimens.

?

Precision Geosynthetic Laboratories

ISO 9002

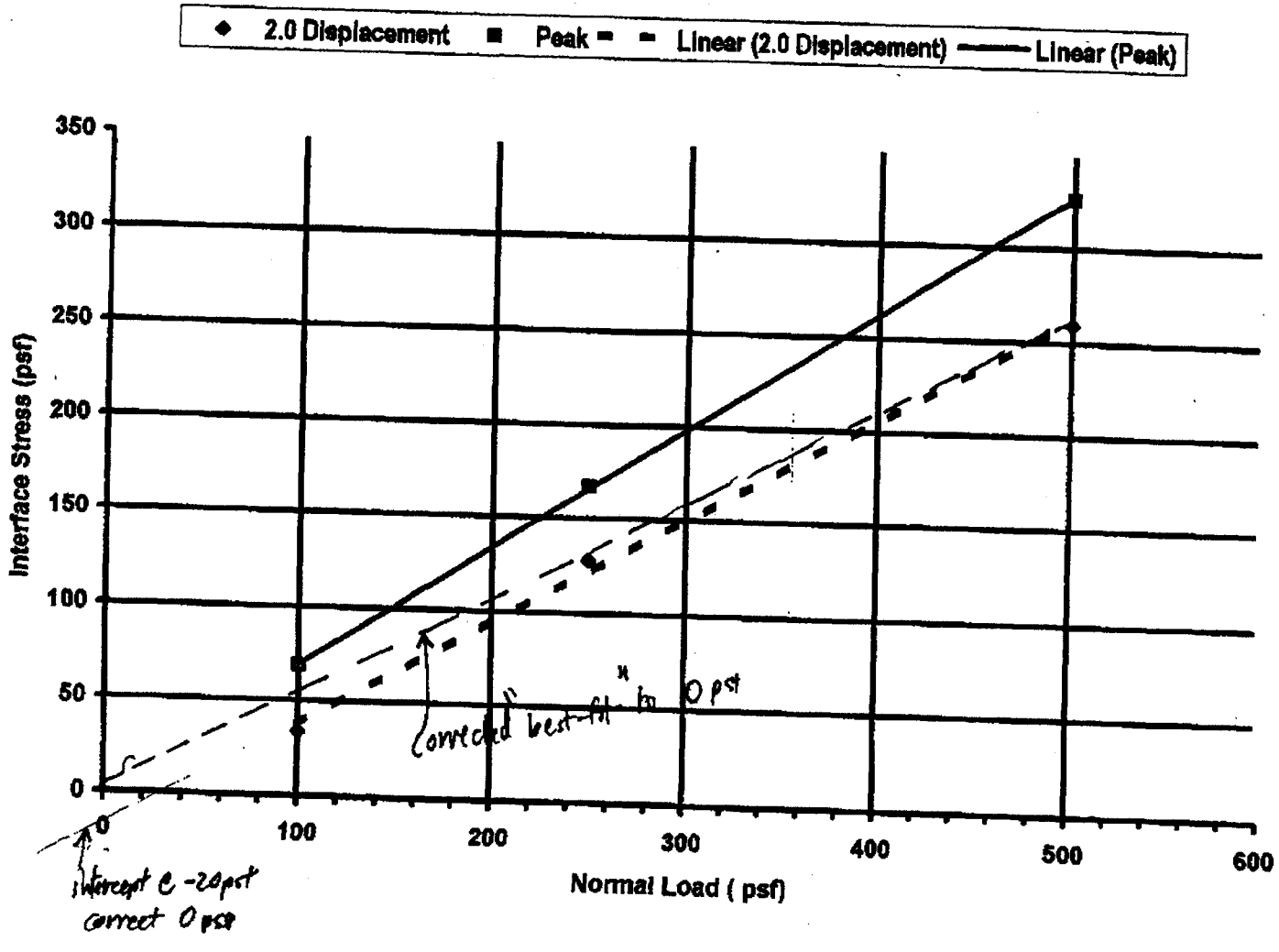
Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 010449_7
Geocomposite Roll#9303641141, C#70809/ GCL (Non-Woven) Roll#1257, C#70751



Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 010449_7
Geocomposite CDN Roll# 9303641141, C#70809 / GCL(Non-Woven) Roll# 1257, C#70751



Precision Geosynthetic Laboratories

ISO 9002

TABLE 8.

CLIENT: CH2M HILL
PROJECT: INEEL CDF

INTERFACE SHEAR TEST RESULT (ASTM D6243)
(PGL Job No. 010449)

QC'd by: _____
June 7, 2001

TEST CONFIGURATION #8

TOP BOX

Geocomposite CDN Roll#9303641141 / C# 70809

GCL Bentomat DM (Non- Woven) Roll#1257 L#20011910 / C#70761

BOTTOM BOX

TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 20" x 20".

HYDRATION:

1. GCL specimens were hydrated for 24hours at normal load.

CONSOLIDATION:

1. Each set of specimen was consolidated under drained condition for 15 min at normal load before shearing.

SHEAR TEST:

1. Shear test was conducted at 0.04 in/ min.
2. Sheared at minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in drained condition.
4. Initial moisture content of the GCL was 17.6%, and the final were 63.4%, 62.4%, and 60.1% at normal loads of 1000psf, 4000psf, and 8000psf respectively.
5. Tests were performed in general accordance with ASTM D6243-98 using Brainard- Kilman LG-112 Direct Shear machine with effective area of 12 in x 12 in.

TEST RESULTS:

NORMAL STRESS (psi)	NORMAL STRESS (psf)	PEAK STRENGTH SHEAR STRESS (psf)	PEAK STRENGTH PEAK SECANT ANGLE	2.0" DISPLACEMENT STRENGTH SHEAR STRESS (psf)	2.0" DISPLACEMENT STRENGTH 2.0" DISPLACEMENT SECANT ANGLE
6.94	1000	586	30	456	25
27.8	4000	1898	25	1654	22
55.6	8000	3863	26	3309	22

	PEAK STRENGTH	2.0" DISPLACEMENT STRENGTH
COHESION (psf):	82	39
FRICTION ANGLE (degrees):	25.1	22.2
COEFFICIENT OF FRICTION:	0.47	0.41

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

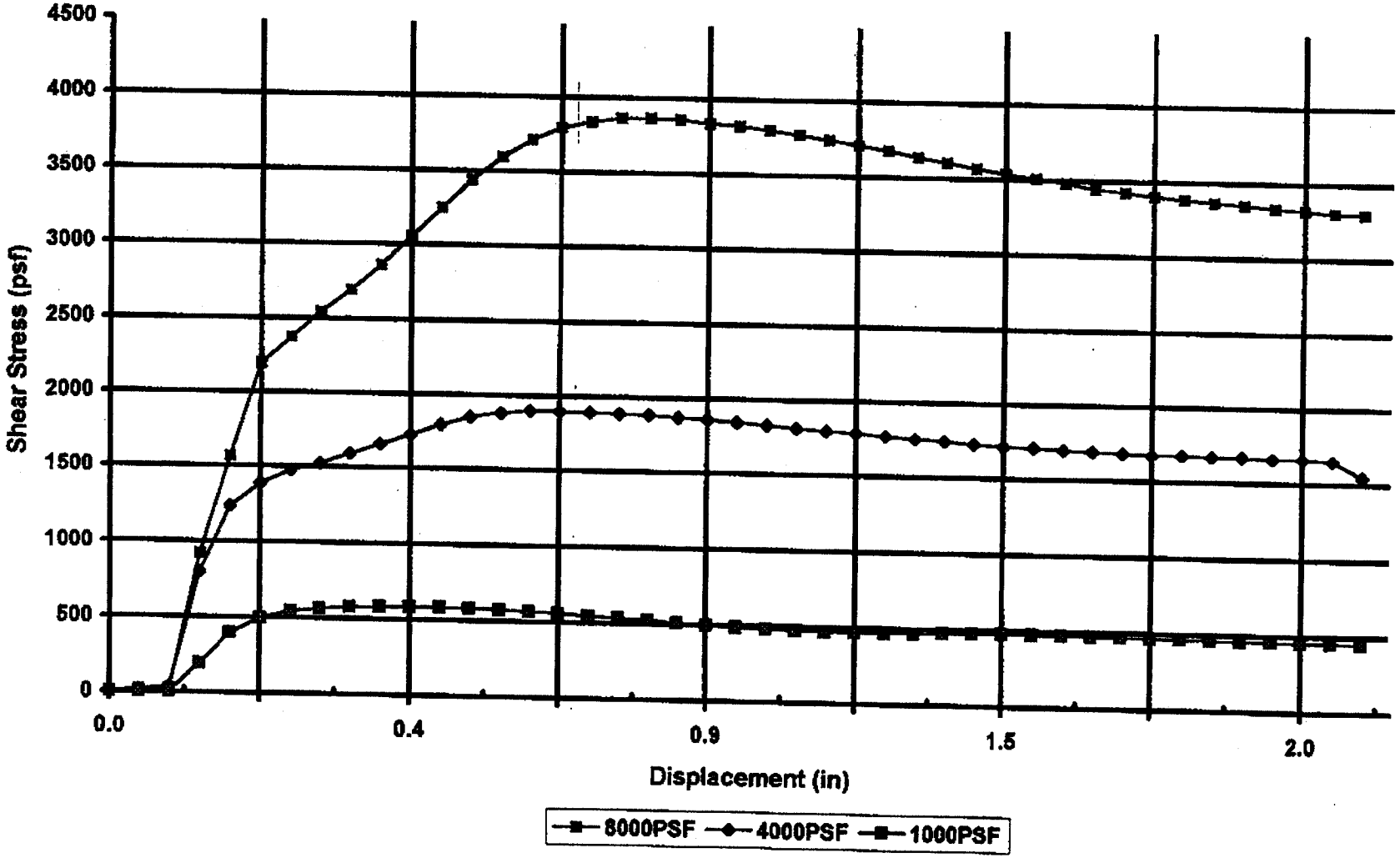
OBSERVATIONS:

Failure occurred along the interface. See Figure #1 and #2
Stretching, an[illegible]ion of the GCL was observed even at low load of 1000 psf. The degree of deformation is more pronounced at fi[illegible] .

