Phase 2 Geotechnical Services SR 107 MP 4.7 Landslide Montesano, WA

By

Landslide Technology

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TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS

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July 7, 2006 1744

Mr. Steve Lowell, L.G., L.E.G.
Washington State Department of Transportation
P.O. Box 47365
Olympia, WA 98504-7365

Phase 2 Geotechnical Services
SR 107, Milepost 4.7 Landslide
Montesano, Washington

Dear Mr. Lowell:

In accordance with your authorization, we have completed the Phase 2 geotechnical investigation of the State Route 107 Milepost 4.7 Landslide near Montesano, Washington. This letter-report summarizes our field and laboratory investigation programs and shear pile design.

Background

General. The landslide is situated on a north-facing hillside above the Chehalis River. State Route 107 traverses the toe of the hillside in an east-west direction (see Vicinity Map, Figure 1). The slide movement began during a torrential rainstorm on the night of December 28, 2005. By December 30, 2005, a 300-foot-wide segment of the highway had shifted nearly 15 feet toward the river. The Washington State Department of Transportation (WSDOT) closed the highway shortly after the slide started; however, the road surface was re-graded with crushed rock and opened to reduced-speed traffic near the end of January 2006. We understand that the State is tasked with stabilizing the landslide and returning the highway to its pre-slide condition on a fast-track basis.

Phase 1 Investigation. Our firm performed a Phase 1 geotechnical investigation of the slide between January and March 2006. Phase 1 tasks included: (i) a geologic reconnaissance of the site; (ii) a field investigation of the landslide to evaluate the subsurface conditions and to install instrumentation to monitor slide movement and groundwater pressure; (iii) laboratory testing to determine basic index and strength parameters: (iv) slope stability analyses to evaluate conceptual methods for repairing the slide; (v) report preparation; and (vi) a subsequent meeting with the State to discuss the conceptual repair options. Details of the Phase 1 investigation are summarized in our report dated April 4, 2006. Logs of borings drilled for this phase are included in Appendix E. The meeting was held at WSDOT headquarters on March 24, 2006. Following the March 24 meeting, WSDOT elected to proceed with final design of a shear pile wall to stabilize the landslide. The shear pile wall is to be located along the inboard side of the roadway,

parallel to the road alignment. The Phase 2 tasks outlined below include our services for final design assistance on the shear piles.

Scope of Work (Phase 2). Our scope of work, as outlined in our proposal dated April 20, 2006 consisted of the following tasks:

- Kickoff Meeting
- Field Investigation.
- Laboratory Investigation
- Shear Pile Wall Design
- Meetings and Coordination
- Geotechnical Report (this report)

Field Investigations

Field Explorations. The field exploration program consisted of drilling three borings, designated LT-8, LT-8b, and LT-9, at the locations shown on the Site Plan, Figure 2. As shown in Figure 2, the borings were drilled between the previously drilled borings of H-1-06, LT-2, and H-2-06 on the outboard side of the highway shifted by the landslide.

A WSDOT drill crew performed the drilling on April 24, 25 and 26 using a track-mounted CME-850 drill rig. The borings were drilled using HWT casing advancer in overburden soils and HQ3 wireline coring method in rock. Standard Penetration Tests (SPT) were generally performed at 2.5-foot intervals in the overburden. Shelby Tube samples were obtained in cohesive soils at varying depths. A geologist from our firm was present throughout the field explorations to coordinate the work, and to collect and log soil and rock samples.

Borings LT-8 and LT-9 were drilled to depths of 44.0 feet and 58.0 feet, respectively. Bedrock was encountered at a depth of 22.5 feet in LT-8 and 36.5 feet in LT-9. Boring LT-8b was quick-drilled to a depth of 24 feet for the purpose of obtaining Shelby Tube samples in cohesive soils above the soil/bedrock interface. Material descriptions of the subsurface materials encountered in the borings are shown on summary boring logs, Figures 3, 4, and 5.

Instrumentation. Borings LT-8 and LT-9 were instrumented with piezometers consisting of 10-foot long, 2-inch diameter, slotted PVC tip connected to a 2-inch diameter PVC riser pipe. The annular space between the slotted tip and boring sidewall was backfilled with No. 10-20 sand; the remainder of the boring was sealed with bentonite chips to the surface and capped with a monument. No instrumentation was provided for boring LT-8b, which was backfilled with bentonite chips.

Subsurface Conditions.

The exploratory borings indicated subsurface conditions that were similar to those indicated by borings that were drilled in January 2006 (Landslide Technology, 2006 and Appendix E).

General. The subsurface conditions of the SR 107 slide area generally consist of fine-grained soil overburden overlying siltstone of the Lincoln Creek Formation. The soil overburden is comprised of a layer of soft to stiff, slightly sandy, silty clay with scattered rootlets and wood fragments, underlain by a layer of very stiff, slightly sandy, silty clay with coarse gravel- to boulder-sized fragments of siltstone and traces of mica and shell fragments. Both of these layers appear to be blocky and disturbed. The bedrock generally consists of very soft (R1), slightly weathered siltstone, which is moderately jointed, with scattered shell fragments and occasional sandstone lenses.

Groundwater. Groundwater levels could not be measured in the borings during drilling operations because the casing advancer and coring methods circulated water as drilling fluid. Initial readings in piezometers LT-8 and LT-9 after bailing were about 9 feet below the ground surface. An additional reading was taken 24 hours after installation in LT-9, which was about 7.6 feet below the ground surface.

Laboratory Testing

Laboratory testing consisted of natural water content determinations, liquid and plastic limit determinations (Atterberg limits), unconsolidated-undrained triaxial compression tests on cohesive soils, and point-load tests and unconfined compression tests on selected rock core samples. Soil and rock core samples were re-examined in the laboratory to refine field classifications.

Natural Moisture Content. Moisture contents were determined on all SPT samples retrieved from the borings in general accordance with ASTM D-2216. The moisture contents are shown on summary boring logs, Figures 3, 4, and 5.

Atterberg Limits. Atterberg limits were determined for two soil samples indicated in Table 1 below. Tests were performed in general conformance with ASTM D-4318. Results are shown in Table 1 and plotted in Figure 6, Plasticity Chart. The results are also shown in the summary boring logs, Figures 4 and 5.

Table 1 Atterberg Limits

Boring	Sample No.	Depth (feet)	Natural Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
LT-8b	S-2	21.5-21.7	24	85	25	60
LT-9	S-10	24.1-24.3	38	72	29	43

Unconsolidated-Undrained Triaxial Compression Tests (UU Tests). UU tests were performed on four samples of silty clay in general accordance with ASTM D-2850. Results are shown on figures 7 through 12. Undrained shear strengths ranged from about 500 psf to 2700 psf.

Unconfined Compression Tests (Rock Cores). Unconfined compression tests were performed on selected cores by the WSDOT Materials Laboratory in Tumwater. Detailed results are presented in Appendix A, and also summarized briefly in Table 2 below.

Table 2 Rock Unconfined Compression Test Results

Boring No.	Sample No.	Sample Depth (Feet)	Wet Density (lbs/ft^3)	q_u (1) (psi)	Rock Type
LT-8	C-1	24.2-24.9	117.4	154	Siltstone
LT-8	C-2	29.0-30.2	130.2	247	Siltstone
LT-9	C-3	38.8-39.5	120.9	245	Siltstone
LT-9	C-4	43.8-44.8	123.1	380	Siltstone with Sandstone Lens

Notes:
(1) Unconfined compressive strength

Point Load Tests. A total of 20 point load tests were performed on rock core specimens. Point load strength index is an indicator of strength obtained by subjecting a rock specimen to an increasing concentrated point load, applied through a pair of truncated, conical platens, until failure. The failure load is used to calculate the point load strength index ($I_{s(50)}$), and to estimate the unconfined compressive strength of the rock core specimen. Tests were performed in both diametral (load applied along the diameter of the core) and axial (load applied along a line perpendicular to the core end faces) directions. The tests were performed in general accordance with ASTM D 5731-95. The results of the point load tests are summarized in Table 3 below.