ISO 9002

Precision Geosynthetic Laboratories

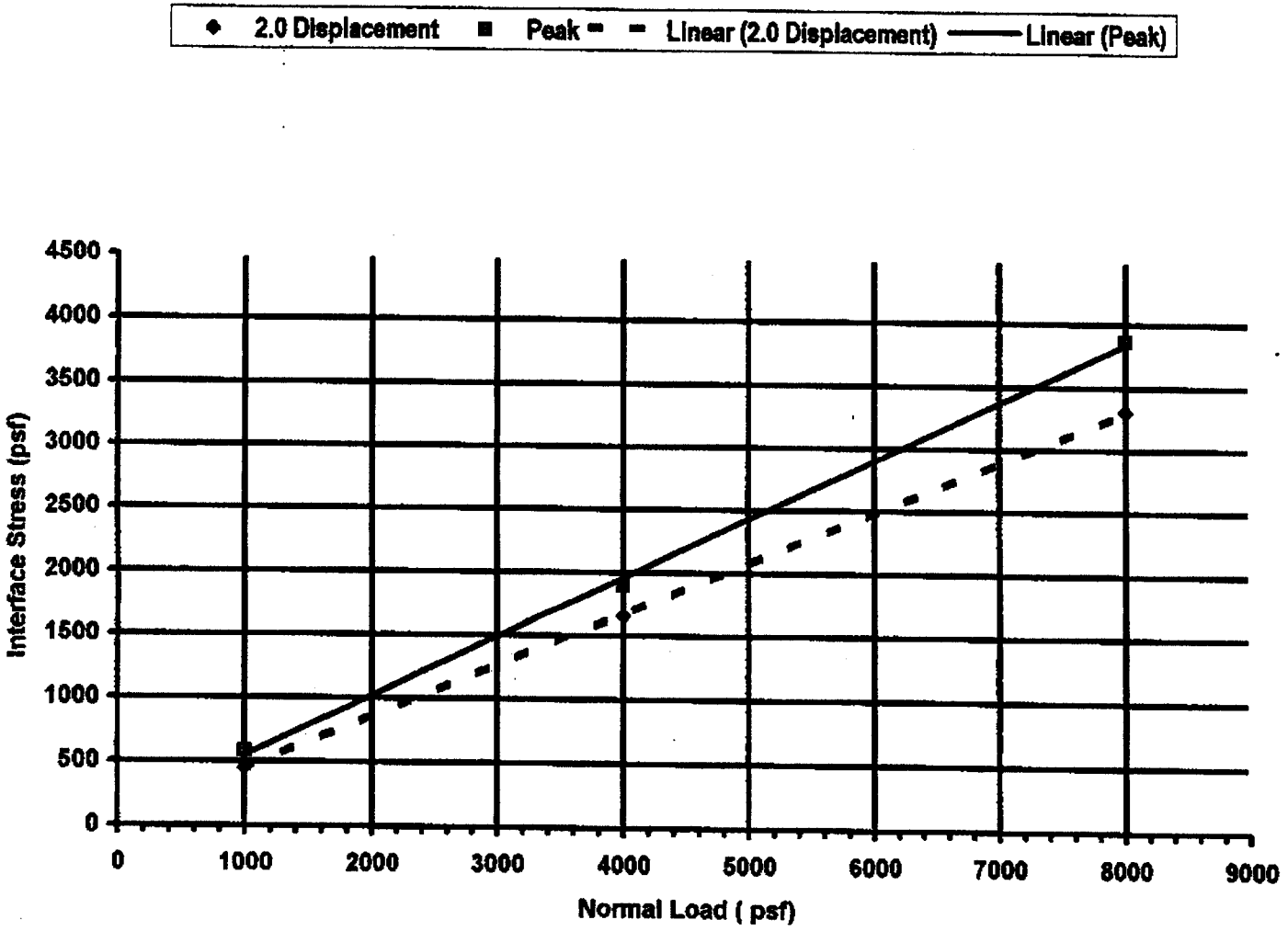
Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 010449_8
GeocompositeCDN Roll#9303641141, C#70809 / GCL(Non- Woven) Roll#1257, C#70751



Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 010449_8
Geocomposite CDN Roll#9303641141, C#70809 / GCL (Non- Woven) Roll#1257, C#70751



Precision Geosynthetic Laboratories

ISO 9002

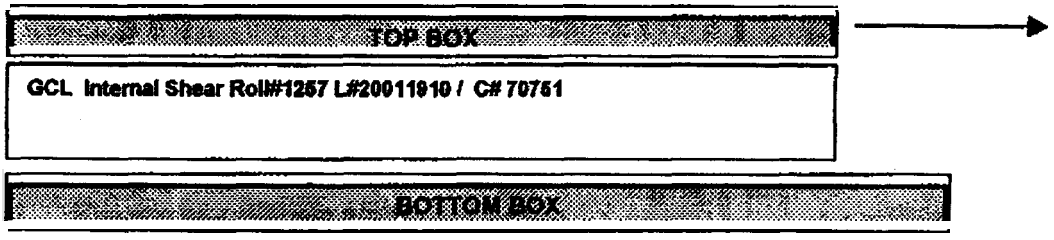
TABLE 9

CLIENT: CH2M HILL
PROJECT: INEEL CDF

INTERNAL SHEAR TEST RESULT (ASTM 6243)
PG Job No. 010449)

QC'd by: _____
June 6, 2001

TEST CONFIGURATION #9



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut to 20" x 20"
2. GCL specimens were constrained between two wooden boards with mending plates. The ends of each geotextile were then sandwiched between a second wooden substrate with mending plates.

HYDRATION:

1. GCL specimens were hydrated for 24 hours at normal load.

CONSOLIDATION:

1. Each set of specimen was consolidated under drained condition for 15 min at normal load before shearing.

SHEAR TEST:

1. Shear test was conducted at 0.04in/ min.
   Sheared at minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in drained condition.
4. Initial moisture content of the GCL was 19.4%, and the final moisture content were 93.6 %, 88.6 %, and 83.5 % at normal loads of 1000psf, 4000psf, and 8000 psf respectively.
5. Tests were performed in general accordance with ASTM D6243-98 using Brainard- Kilman LG-112 Direct Shear machine with effective area of 12 in x 12 in.

TEST RESULTS:

NORMAL STRESS (psi)	NORMAL STRESS (psf)	PEAK STRENGTH: SHEAR STRESS (psf)	PEAK STRENGTH: PEAK SECANT ANGLE	2.0" DISPLACEMENT STRENGTH: SHEAR STRESS (psf)	2.0" DISPLACEMENT STRENGTH: 2.0" DISPLACEMENT SECANT ANGLE
6.94	1000	1297	52	606	31
27.8	4000	2473	32	1832	25
55.6	8000	3069	21	2807	19

	PEAK STRENGTH	2.0" DISPLACEMENT STRENGTH
COHESION (psf):	1207	404
FRICTION ANGLE (degrees):	13.9	17.2
COEFFICIENT OF FRICTION:	0.25	0.31

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

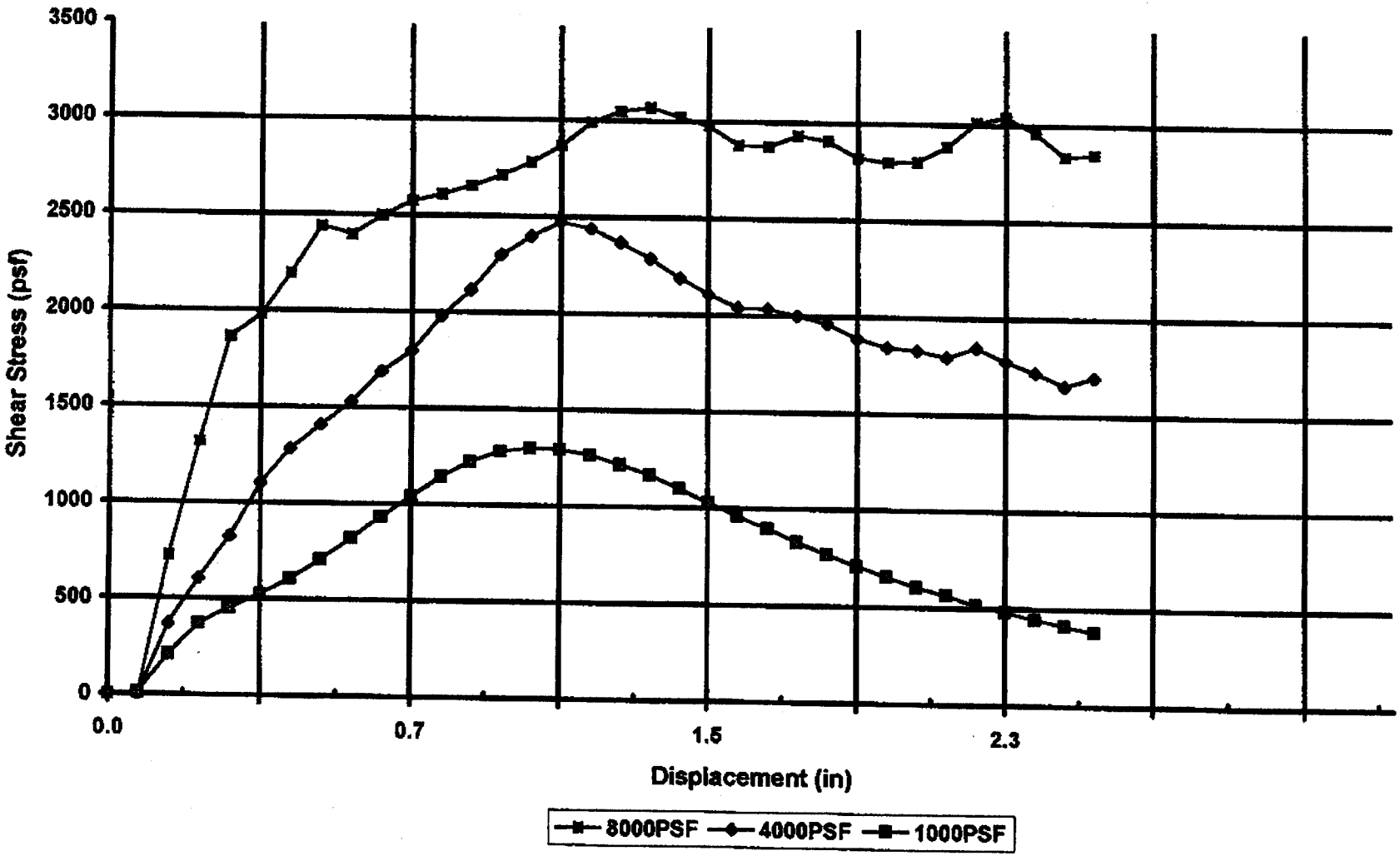
OBSERVATIONS:

See Figure #

ISO 9002

Precision Geosynthetic Laboratories

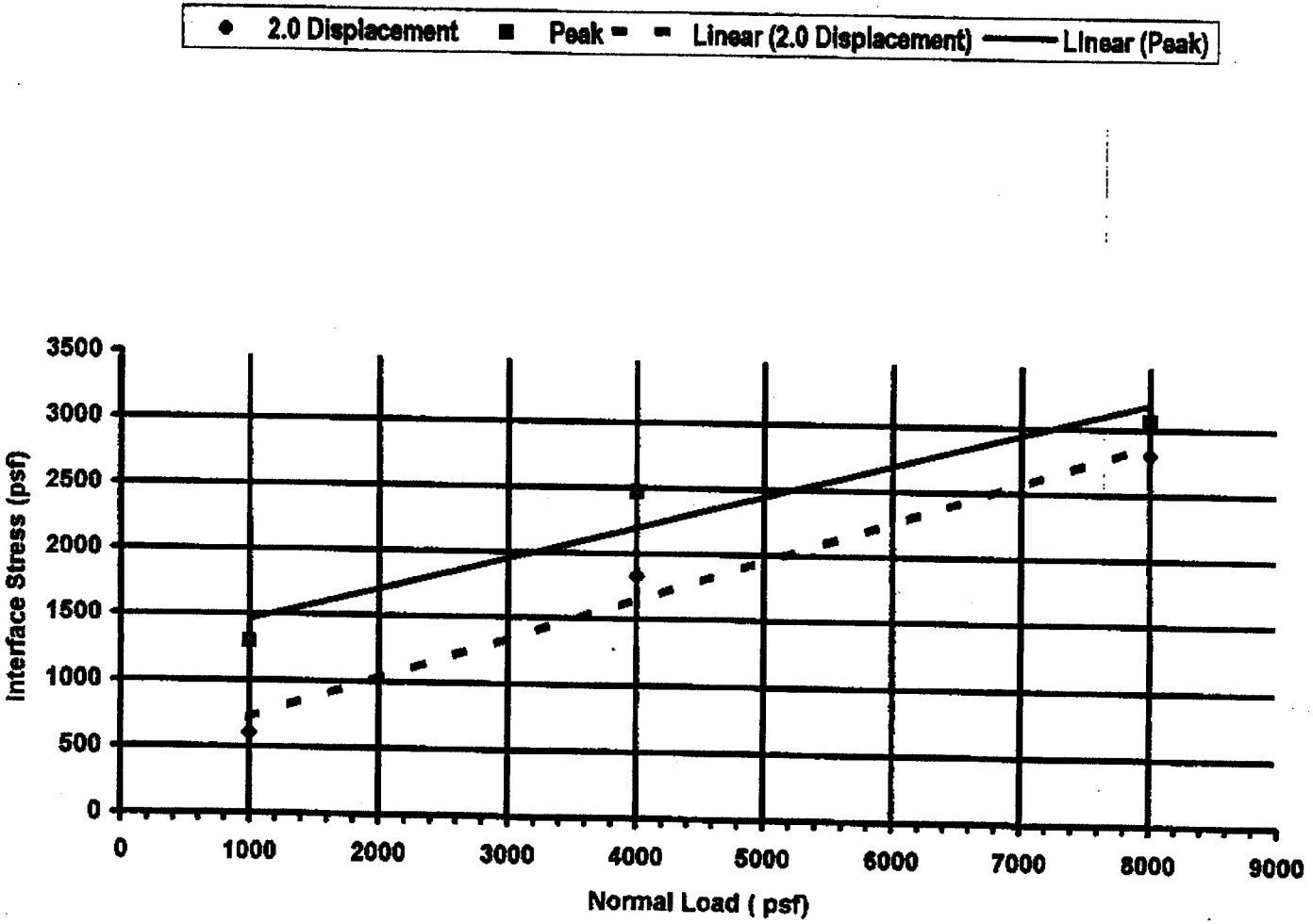
Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 010449_9
Internal Shear, GCL Roll#1257 L#20011910, C#70751



Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 010449_9
Internal Shear, GCL Roll# 1257 L#20011910, C# 70751



Precision Geosynthetic Laboratories

ISO 9002

TABLE 10R
CLIENT: CH2MHILL
PROJECT: INEEL CDF

INTERFACE SHEAR TEST RESULT (ASTM D5321)
PGL Job No. G010449

QC'd by: _____
15-Jun-01

TEST CONFIGURATION # 10R

TOP BOX

Soil Bentonite / C#70707

Textured HDPE / C#70694

BOTTOM BOX

TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimen were cut along machine direction to 14" x 18".
2. Soil was compacted to 102.0 pcf @ 17.2 % moisture content.

CONSOLIDATION:

1. Each set of specimen was consolidated under wet condition (sprayed with water), for 15 min @ normal load before shearing.

SHEAR TEST:

1. Shear test was conducted @ 0.04 in/ min.
2. Sheared @ minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in wet condition(sprayed with water).
4. Test were performed in general accordance with ASTM D5321-92 using Brainard-Kilman LG-112 Direct Shear machine with effective area of 12 in X 12 in.

TEST RESULTS:

Normal Stress (psi)	Normal Stress (psf)	FINAL MC (GCL) (%)	FINAL MC (Soil) (%)	PEAK STRENGTH SHEAR STRESS (psf)	PEAK STRENGTH PEAK SECANT ANGLE (degrees)	2.0 " DISPLACEMENT STRENGTH SHEAR STRESS (psf)	2.0 " DISPLACEMENT STRENGTH 2.0 " DISPLACEMENT SECANT ANGLE (degrees)
0.69	100	n/a	18.4	197	63	193	63
1.74	250	n/a	18.2	274	48	272	47
3.47	500	n/a	18.2	462	43	430	41

	PEAK STRENGTH	2.0 " DISPLACEMENT STRENGTH
COHESION (psf):	120.7	129.3
COEFFICIENT OF FRICTION:	0.67	0.60
FRICTION ANGLE(degrees):	33.9	30.8

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

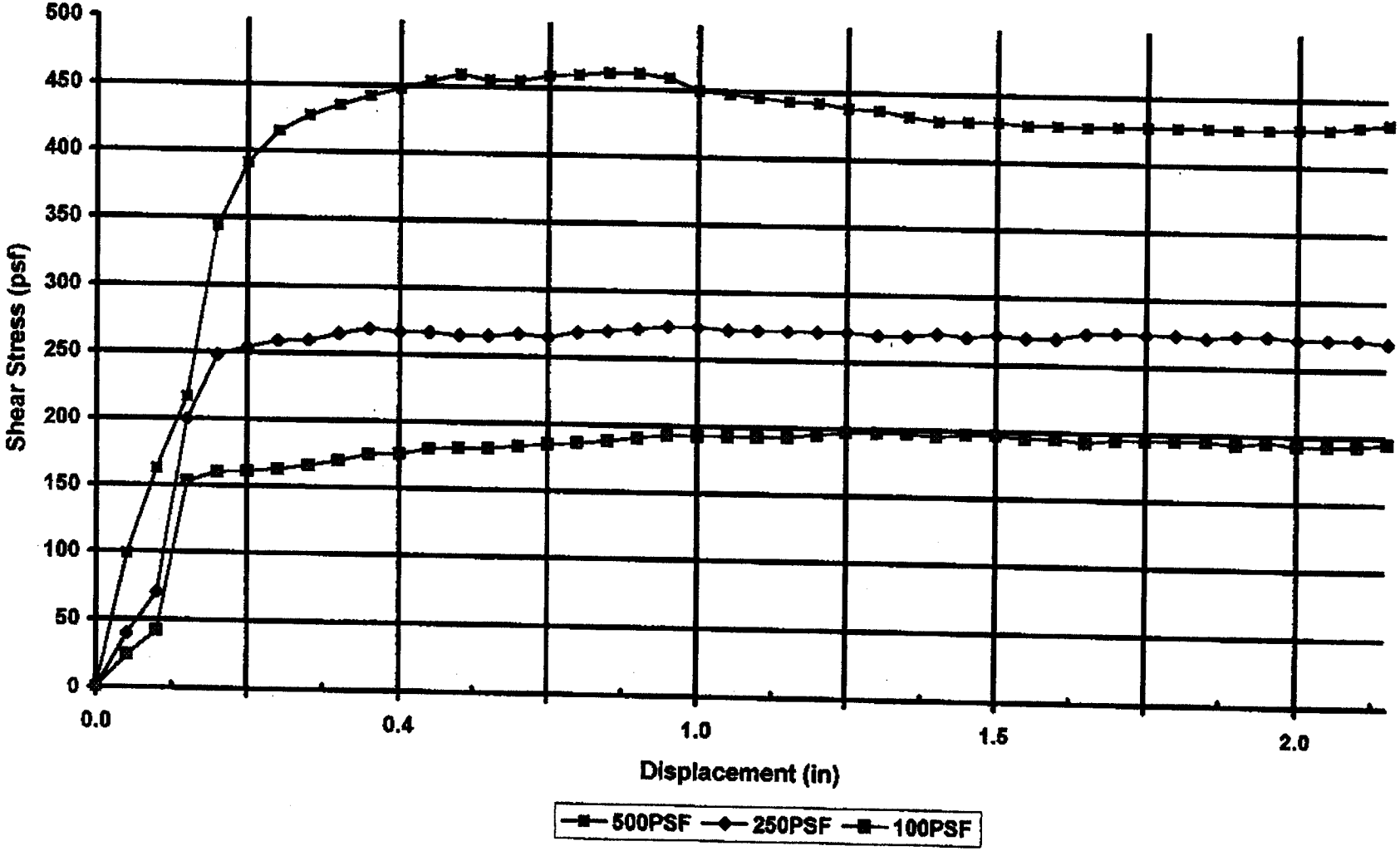
See Figure #1 and #2

No stretching, abrasion, or tearing was observed on the HDPE specimens.