Table 3 Summary of Point Load Tests

Boring No.	Depth (ft)	Test Type*	$Is_{(50)}$	Estimated Unconfined Compressive Strength (psi)
LT-8-1	42	D	0.25	883
LT-8-2	40.4	D	0.26	919
LT-8-3	37.5	D	0.23	819
LT-8-4	34.6	D	0.22	790
LT-8-5	26.3	D	0.20	697
LT-8-6	27.5	D	0.20	702
LT-8-7	27	D	0.22	795
LT-8-8	28.5	D	0.24	866
LT-8-9	28.9	A	0.32	1,125
LT-8-10	26	A	0.29	1,041
			Mean Diametral LT-8	809
			Mean Axial LT-8	1,083
LT-9-1	57.5	D	0.34	1,201
LT-9-2	55.2	D	0.22	787
LT-9-3	53	D	0.21	749
LT-9-4	50.2	D	0.20	721
LT-9-5	39.5	D	0.21	744
LT-9-6	41	D	0.20	697
LT-9-7	41.5	D	0.18	628
LT-9-8	42.5	D	0.17	604
LT-9-9	42.8	A	0.27	964
LT-9-10	39.9	A	0.21	733
			Mean Diametral LT-9	766
			Mean Axial LT-9	849

*D = diametral test, along the bedding plane

A = axial test, perpendicular to the bedding plane

Slope Stability Analyses for Shear Pile Design

General. Forces required from shear piles to stabilize the landslide are determined by performing slope stability analyses. None of the inclinometers installed in January 2006 (see Figure 2) have shown landslide movement. Therefore, the location of the slide plane has not been established. In addition, the relationship between water levels in the piezometers and landslide movement is not known. On that basis, the slide plane location and also the water level that would trigger additional slide movement needed to be estimated in the slope stability model.

Slide Plane and Water Levels. The slide plane was modeled at the top of the siltstone bedrock as shown on Figure 13. This location was estimated based on: (i) blowcount profiles from the borings, (ii) our previous experience with similar landslides in western Washington and Oregon, and (iii) review discussions with the WSDOT geotechnical group.

Regarding the relationship between the water levels and the slide movement, we have assumed that the landslide would reach limit equilibrium (i.e., the factor of safety would drop to one) when the water level rises to 5 ft higher than the level observed on 2/16/06 as shown in Figure 13. The effective residual friction angle of the slide plane was back-calculated based on this condition and was 15.7 degrees. It was further assumed that the water level could go as high as 2/16/06 level + 10 feet as shown in Figure 13. Slope stability analyses were performed with the computer software SLOPE/W 2004 (GEO-SLOPE International Ltd., 1991-2005) using Spencer's Method.

Shear Pile Forces. Shear pile forces were determined by changing the water levels and performing slope stability analyses to achieve certain factor of safety values. The results are shown in the table in Figure 13. The unfactored shear pile force is the force required from the shear piles to maintain a landslide factor of safety of one when the water level rises to 2/16/06 level +10 feet. The unfactored shear pile force thus calculated was 24 kips/ft width of landslide.

The design shear pile force is based on providing a landslide factor of safety of 1.25 with the water level at the 2/16/06 level + 5 feet. This criteria was accepted by WSDOT. The design shear pile force thus calculated was 52 kips/ft width of landslide.

Shear Pile Design

Shear Pile Wall Location. Shear piles will consist of reinforced concrete drilled shafts. The proposed shear pile wall location is shown in Figures 1 (Site Plan) and 13 (Cross-Section A-A'). The proposed location is at the uphill shoulder of the highway and would extend from boring H-1-06 to boring H-2-06 for a distance of about 300 feet, spanning the entire width of the landslide at this location. In a cross-section, the wall would be located at approximately the one-third point from the toe of the landslide, a typical location to stabilize the entire landslide mass.

Shear Pile Model. The design parameters for the shear pile model are shown in Figure 14. This model depicts the shear pile located within cross-section A-A', between borings LT-2 and LT-7. Subsurface information primarily from borings LT-2 and LT-7 was used to construct the model. A 3-foot thick plastic shear zone, where the net landslide loading is zero, was assumed above the

slide plane. Landslide loading is modeled as a rectangular distribution as shown in Figure 14. The computer program LPILE (ENSOFT Inc., 2000) was used to perform a preliminary check of the lateral load analyses for the shear pile. It is our understanding that the WSDOT Bridge and Structures Office will perform the final structural design of the shear piles under the unfactored and design landslide loads discussed below. In the LPILE analyses, only the portion of the shear pile below the slide plane is analyzed. Therefore, the rectangular landslide loading is applied as shear and bending moment at the pile head located at a depth of 40 feet.

Material Properties. Material properties were determined from the subsurface conditions encountered in the borings and the results of the laboratory testing program. Details of material property determinations are included in Appendix B. The material properties used in the shear pile model are shown in Figure 14, as well as other material parameters that are needed to run the LPILE program.

Based on the shear pile model, landslide loading is exerted to the shear piles by the medium stiff to stiff, silty clay that exists above the plastic shear zone. The undrained shear strength of this soil was estimated to be 1,250 psf (see Appendix B). The very soft, slightly weathered siltstone below the slide plane provides the passive resistance in response to the landslide loading. The unconfined compressive strength of this rock was estimated to be 600 psi (see Appendix B). The unconfined compression test results shown in Table 2 are less than this value primarily due to (i) the compression tests were performed with no confining pressures, (ii) the strength results were probably influenced by presence of fractures, and (iii) cores of weak rock such as this one are prone to damage during compression test sample preparation. However, the test results provide a check for the validity of the estimated strength used in the shear pile modeling.

The p-y curve for this rock was developed using the model based on field load tests performed by the Kansas DOT (Frantzen and Stratton, 1987). Details of the rock p-y curve are also included in Appendix B.

Design Criteria. The design criteria for the shear pile are expressed in factors of safety as shown in Table 4 below.

Table 4 Design Criteria (Factors of Safety)

Criteria	Under unfactored landslide load 24 kips/ft	Under design landslide load 52 kips/ft
Global Landslide Stability	1.0	1.25
Rock Reaction Capacity	≥ 3.0	≥ 1.5

Shear Pile Wall Design Recommendations. Parameters that determine the specifics of the shear pile wall are:

- Shear pile diameter, b
- Shear pile spacing, s (measured on centers)
- Amount of steel, a (expressed as a percentage of the cross-sectional area)
- Number of rows of shear piles (transverse to the direction of sliding)
- Depth of embedment below the slide plane

After evaluating several parameter combinations, we present the following as a possible shear pile wall design.

- Shear pile diameter, b = 6 ft
- Shear pile spacing, s = 9 ft on centers
- Amount of steel, a = 1.5% (equivalent to 39 #11 bars, equally distributed in a circular pattern with 7.5-inch cover from rebar center to edge of shaft)
- Single row of piles
- Depth of embedment = 30 feet below the slide plane
- Total shear pile depth = up to 70 feet

It is noted that the amount of steel of a = 1.5% was needed to obtain LPILE results that would satisfy the rock reaction design criteria indicated in Table 4. Results of LPILE runs are included in Appendix C for both unfactored landslide load and design landslide load conditions. The first page of Appendix C shows the pile head boundary conditions of shear and bending moment for the two load conditions.

The depth of embedment was determined by analyzing the embedment depths of 20, 25, and 30 feet using LPILE. The embedment depth of 30 feet was necessary to satisfy the rock reaction factors of safety indicated in Table 4. LPILE run results for embedment depths of 20 and 25 feet are included in Appendix C for reference.

Use of LRFD. The rectangular landslide loading shown in Figure 14 can be considered to be the nominal load, and LRFD may be used to assist with the shear pile design. Details of the LRFD approach are included in Appendix D.

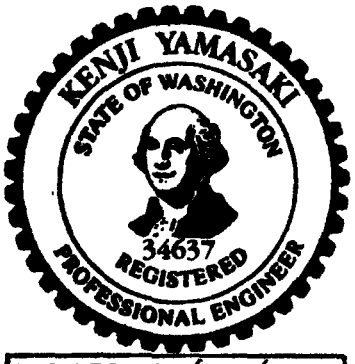
Shear Pile Wall Profile. A proposed limit of the shear pile wall is shown in Figure 15. Most of the wall would extend to a depth of 70 feet below the ground surface. The top of bedrock rises from a depth of about 40 feet at boring LT-2 to a depth of about 10 feet at boring H-2-06. Therefore, the wall could be terminated at a depth of 50 feet for the last 50 to 60 feet at the west end as shown in Figure 15.

We appreciated the opportunity to be of service on this project. If you have any questions, please call.

Sincerely,

LANDSLIDE TECHNOLOGY

Kenji Yamasaki, P.E.
Senior Associate Engineer



EXPIRES: 8/13/08

Michael R. Meyer, P.E.
Senior Associate Engineer

EXPIRES 6/8/07

REFERENCES

ENSOFT, Inc. (2000). "Computer Program LPILE Plus Version 4.0," *A Program for the Analysis of Piles and Drilled Shafts Under Lateral Loads,* User's Manual, Austin, Texas.

Frantzen, J. and Stratton, F.W. (1987). "P-y Curve Data for Laterally Loaded Piles in Shale and Sandstone," *Report No. FHWA-KS-87-2*, Kansas DOT.

GEO-SLOPE International Ltd. (1991-2005). SLOPE/W 2004 version 6.16, GeoStudio 2004, Calgary, Alberta, Canada.

Landslide Technology. (2006). Geotechnical Investigation, SR 107, Milepost 4.7 Landslide, Montesano, Washington. A report to Washington State Dept. of Transportation dated April 4, 2006.

Limitations in the Use and Interpretation of This Geotechnical Report

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross-sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.

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744101 MWT

VICINITY MAP

SR 107, MP 4.7 LANDSLIDE
MONTESANO, WASHINGTON

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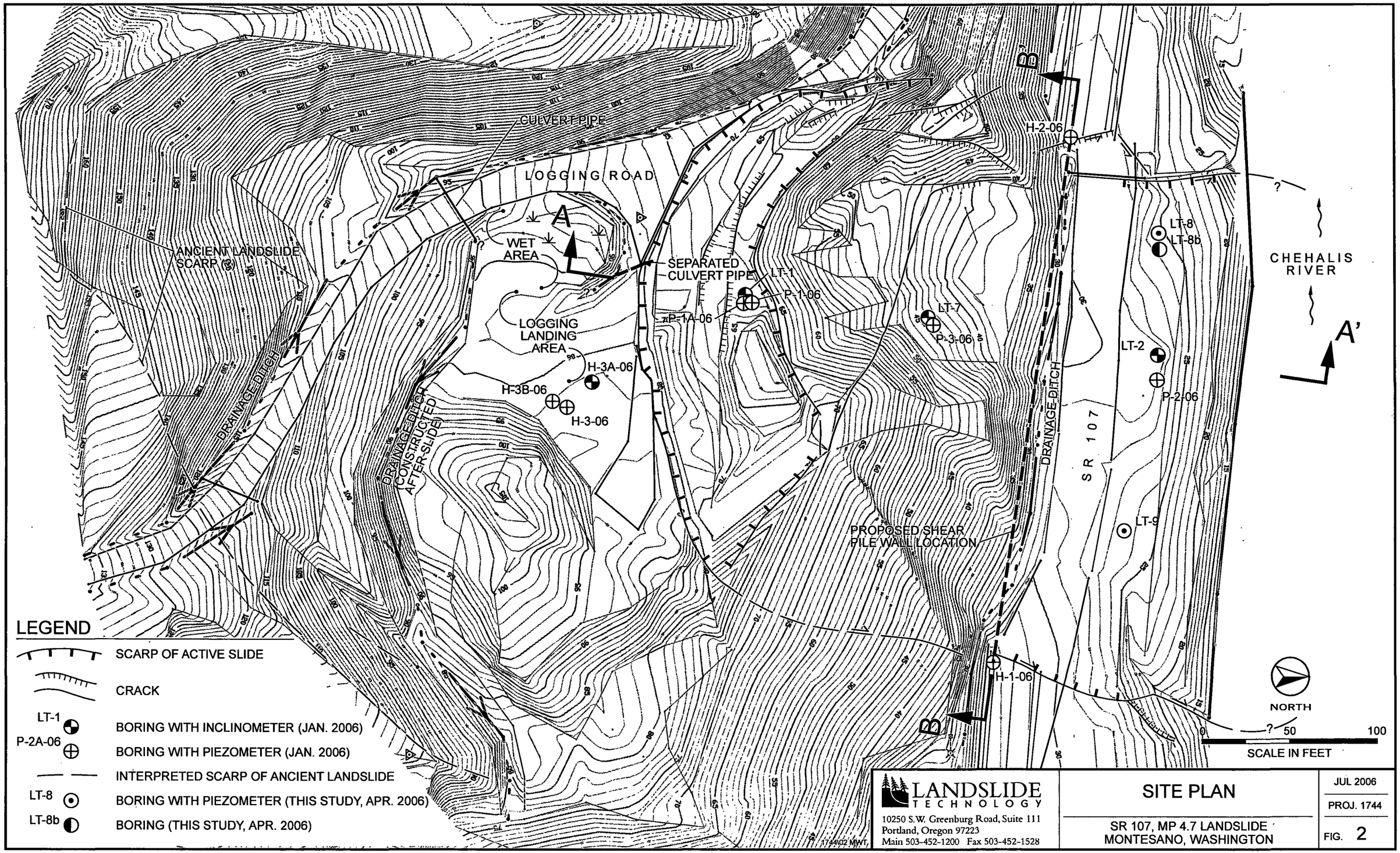
PROJ. 1744

FIG. 1



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SITE PLAN

SR 107, MP 4.7 LANDSLIDE
MONTESANO, WASHINGTON

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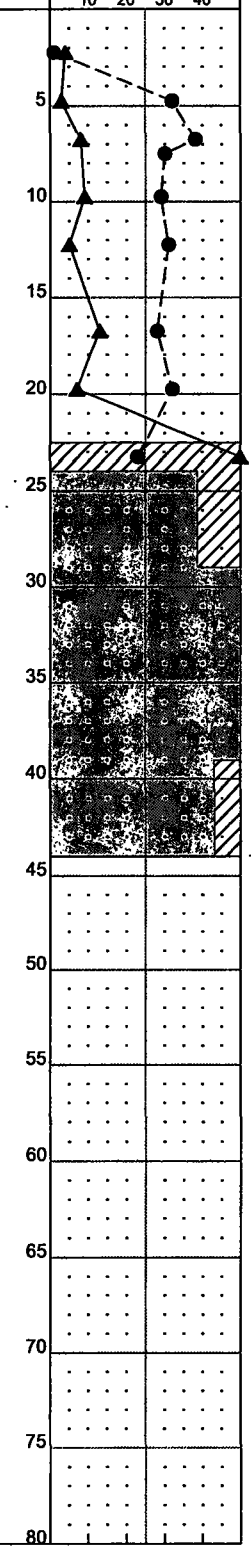
FIG. 2

DEPTH IN FEET	MATERIAL DESCRIPTION	RUN NO.	SAMPLE NO.	PEN. DATA
	MEDIUM STIFF, black to yellow-brown, sandy, silty CLAY; gravel sized crushed rock fragments (ROAD FILL)		S-1	3 2 2
3½	MEDIUM STIFF to STIFF, dark gray, silty CLAY; scattered fine siltstone fragments (DECOMPOSED SILTSTONE/SLIDE DEBRIS)		S-2	1 2 1
			S-3a	3 4
			S-3b	4 4
			S-4	5 4
			S-5	3 2 3
			S-6	
			S-7	5 6 7
			S-8	3 3 4
			S-9	
22½	EXTREMELY SOFT to V. SOFT, dark gray, fresh SILTSTONE; slightly jointed, scattered shells (LINCOLN CREEK FORMATION)	R-1	S-10	21 38 50
		R-2		
		R-3		
		R-4		
		R-5		
44	Bottom of Boring: 44 FT			

GROUND WATER/ INSTRUMENT INSTALLATION



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- ▲ STANDARD PENETRATION TEST (BLOWS/FT.)
- ● WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.