Precision Geosynthetic Laboratories

ISO 9002

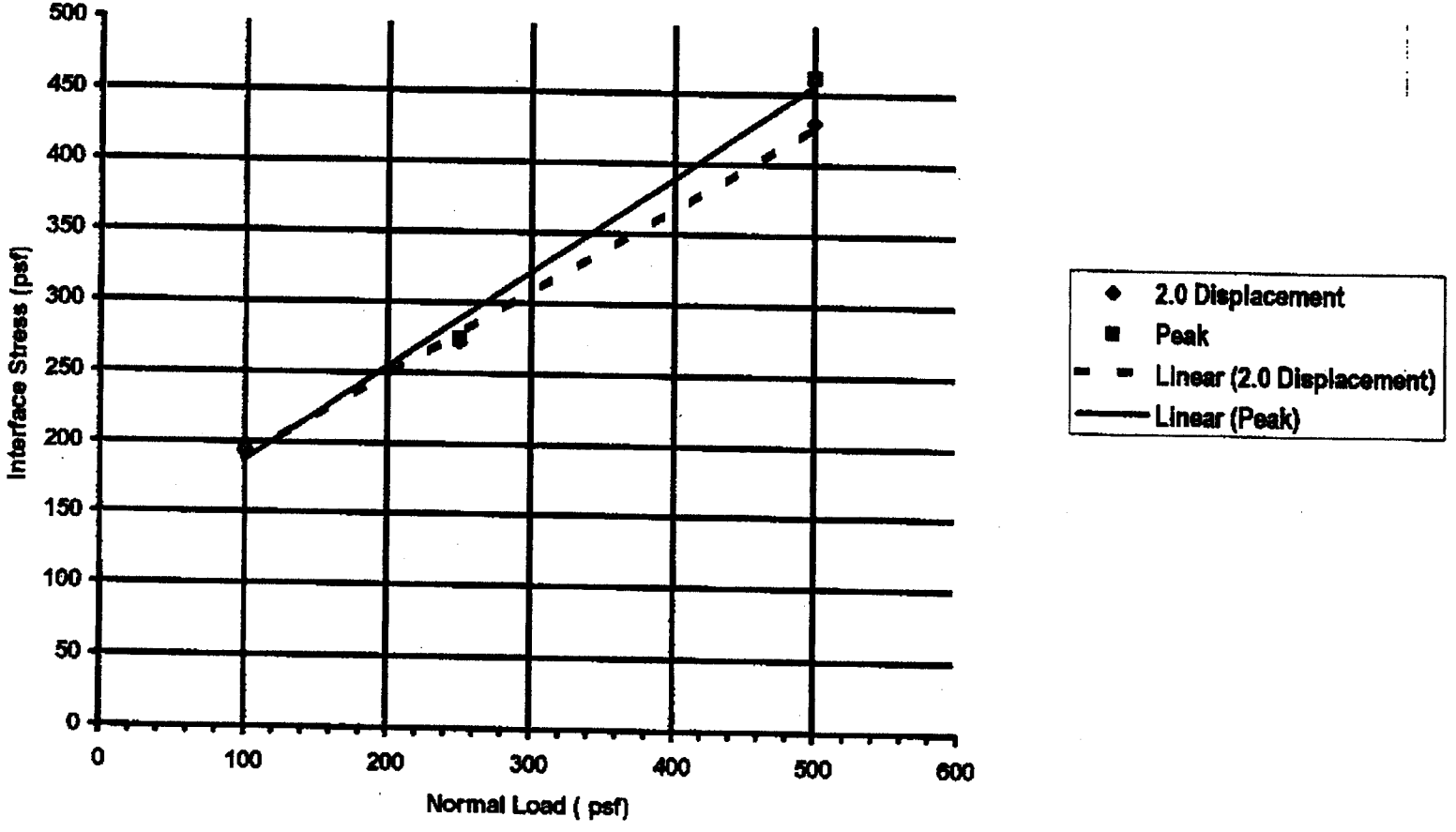
Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 010449_10R
Soil Bentonite, C#70707 / Textured HDPE, C#70693



Precision Geosynthetic Laboratories

ISO 9002

Figure #2
Normal Stress/ Interface Stress
PGL Job No. 010449_10R
Soil Bentonite, C#70707 / Textured HDPE, C#70693



Precision Geosynthetic Laboratories

ISO 9002

TABLE 11R
CLIENT: CH2MHILL
PROJECT: INEEL CDF

INTERFACE SHEAR TEST RESULT (ASTM D 5321)
PGL Job No. G010449

QC'd by: _____ 18-Jun-01

TEST CONFIGURATION # 11R

TOP BOX
Soil Bentonite / C#70707
Textured HDPE / C#70694
BOTTOM BOX

TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimen were cut along machine direction to 14" x 18".
2. Soil was compacted to 102.0 pcf @17.6% moisture content.

CONSOLIDATION:

1. Each set of specimen was consolidated under wet condition(sprayed with water) for 15 min @ normal load before shearing.

SHEAR TEST:

1. Shear test was conducted @ 0.04 in/ min.
2. Sheared @ minimum 2.0 inch horizontal displacement.
3. The test specimens were sheared in wet (sprayed with water) condition.
4. Test were performed in general accordance with ASTM D5321-92 using Brainard-Kilman LG-112 Direct Shear machine with effective area of 12 in X 12 in.

TEST RESULTS:

Normal Stress (psi)	Normal Stress (psf)	FINAL MC (GCL) (%)	FINAL MC (Soil) (%)	SHEAR STRESS (psf)	PEAK SECANT ANGLE (degrees)	SHEAR STRESS (psf)	2.0 " DISPLACEMENT SECANT ANGLE (degrees)
				PEAK STRENGTH		2.0 " DISPLACEMENT STRENGTH	
6.94	1000	n/a	19.5	590	31	555	29
27.78	4000	n/a	19.6	2260	29	2221	29
55.56	8000	n/a	19.2	4552	30	4374	29

COHESION (psf):	13.0	20.9
COEFFICIENT OF FRICTION:	0.57	0.55
FRICTION ANGLE(degrees):	29.5	28.6

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

See Figure #1 and #2

No stretching, or tearing was observed on the HDPE specimens.

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Figure #1
Shear Stress/ Displacement Curve
PGL Job No. 010449_11R
Soil Bentonite, C#70707 / Textured HDPE, C#70694