HAMMER ASSEMBLY: NOT APPLICABLE SPT SAMPLER: NOT APPLICABLE
DRILL ROD USED: AWJ BOREHOLE DIAM.: 4.5 INCH

DRILLER: WA DOT
DATE START: 4/25/2006 FINISH: 4/25/2006
DRILLING TECHNIQUE: HWT Casing Advancer

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SUMMARY BORING LOG LT-8

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FIG. 3

DEPTH IN FEET	MATERIAL DESCRIPTION	SAMPLE NO.	PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION	PENETRATION TEST (BLOWS PER FOOT) / WATER CONTENT (%) 10 20 30 40
	MEDIUM STIFF, dark gray, silty CLAY, scattered siltstone fragments (DECOMPOSED SILTSTONE/SLIDE DEBRIS)	S-1 S-2 S-3			85
24	Bottom of Boring: 23.9 FT				

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

20 40 60 80
RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.

HAMMER ASSEMBLY: NOT APPLICABLE SPT SAMPLER: NOT APPLICABLE
DRILL ROD USED: AWJ BOREHOLE DIAM.: 4.5 INCH

DRILLER: WA DOT
DATE START: 4/26/2006 FINISH: 4/26/2006
DRILLING TECHNIQUE: HWT Casing Advancer

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SUMMARY BORING LOG
LT-8b

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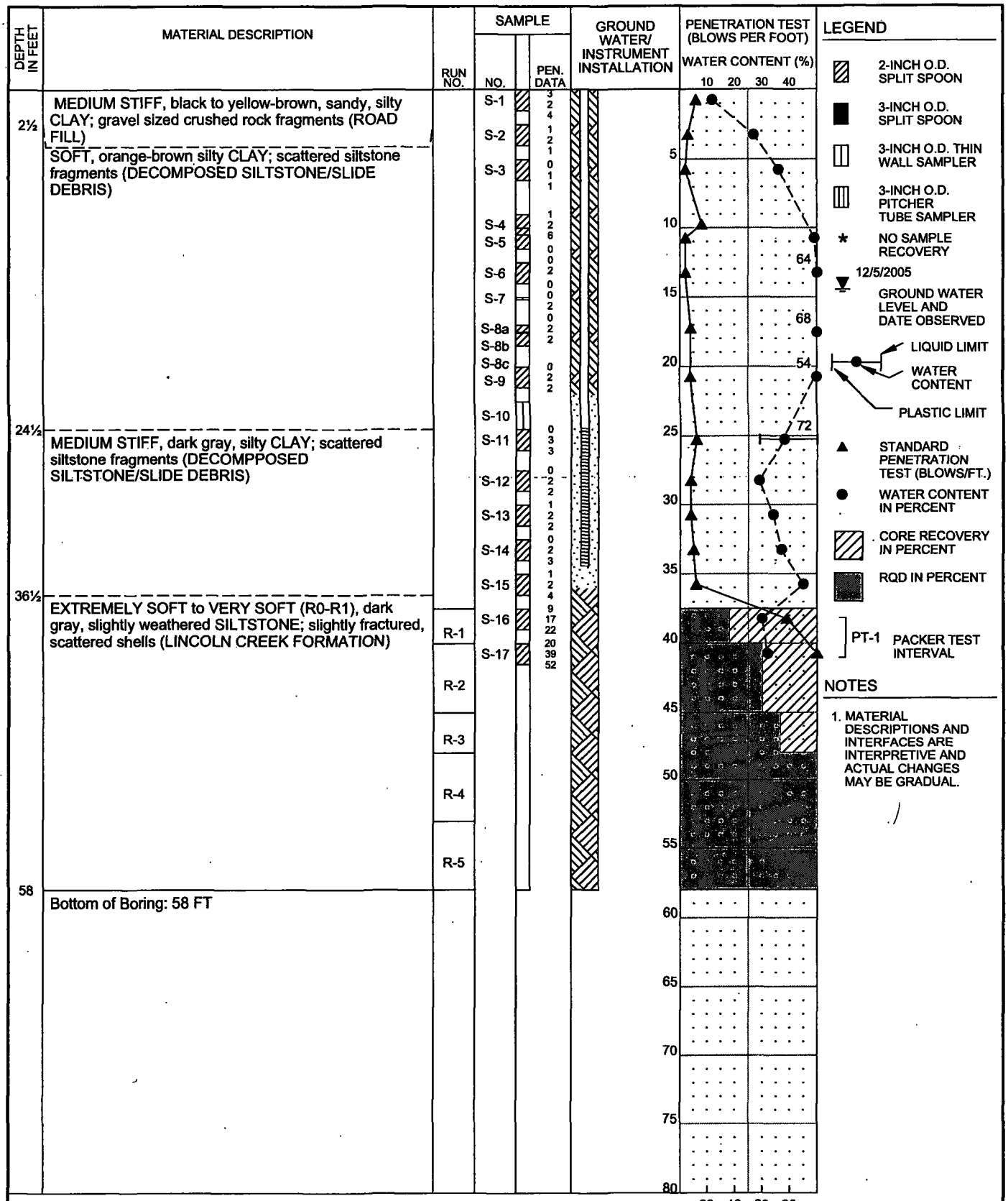
FIG. 4

DEPTH IN FEET	MATERIAL DESCRIPTION
2½	MEDIUM STIFF, black to yellow-brown, sandy, silty CLAY; gravel sized crushed rock fragments (ROAD FILL)
	SOFT, orange-brown silty CLAY; scattered siltstone fragments (DECOMPOSED SILTSTONE/SLIDE DEBRIS)
24½	MEDIUM STIFF, dark gray, silty CLAY; scattered siltstone fragments (DECOMPPOSED SILTSTONE/SLIDE DEBRIS)
36½	EXTREMELY SOFT to VERY SOFT (R0-R1), dark gray, slightly weathered SILTSTONE; slightly fractured, scattered shells (LINCOLN CREEK FORMATION)
58	Bottom of Boring: 58 FT



NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.

HAMMER ASSEMBLY: NOT APPLICABLE SPT SAMPLER: NOT APPLICABLE
DRILL ROD USED: AWJ BOREHOLE DIAM.: 4.5 INCH

DRILLER: WA DOT
DATE START: 4/24/2006 FINISH: 4/25/2006
DRILLING TECHNIQUE: HWT Casing Advancer

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SUMMARY BORING LOG
LT-9

SR 107, MP 4.7 LANDSLIDE
MONTESANO, WASHINGTON

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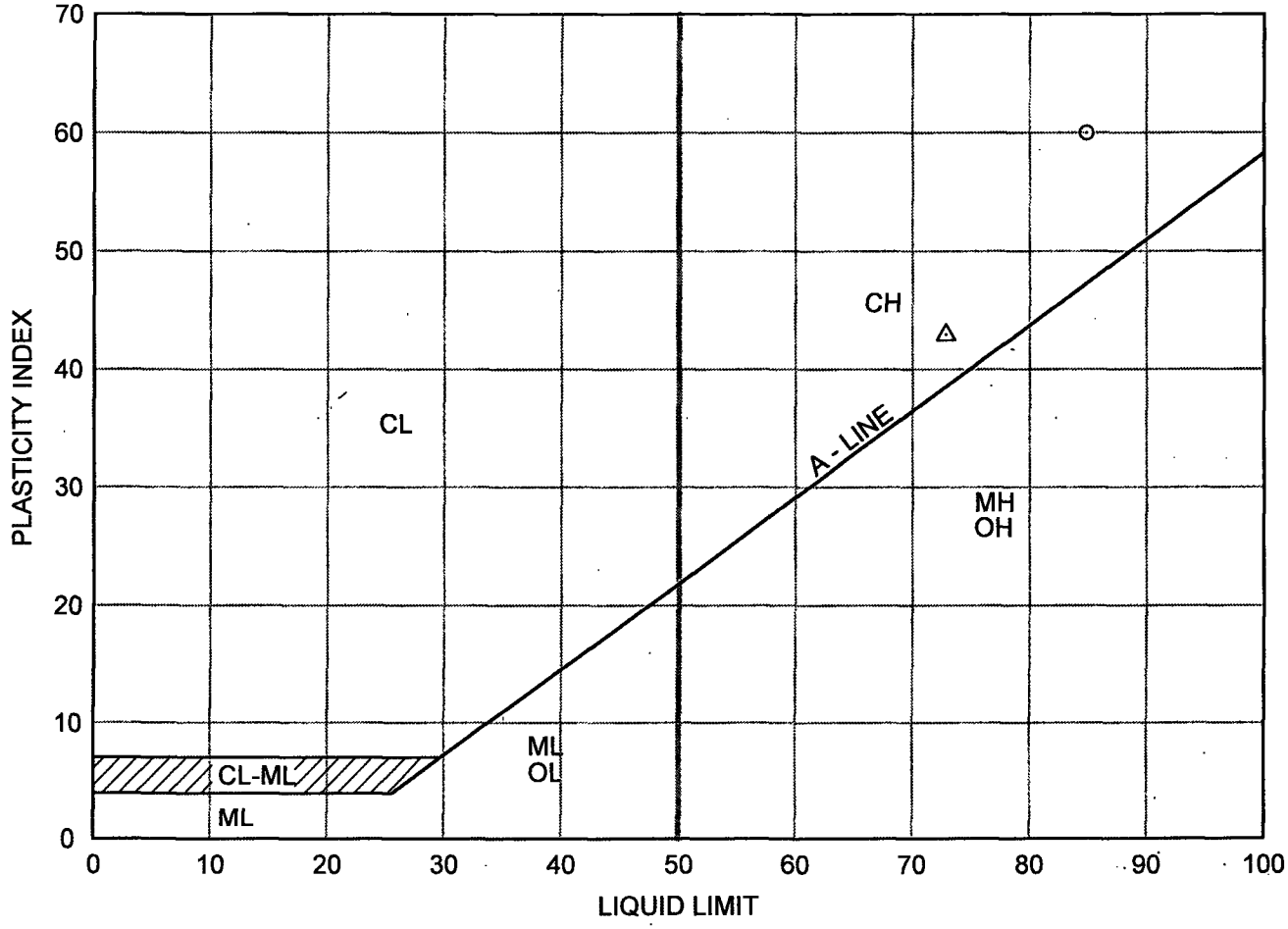
FIG. 5



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⊙ LT-8b, S-2

△ LT-9, S-10

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PLASTICITY CHART

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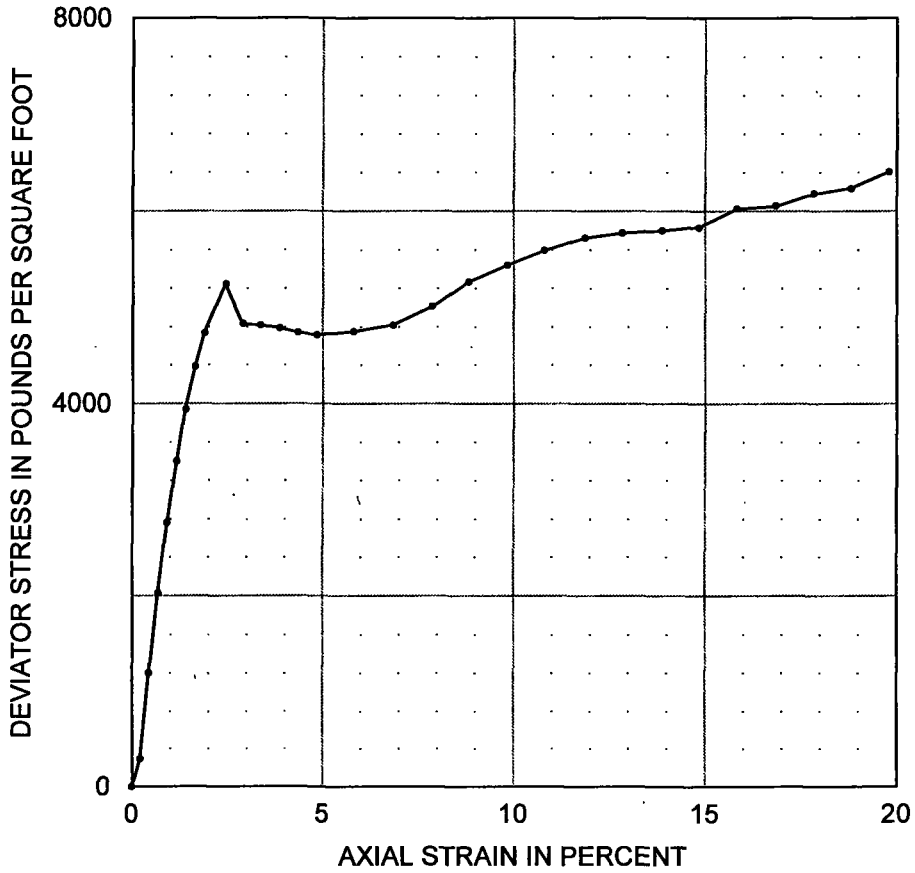
FIG. 6



RESULT:

Peak Stress $\sigma_1 - \sigma_3$

5442 psf

TEST CONDITIONS:

Cell Pressure

2340 psf

Boring No. LT-8b Sample No. S-1 Depth of Sample 19.5 ft.

Soil Description MEDIUM STIFF to STIFF, dark gray, silty CLAY; scattered siltstone fragments

☒ Undisturbed ☐ Compacted

Initial Conditions: Length 6.01 inches Wet Density 120 lb./ft.^{3}

Diameter 2.89 inches Water Content 27 %

Rate of Axial Strain 60 % per hr.

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1744\07 MWT

UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST

SR 107, MP 4.7 LANDSLIDE
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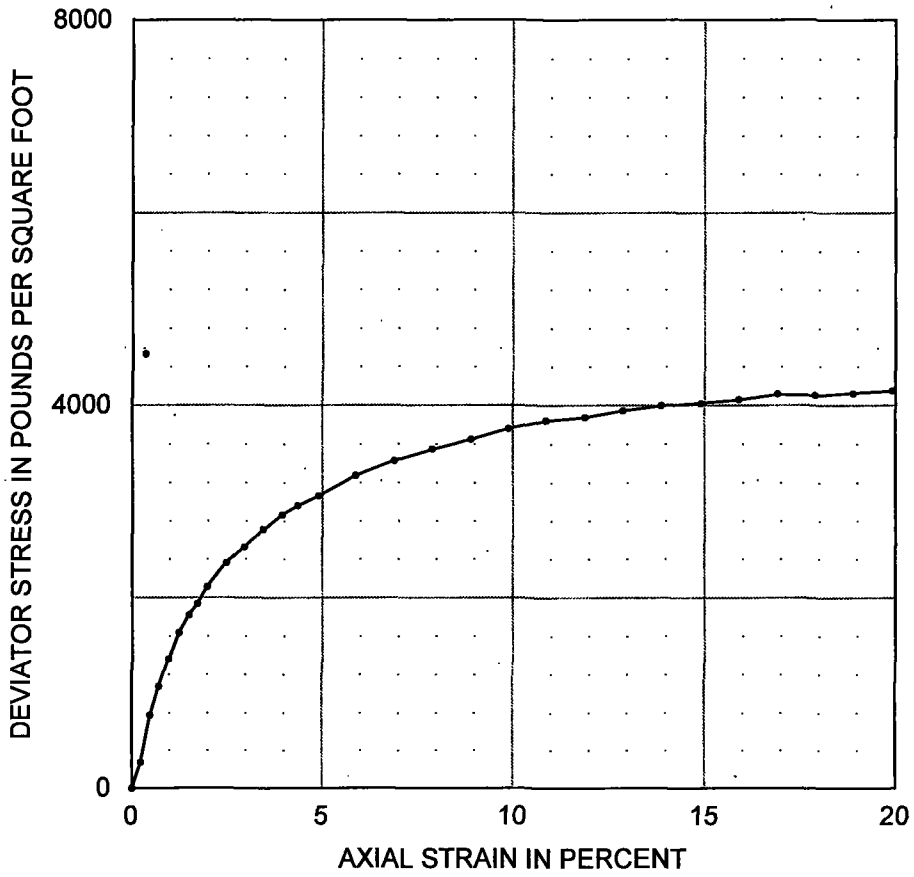
FIG. 7



RESULT:

Peak Stress $\sigma_1 - \sigma_3$

3756 psf

TEST CONDITIONS:

Cell Pressure

2592 psf

Boring No. LT-8b Sample No. S-2 Depth of Sample 21.6 ft.