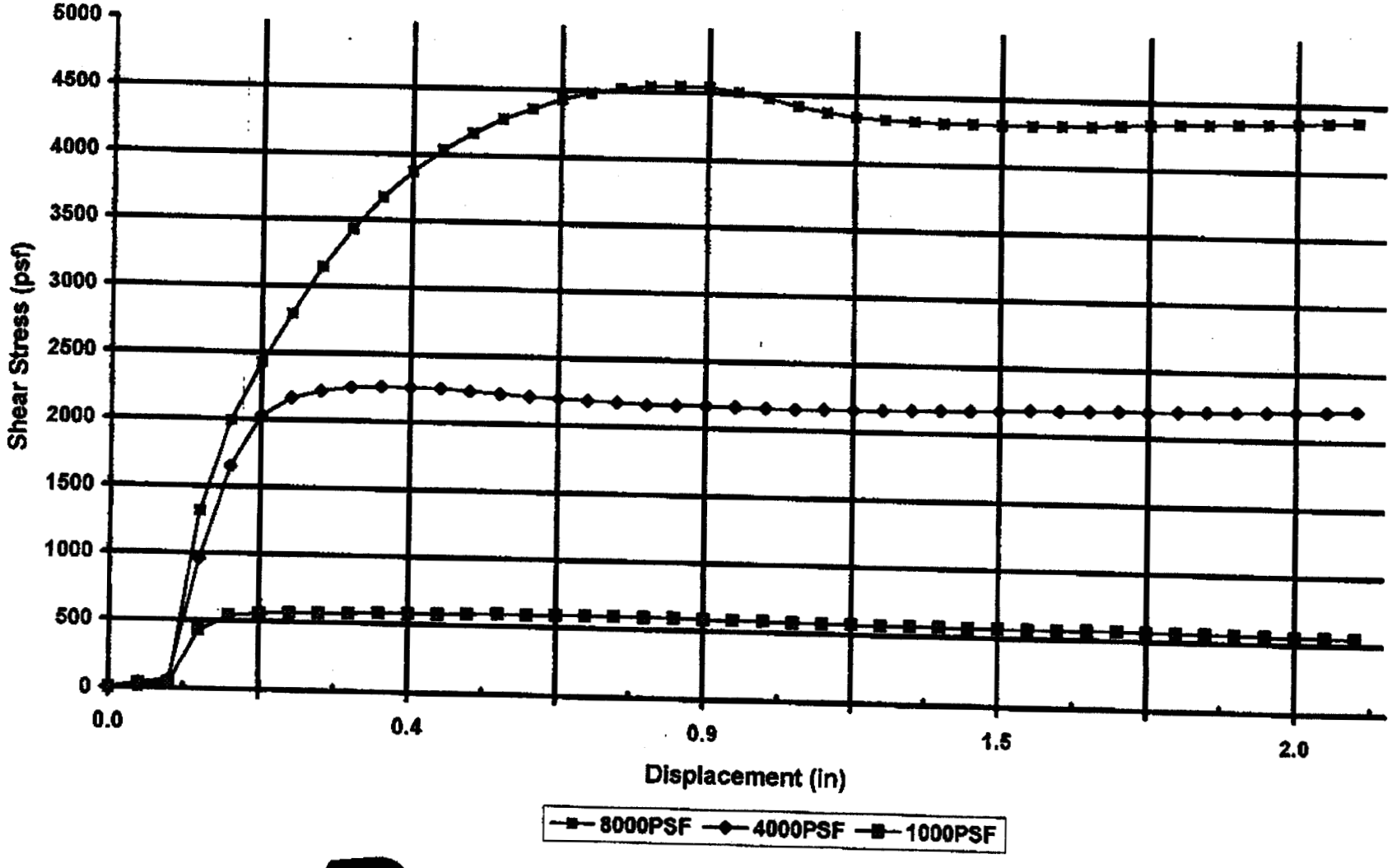

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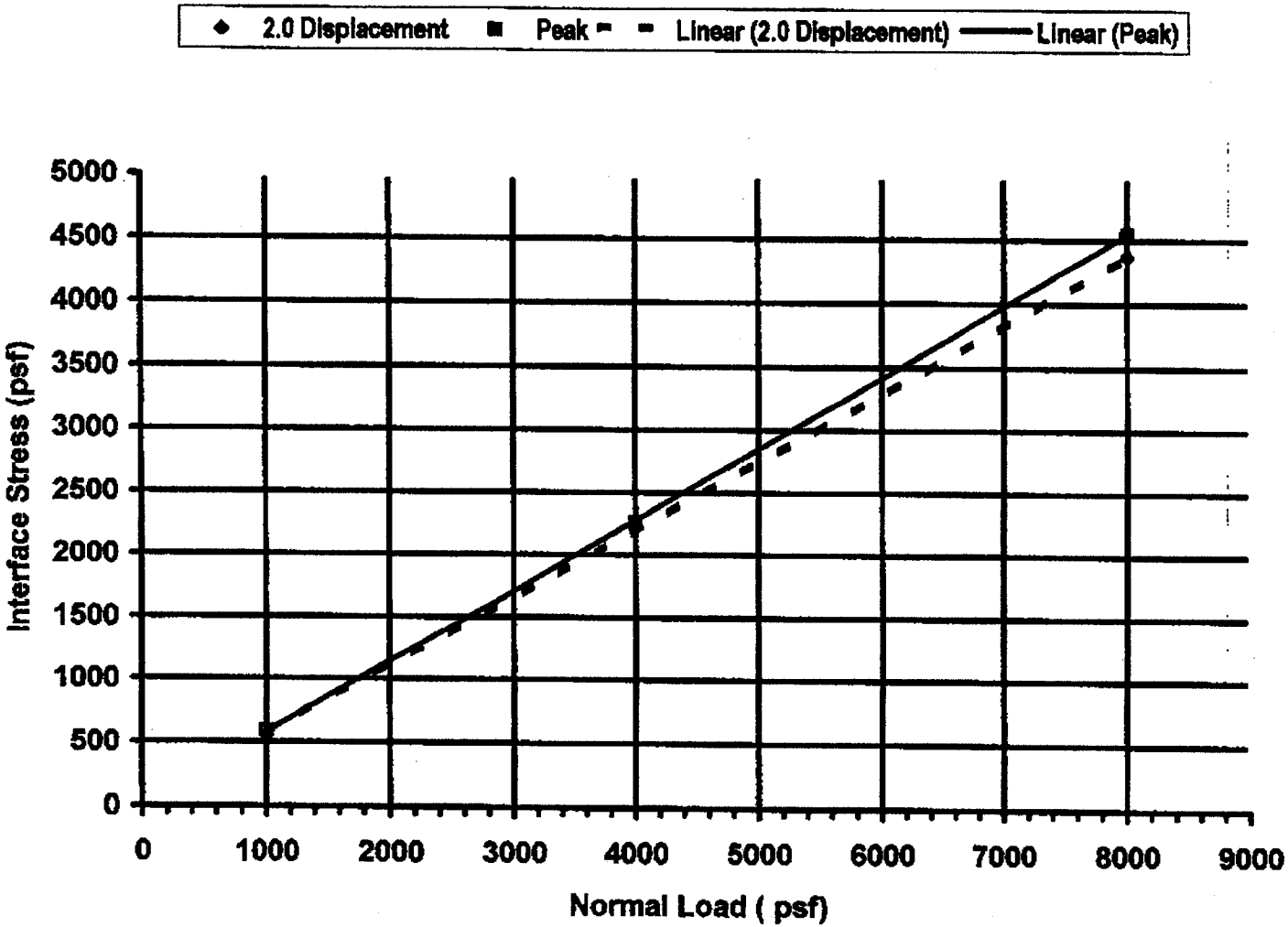
Figure #2
Normal Stress/ Interface Stress
PGL Job No. 010449_11R
Soil Bentonite, C#70707 / Textured HDPE, C#70694