Soil Description MEDIUM STIFF to STIFF, dark gray, silty CLAY; scattered fine siltstone fragments

☒ Undisturbed ☐ Compacted

Initial Conditions: Length 6.01 inches Wet Density 113 lb./ft.^{3}

Diameter 2.86 inches Water Content 24 %

Rate of Axial Strain 60 % per hr.

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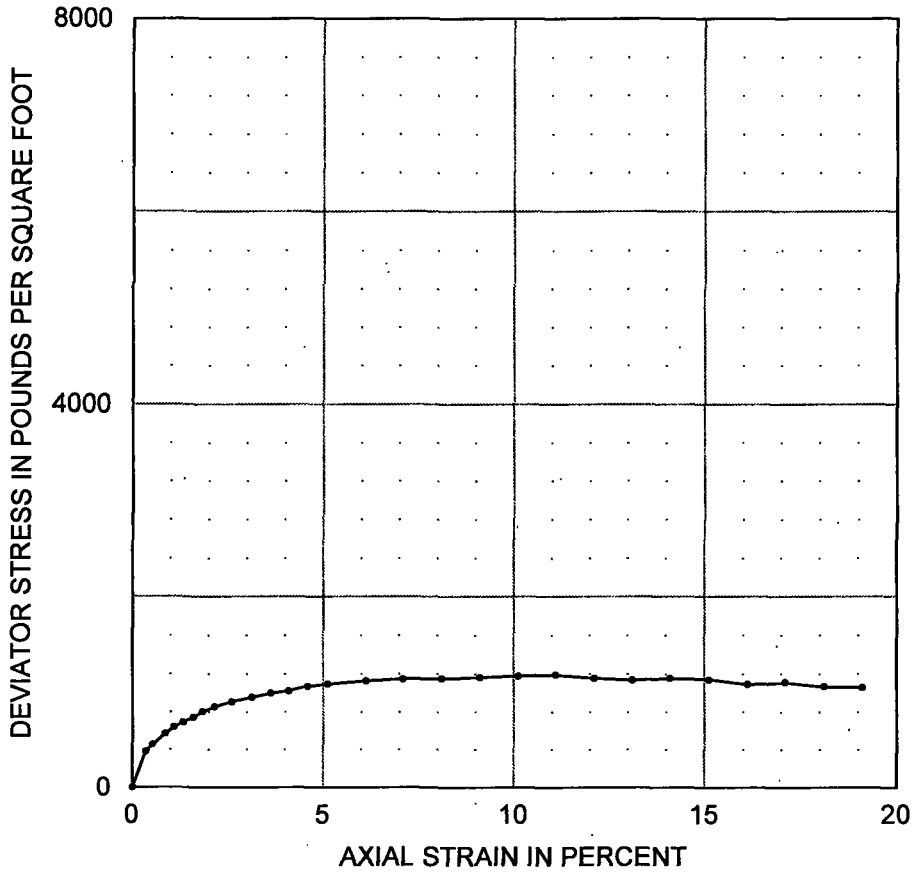
FIG. 8



RESULT:

Peak Stress $\sigma_1 - \sigma_3$

981 psf

TEST CONDITIONS:

Cell Pressure

1930 psf

Boring No. LT-9 Sample No. S-7 Depth of Sample 16.1 ft.

Soil Description SOFT, blue-gray, silty CLAY

☒ Undisturbed ☐ Compacted

Initial Conditions: Length 6.01 inches Wet Density 103 lb./ft.^{3}

Diameter 2.84 inches Water Content 60 %

Rate of Axial Strain 60 % per hr.

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UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST

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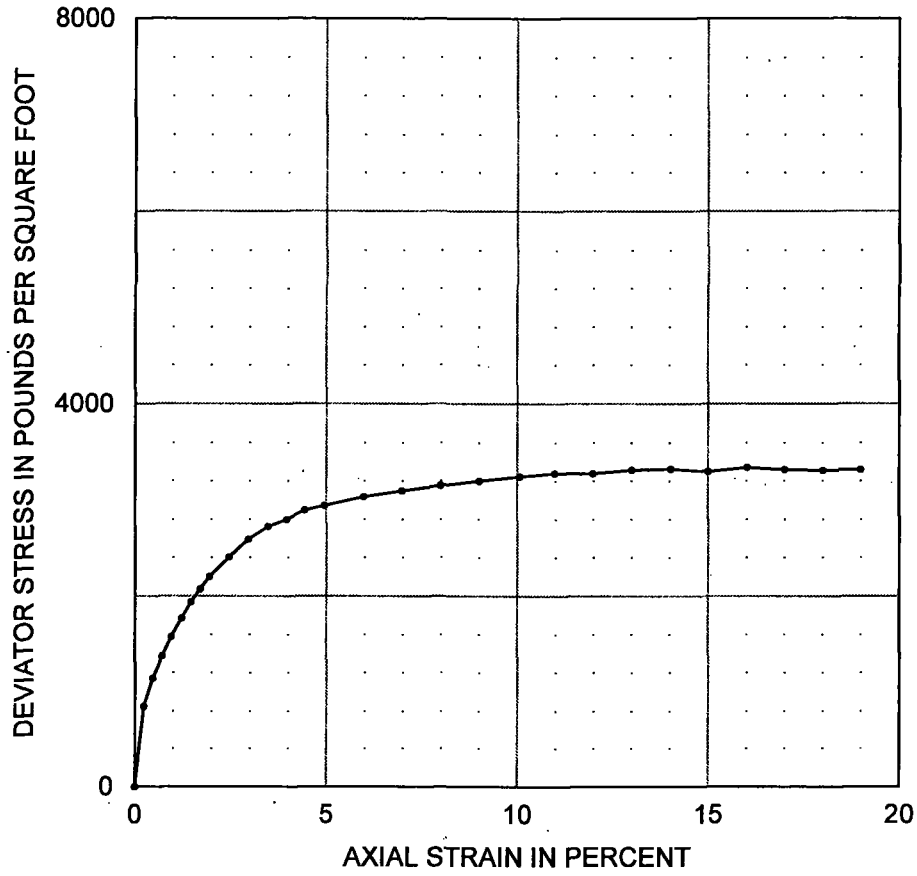
FIG. 9



RESULT:

Peak Stress $\sigma_1 - \sigma_3$

3245 psf

TEST CONDITIONS:

Cell Pressure

2779 psf

Boring No. LT-9 Sample No. S-10 Depth of Sample 23.2 ft.

Soil Description MEDIUM STIFF, orange-brown, silty CLAY

☒ Undisturbed ☐ Compacted

Initial Conditions: Length 6.00 inches Wet Density 110 lb./ft.^{3}

Diameter 2.86 inches Water Content 38 %

Rate of Axial Strain 60 % per hr.

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1744\10 MWT

UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST

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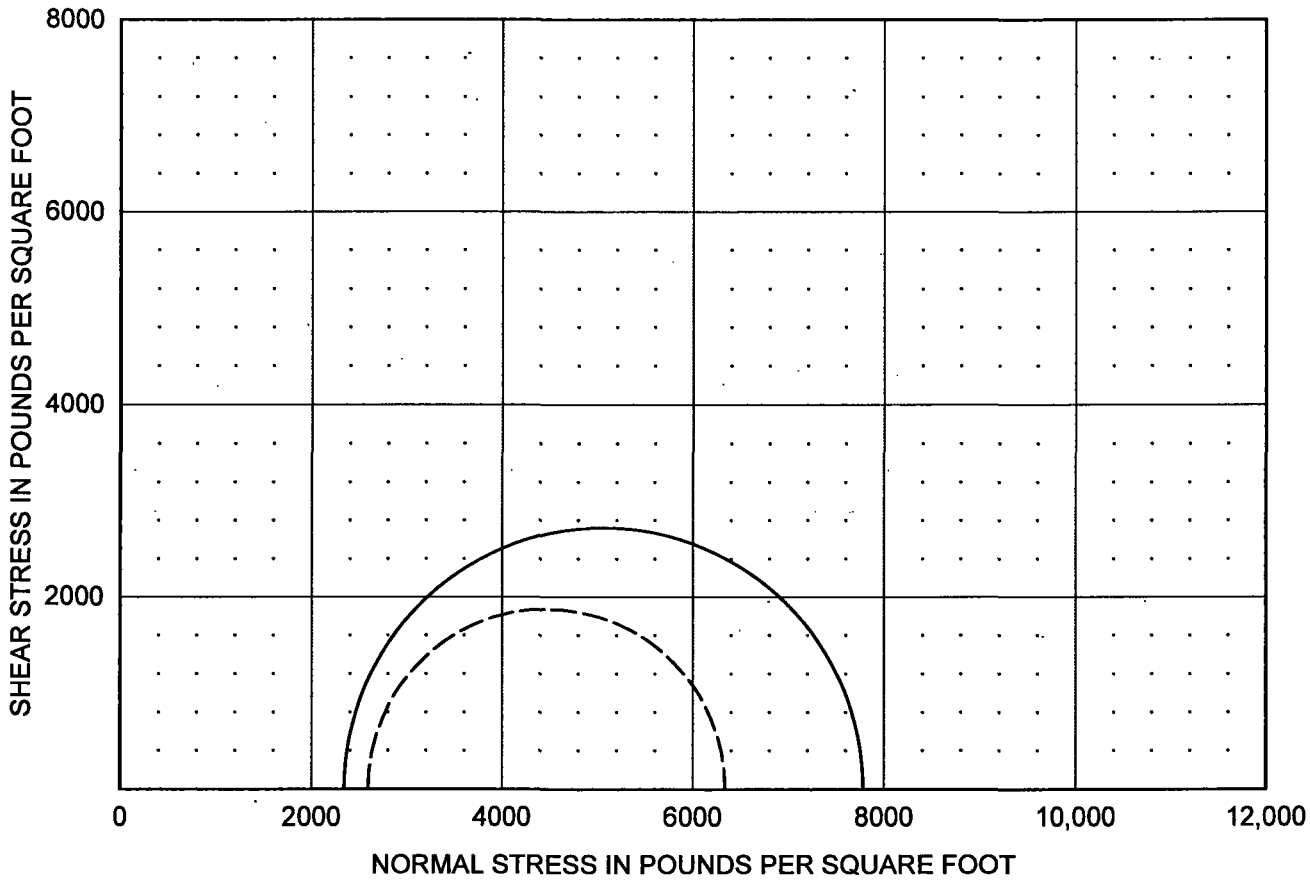
FIG. 10



LEGEND

——— LT-8b, S-1

– – – – LT-8b, S-2

☒ Undisturbed ☐ Compacted

Type of Test: Unconsolidated-Undrained Triaxial

Soil Description:

S-1 MEDIUM STIFF to STIFF, dark-gray, silty CLAY; scattered siltstone fragments

S-2 MEDIUM STIFF to STIFF, dark-gray, silty CLAY; scattered siltstone fragments

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1744\11 LJW

MOHR DIAGRAM-UU TESTS
LT-8b SAMPLES 1 and 2

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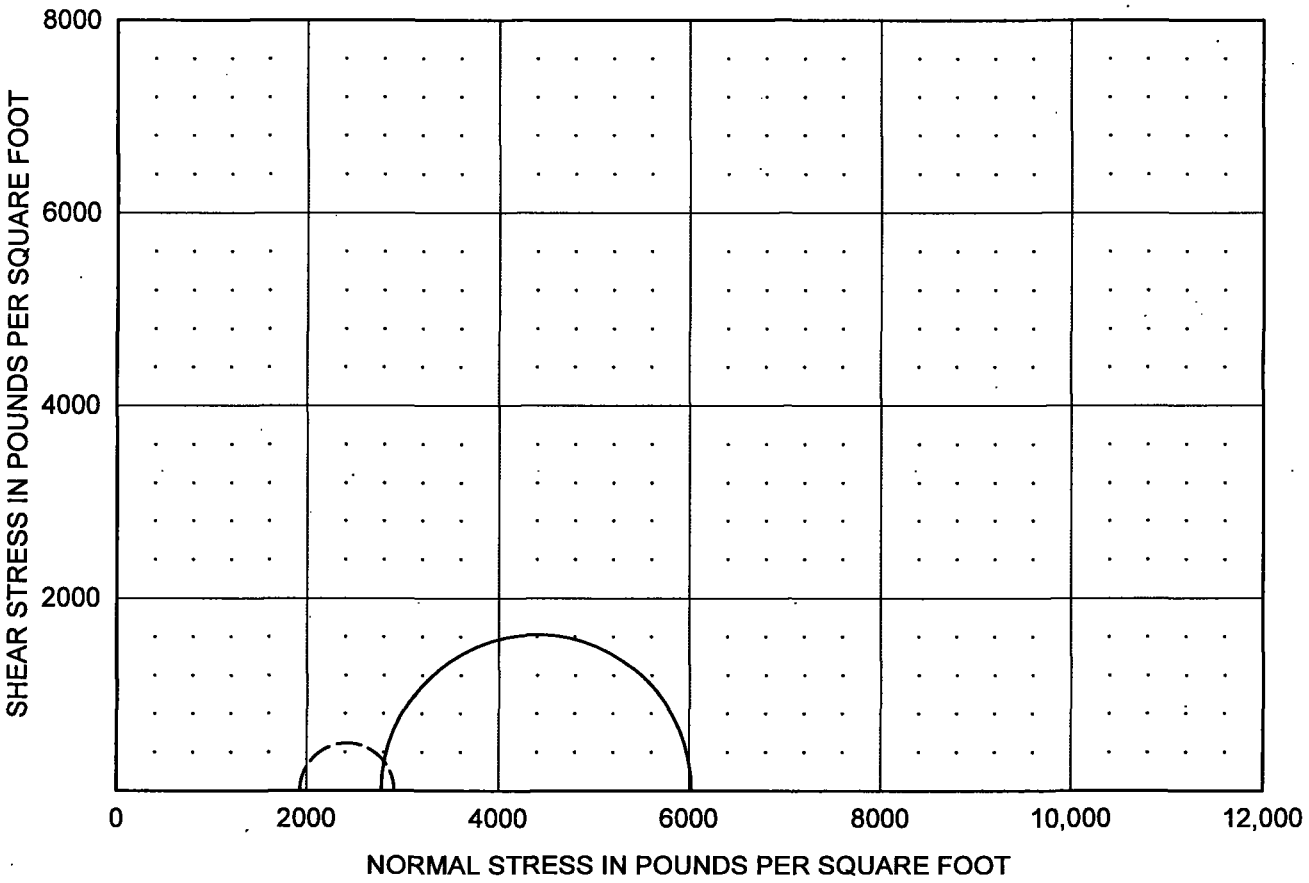
FIG. 11