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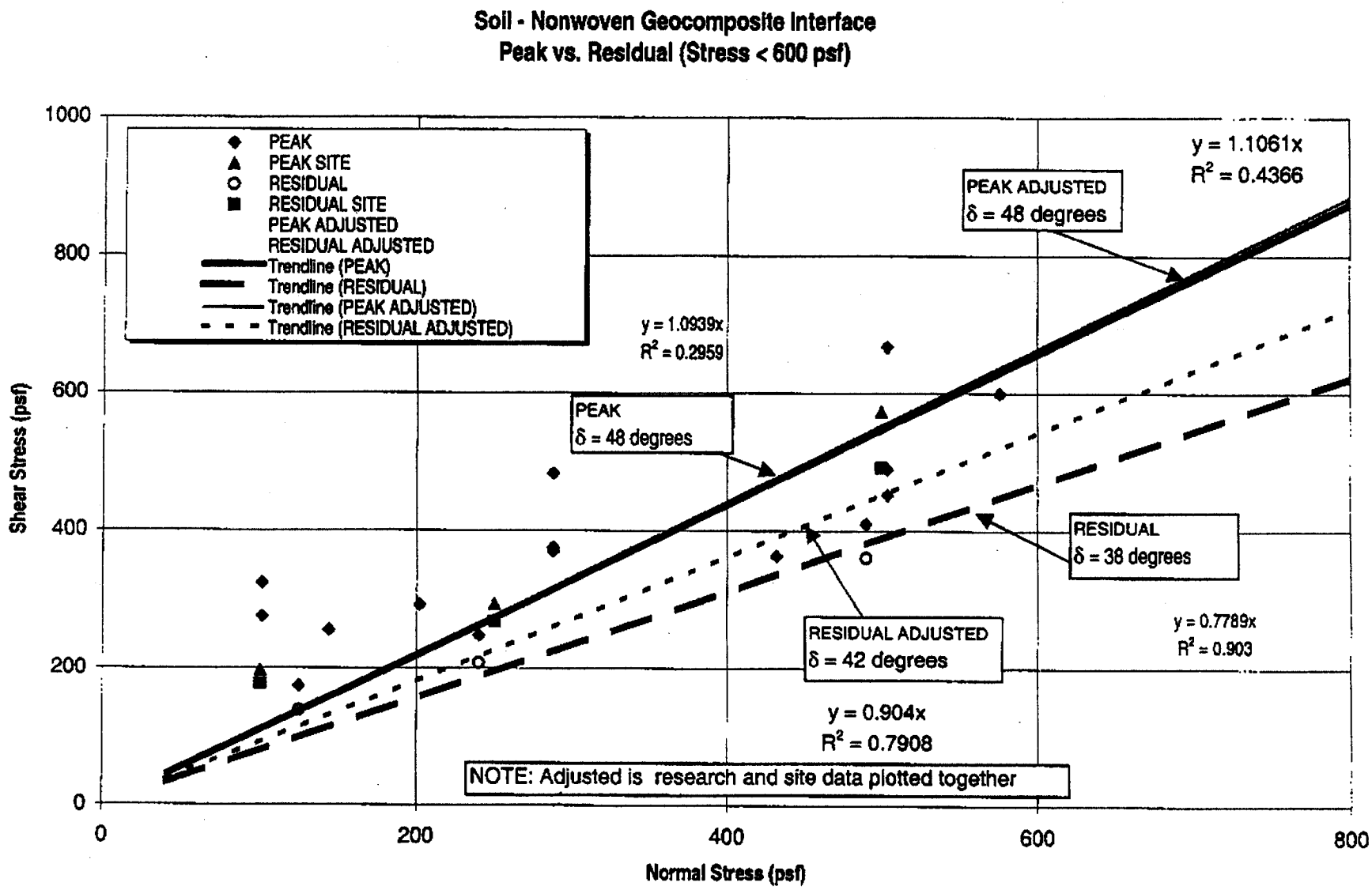
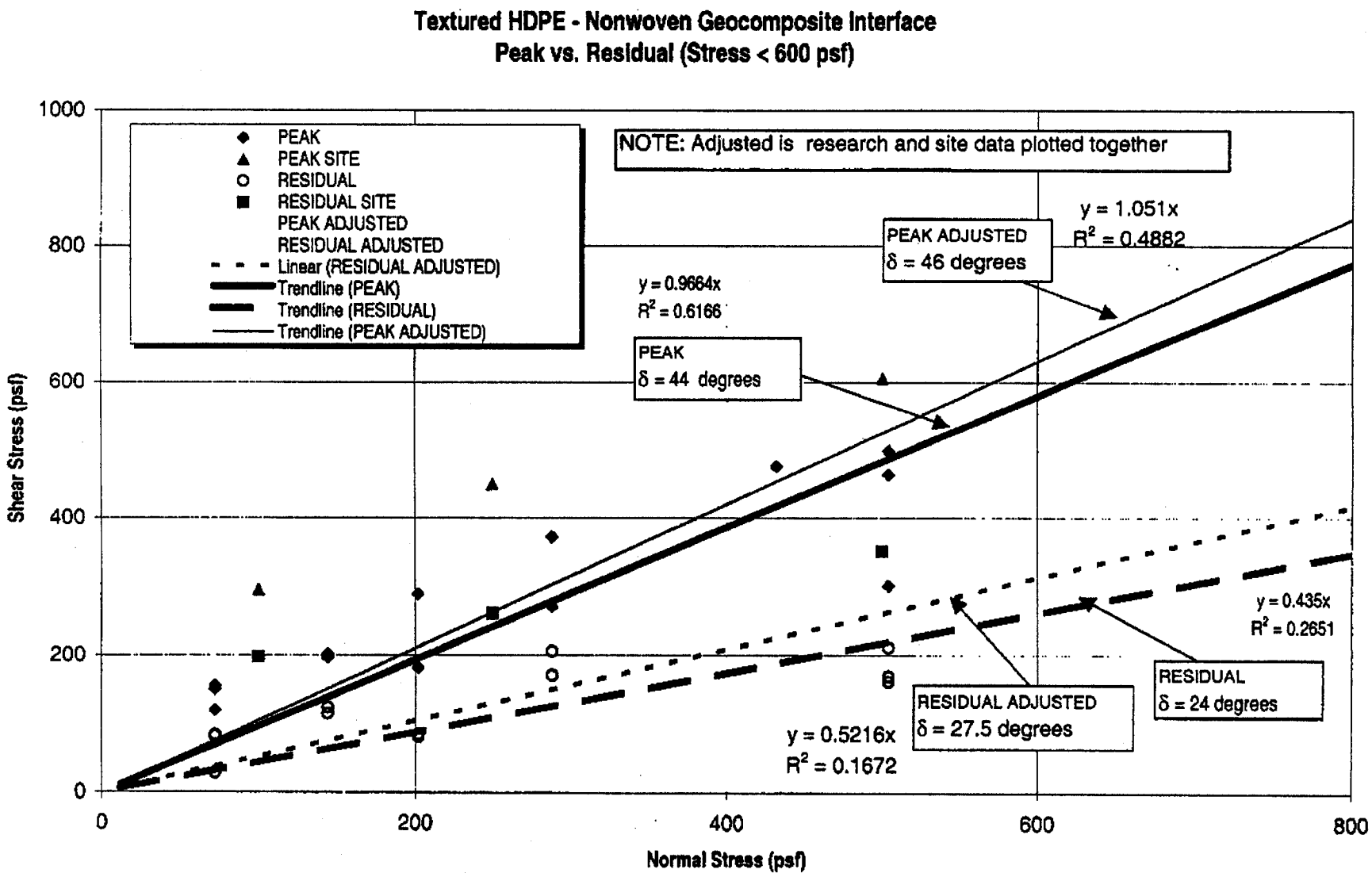
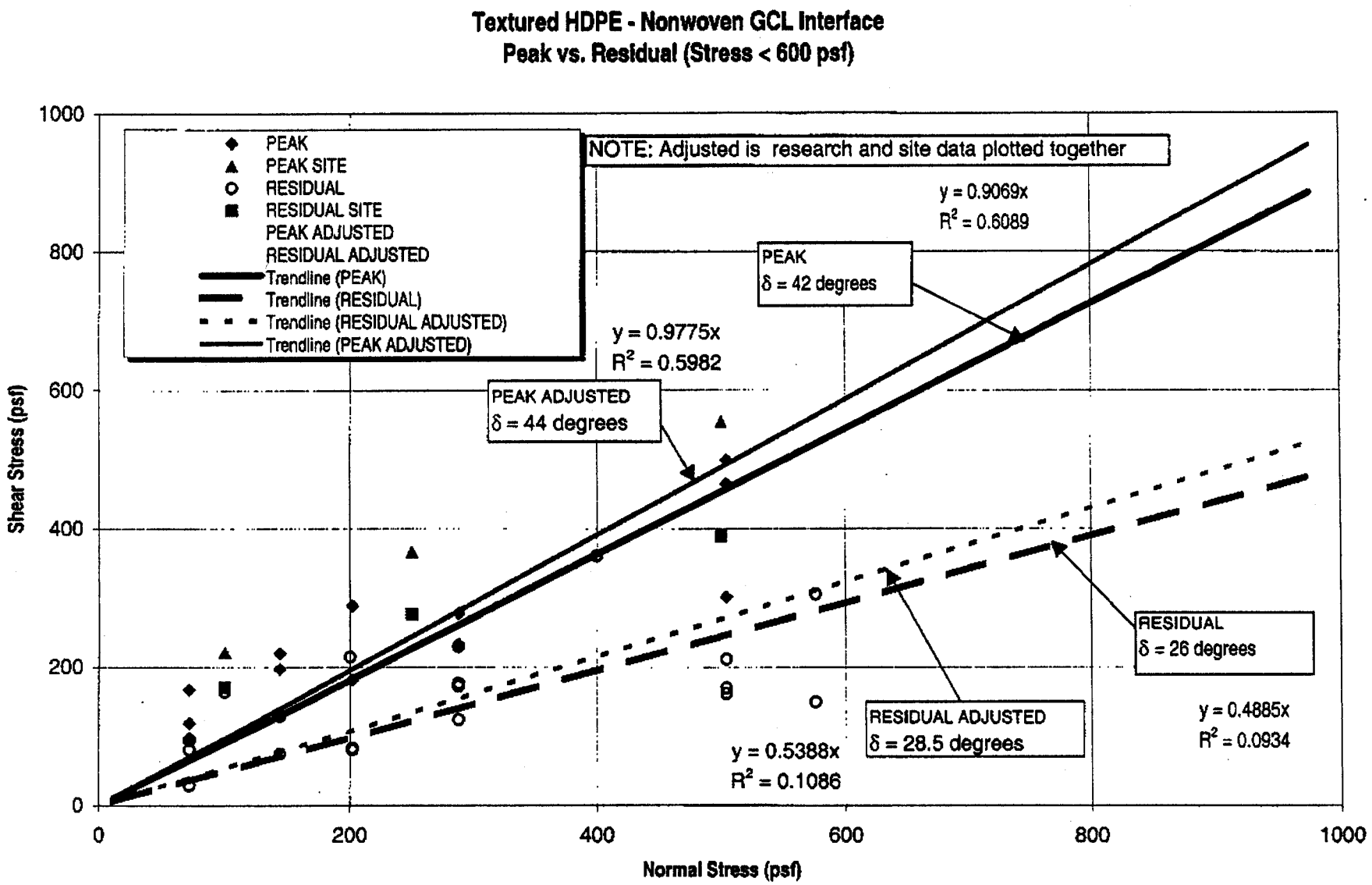
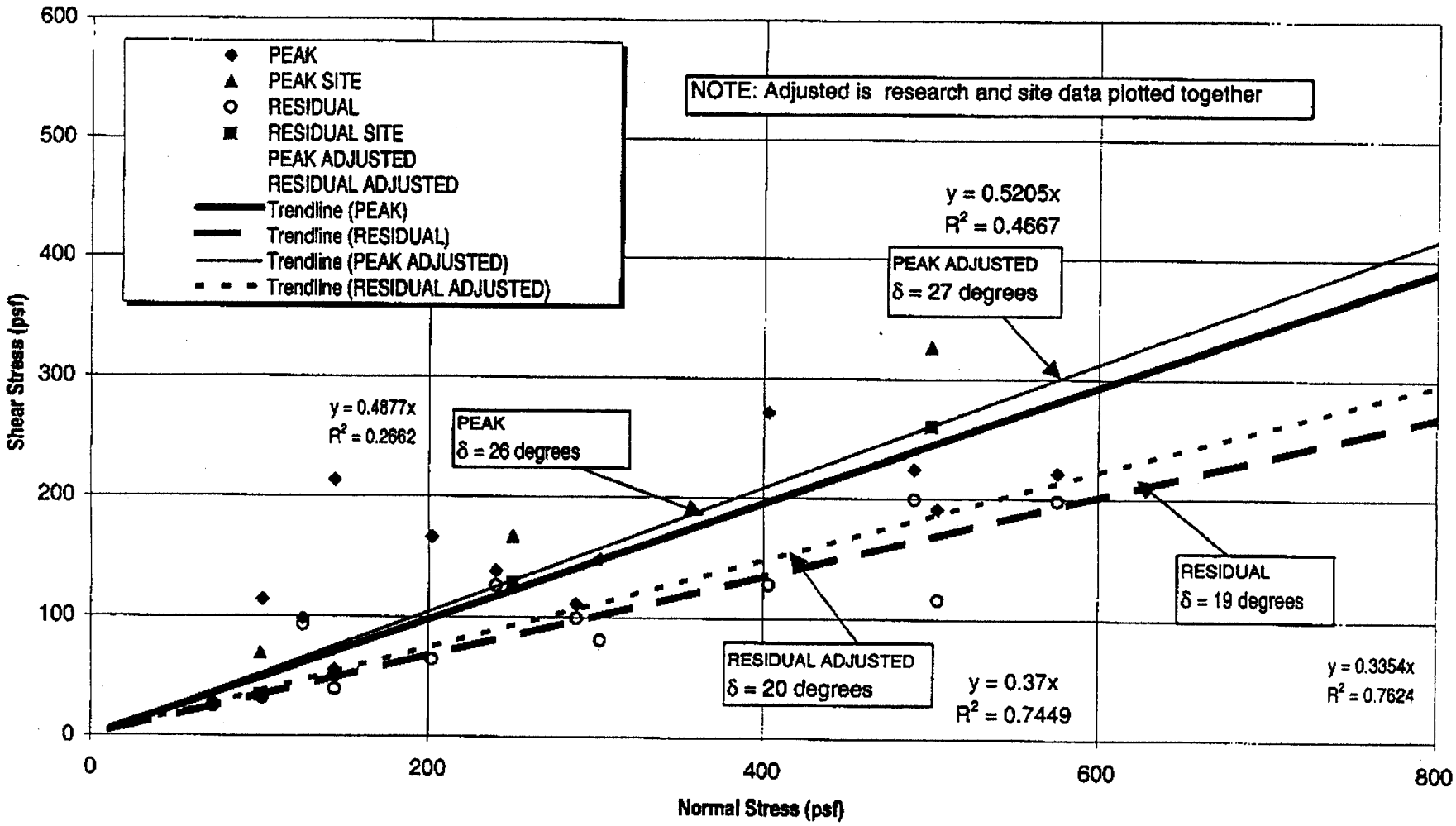
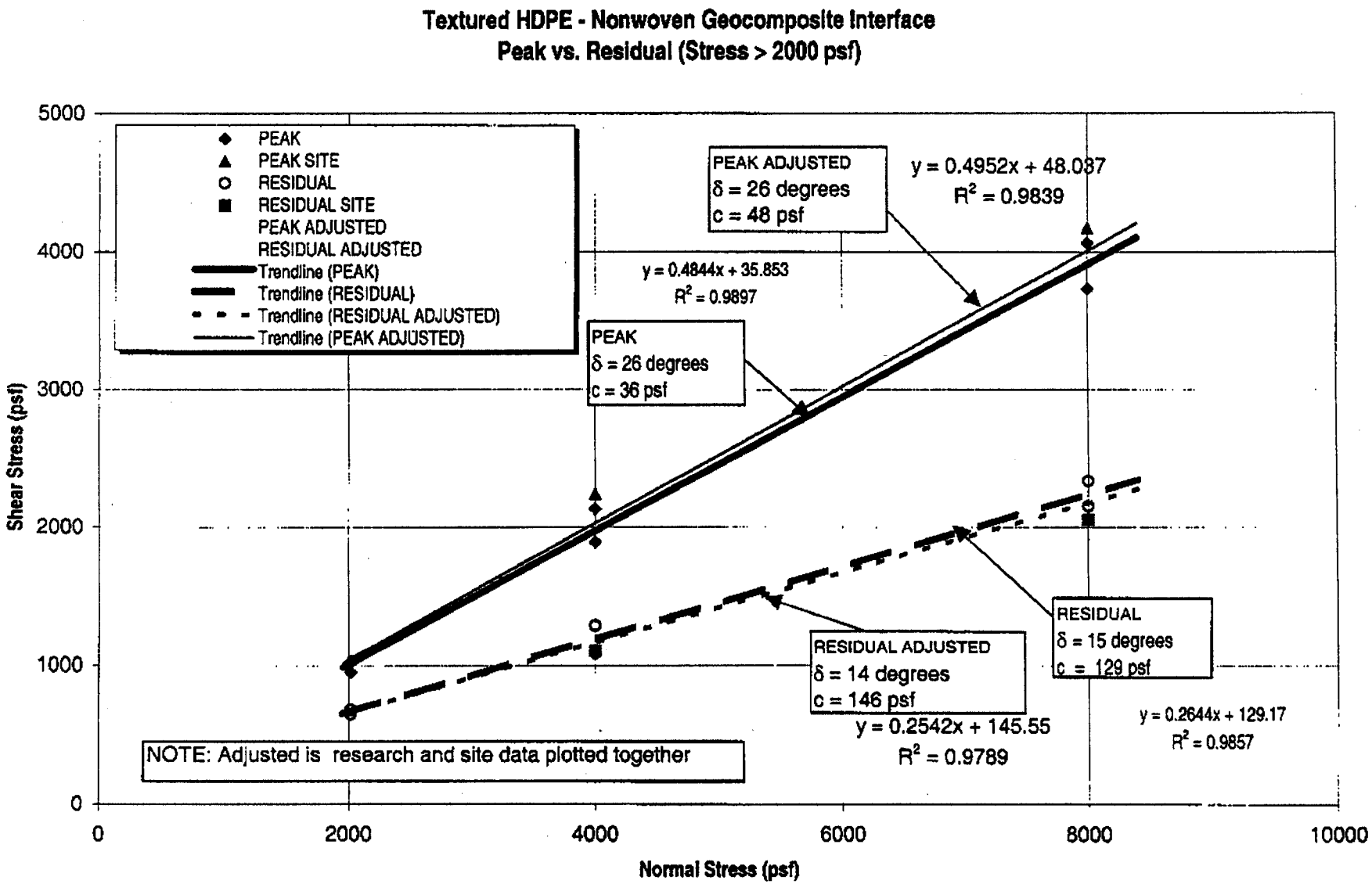

Soil - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress < 600 psf)
PEAK
PEAK SITE
RESIDUAL
RESIDUAL SITE
PEAK ADJUSTED
RESIDUAL ADJUSTED
Trendline (PEAK)
Trendline (RESIDUAL)
Trendline (PEAK ADJUSTED)
Trendline (RESIDUAL ADJUSTED)
y = 1.1061x
R² = 0.4366
PEAK ADJUSTED
δ = 48 degrees
y = 1.0939x
R² = 0.2959
PEAK
δ = 48 degrees
RESIDUAL
δ = 38 degrees
RESIDUAL ADJUSTED
δ = 42 degrees
y = 0.7789x
R² = 0.903
y = 0.904x
R² = 0.7908
NOTE: Adjusted is research and site data plotted together
Shear Stress (psf)
Normal Stress (psf)
0
200
400
600
800
1000

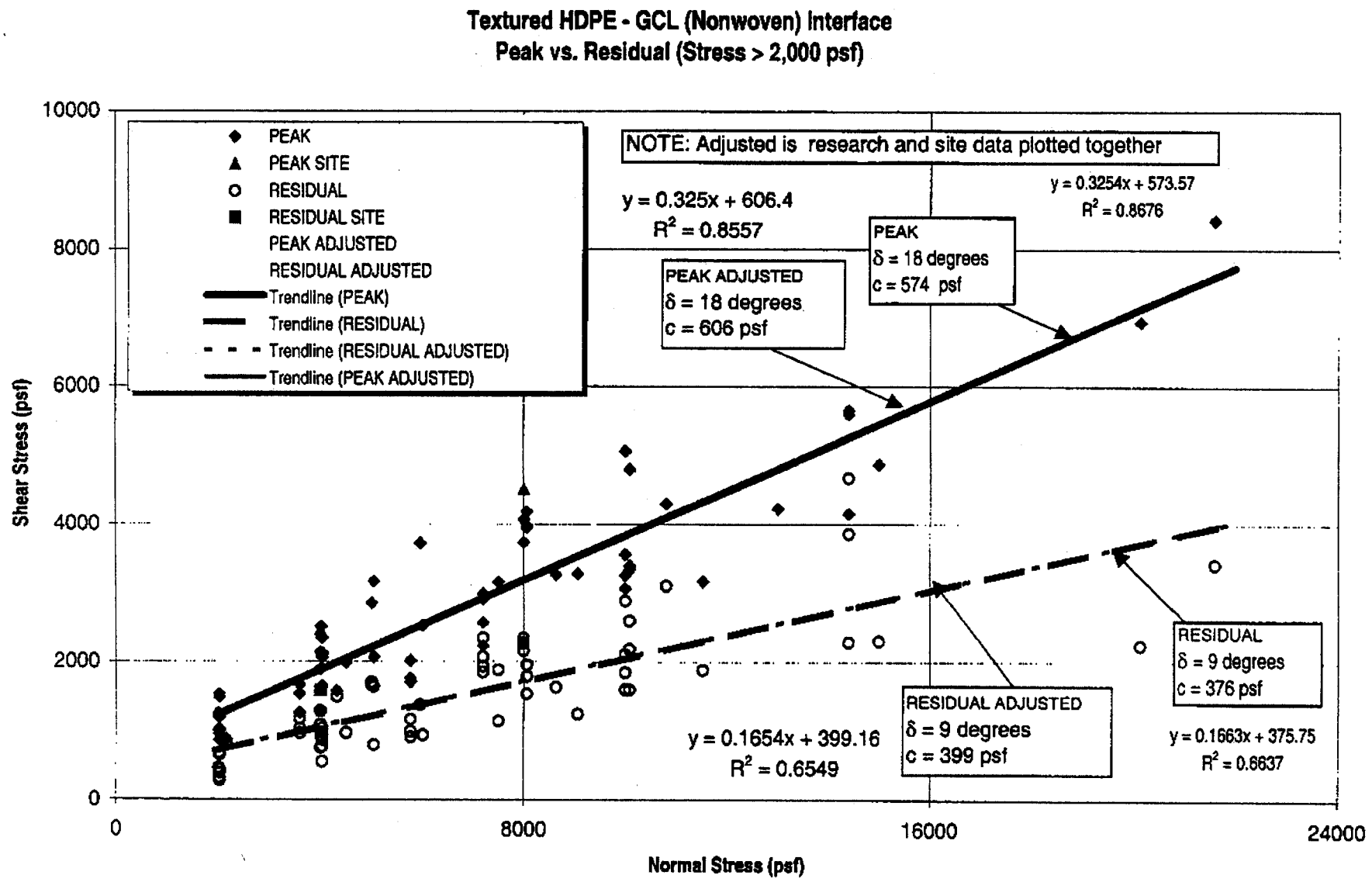

Textured HDPE - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress < 600 psf)
PEAK
PEAK SITE
RESIDUAL
RESIDUAL SITE
PEAK ADJUSTED
RESIDUAL ADJUSTED
Linear (RESIDUAL ADJUSTED)
Trendline (PEAK)
Trendline (RESIDUAL)
Trendline (PEAK ADJUSTED)
NOTE: Adjusted is research and site data plotted together
y = 1.051x
R² = 0.4882
PEAK ADJUSTED
δ = 46 degrees
y = 0.9664x
R² = 0.6166
PEAK
δ = 44 degrees
y = 0.435x
R² = 0.2651
RESIDUAL
δ = 24 degrees
RESIDUAL ADJUSTED
δ = 27.5 degrees
y = 0.5216x
R² = 0.1672
Shear Stress (psf)
Normal Stress (psf)
0
200
400
600
800
1000


Textured HDPE - Nonwoven GCL Interface
Peak vs. Residual (Stress < 600 psf)
PEAK
PEAK SITE
RESIDUAL
RESIDUAL SITE
PEAK ADJUSTED
RESIDUAL ADJUSTED
Trendline (PEAK)
Trendline (RESIDUAL)
Trendline (RESIDUAL ADJUSTED)
Trendline (PEAK ADJUSTED)
NOTE: Adjusted is research and site data plotted together
y = 0.9069x
R² = 0.6089
PEAK
δ = 42 degrees
y = 0.9775x
R² = 0.5982
PEAK ADJUSTED
δ = 44 degrees
RESIDUAL
δ = 26 degrees
RESIDUAL ADJUSTED
δ = 28.5 degrees
y = 0.4885x
R² = 0.0934
y = 0.5388x
R² = 0.1086
Shear Stress (psf)
Normal Stress (psf)
0
200
400
600
800
1000

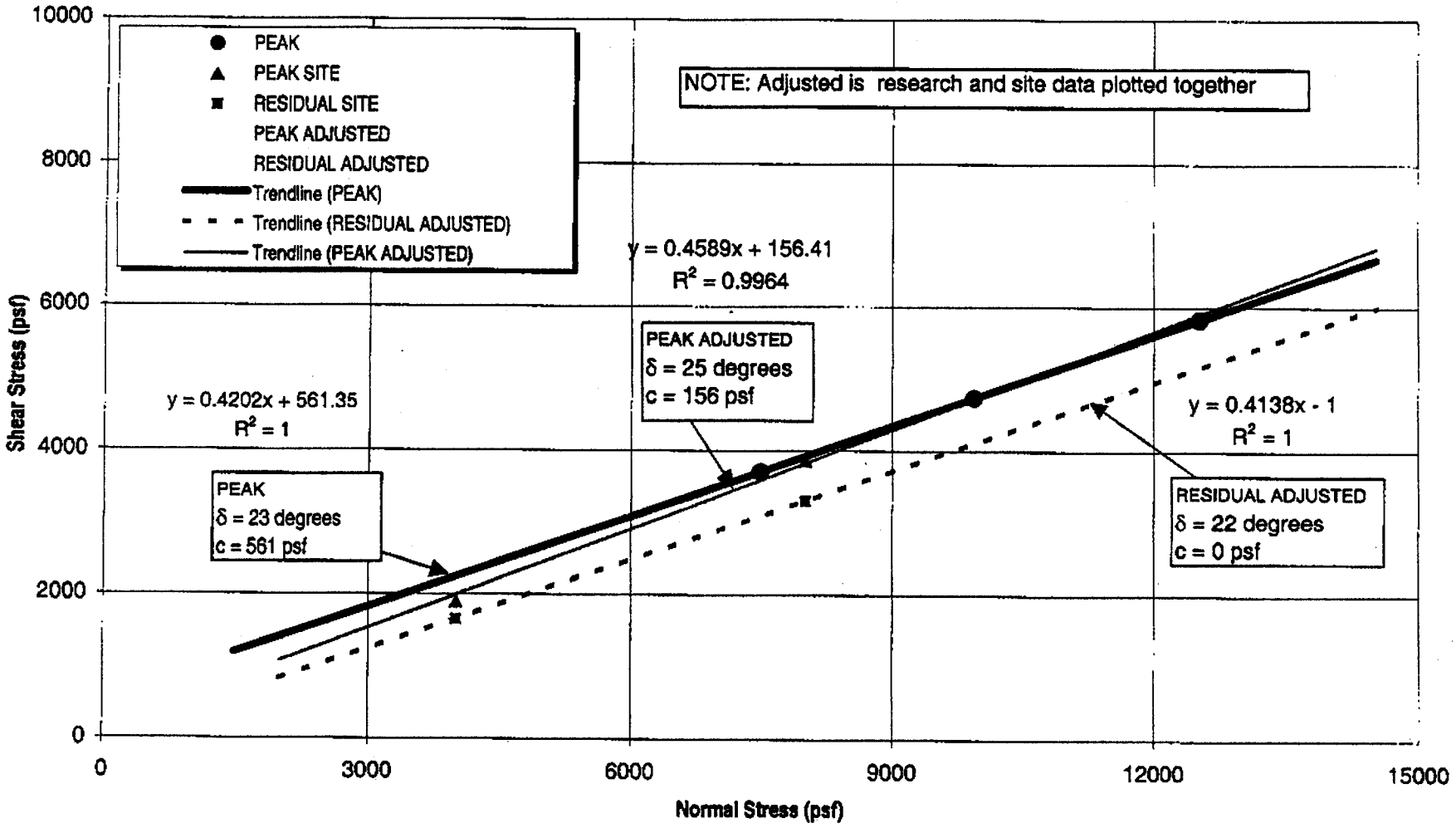
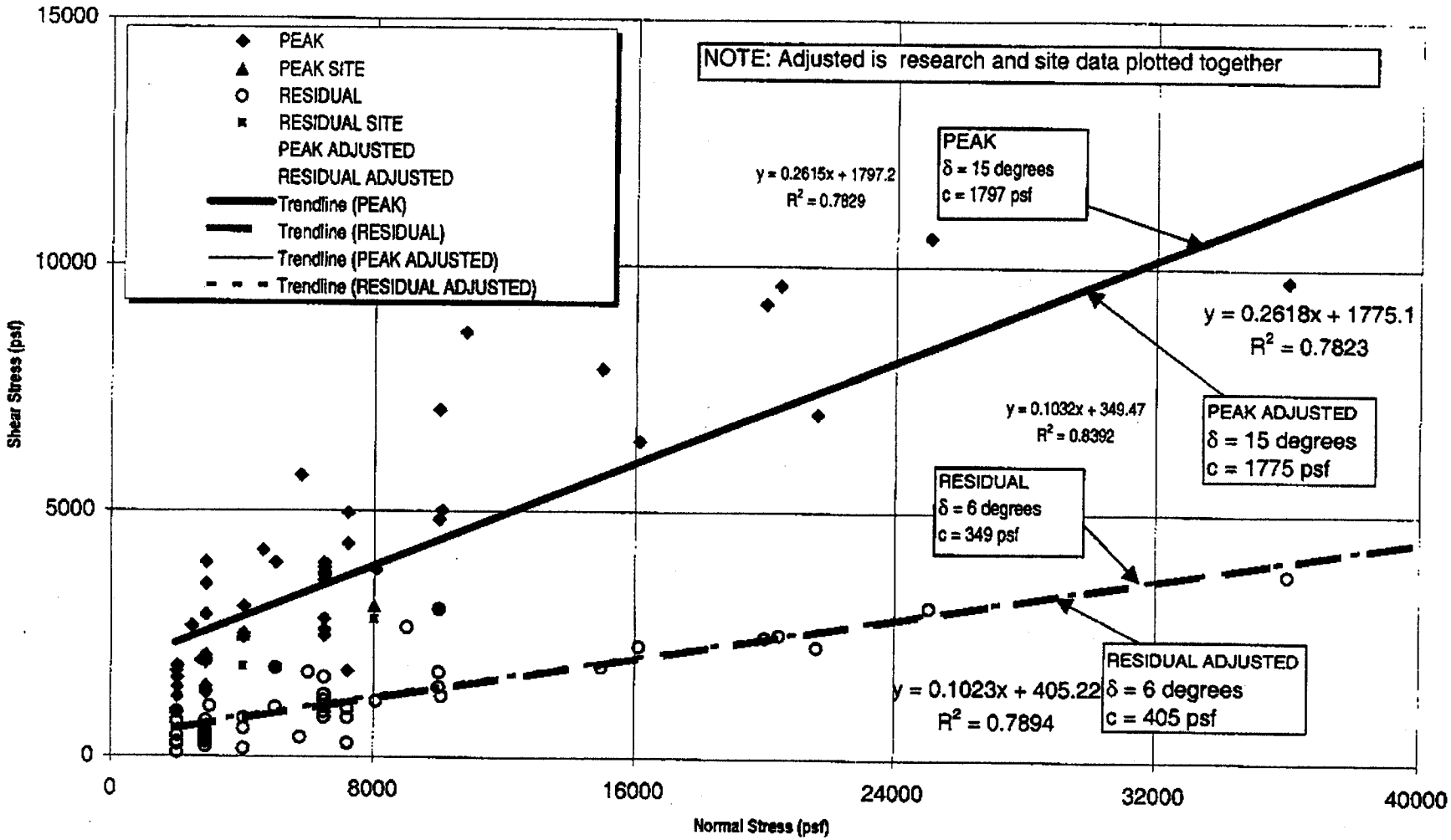
Nonwoven GCL - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress < 600 psf)




Textured HDPE - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress > 2000 psf)
PEAK
PEAK SITE
RESIDUAL
RESIDUAL SITE
PEAK ADJUSTED
RESIDUAL ADJUSTED
Trendline (PEAK)
Trendline (RESIDUAL)
Trendline (RESIDUAL ADJUSTED)
Trendline (PEAK ADJUSTED)
PEAK ADJUSTED
δ = 26 degrees
c = 48 psf
y = 0.4952x + 48.037
R² = 0.9839
y = 0.4844x + 35.853
R² = 0.9897
PEAK
δ = 26 degrees
c = 36 psf
RESIDUAL
δ = 15 degrees
c = 129 psf
RESIDUAL ADJUSTED
δ = 14 degrees
c = 146 psf
y = 0.2542x + 145.55
R² = 0.9789
y = 0.2644x + 129.17
R² = 0.9857
NOTE: Adjusted is research and site data plotted together
Shear Stress (psf)
Normal Stress (psf)
0
1000
2000
3000
4000
5000
0
2000
4000
6000
8000
10000


Textured HDPE - GCL (Nonwoven) Interface
Peak vs. Residual (Stress > 2,000 psf)
PEAK
PEAK SITE
RESIDUAL
RESIDUAL SITE
PEAK ADJUSTED
RESIDUAL ADJUSTED
Trendline (PEAK)
Trendline (RESIDUAL)
Trendline (RESIDUAL ADJUSTED)
Trendline (PEAK ADJUSTED)
NOTE: Adjusted is research and site data plotted together
y = 0.325x + 606.4
R² = 0.8557
y = 0.3254x + 573.57
R² = 0.8676
PEAK
δ = 18 degrees
c = 574 psf
PEAK ADJUSTED
δ = 18 degrees
c = 606 psf
RESIDUAL
δ = 9 degrees
c = 376 psf
RESIDUAL ADJUSTED
δ = 9 degrees
c = 399 psf
y = 0.1654x + 399.16
R² = 0.6549
y = 0.1663x + 375.75
R² = 0.6637
Shear Stress (psf)
Normal Stress (psf)
0
2000
4000
6000
8000
10000
0
8000
16000
24000

Nonwoven GCL - Nonwoven Geocomposite Interface
Peak vs. Residual (Stress > 2,000 psf)



GCL Internal Strength
Peak vs. Residual (Stress > 2,000 psf)