LEGEND

——— LT-9, S-10

– – – – LT-9, S-7

☒ Undisturbed ☐ Compacted

Type of Test: Unconsolidated-Undrained Triaxial Test

Soil Description: S-10 MEDIUM STIFF, orange-brown, silty clay

S-7 SOFT, blue-gray, silty CLAY

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1744\12 LJW

MOHR DIAGRAM-UU TESTS
LT-9 SAMPLES 7 and 10

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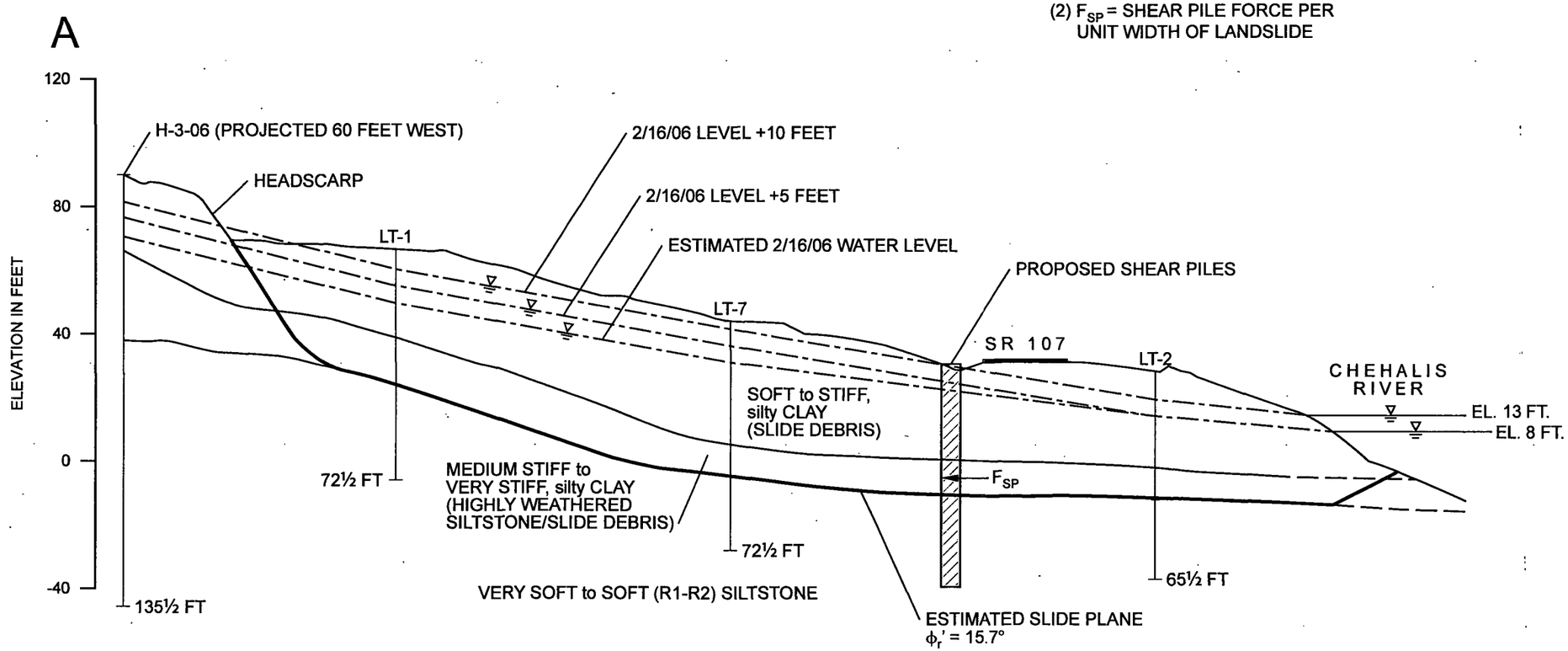
FIG. 12

WATER LEVEL	LANDSLIDE FS WITHOUT SHEAR PILE	LANDSLIDE FS WITH SHEAR PILE	REMARKS
2/16/06 LEVEL	1.11	1.25 WITH F_{SP} (2) = 29 kips/ft	
2/16/06 LEVEL +5 FT.	1.00 (1)	1.25 WITH F_{SP} = 52 kips/ft	DESIGN LOAD
2/16/06 LEVEL +10 FT.	0.90	1.00 WITH F_{SP} = 24 kips/ft	UNFACTORED LOAD
2/16/06 LEVEL +10 FT.	0.90	1.25 WITH F_{SP} = 69 kips/ft	

NOTE: (1) BACK-CALCULATED $\phi_r' = 15.7°$
(2) F_{SP} = SHEAR PILE FORCE PER UNIT WIDTH OF LANDSLIDE



0 40 80
SCALE IN FEE T

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1744\13 MWT

SLOPE STABILITY ANALYSES (CROSS SECTION A-A')

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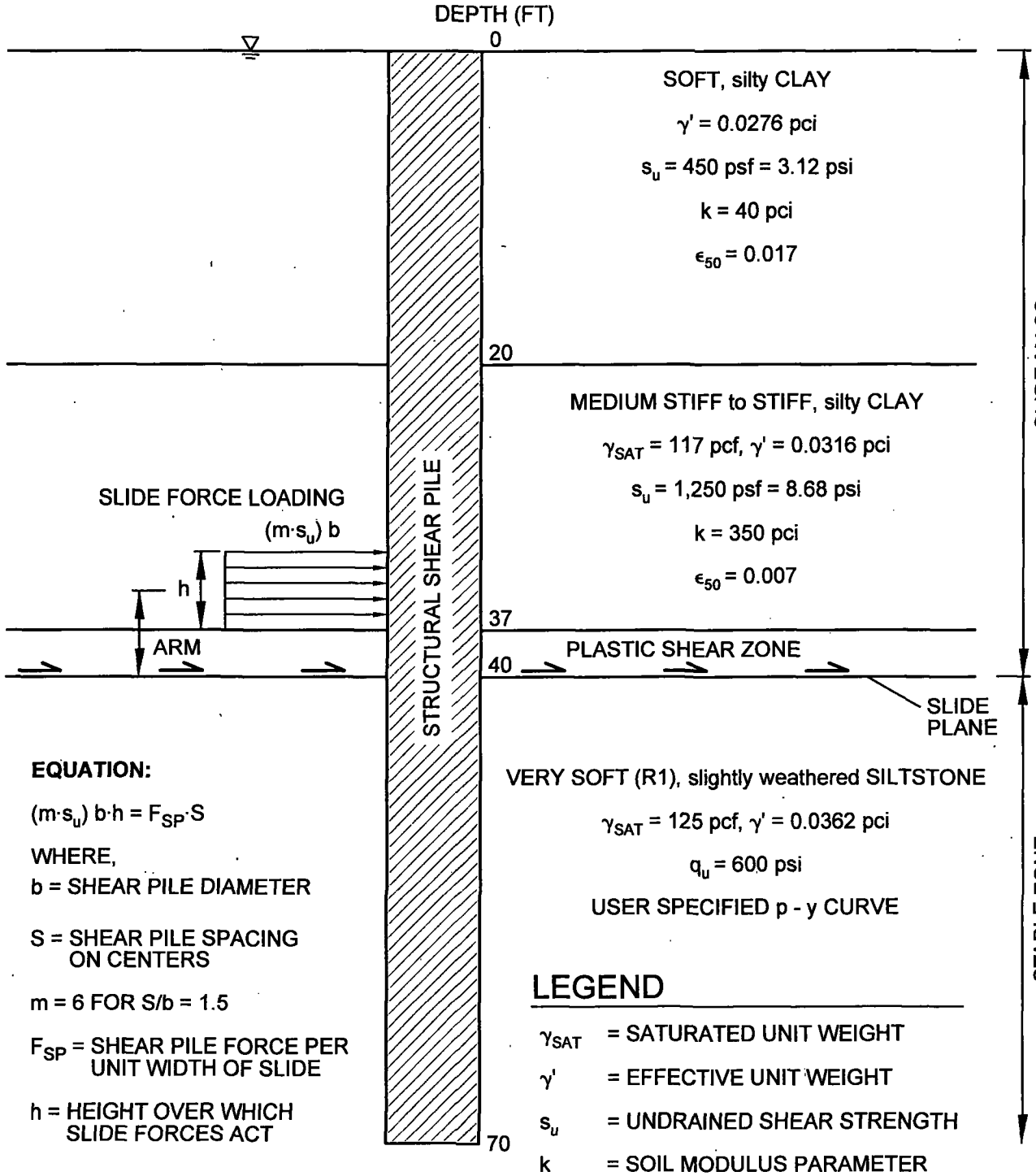
FIG. 13



EQUATION:

$(m \cdot s_u)\, b \cdot h = F_{SP} \cdot S$

WHERE,

b = SHEAR PILE DIAMETER

S = SHEAR PILE SPACING ON CENTERS

m = 6 FOR S/b = 1.5

F_{SP} = SHEAR PILE FORCE PER UNIT WIDTH OF SLIDE

h = HEIGHT OVER WHICH SLIDE FORCES ACT

NOT TO SCALE

LEGEND

γ_{SAT}	= SATURATED UNIT WEIGHT
γ'	= EFFECTIVE UNIT WEIGHT
s_u	= UNDRAINED SHEAR STRENGTH
k	= SOIL MODULUS PARAMETER
ϵ_{50}	= VALUE OF STRAIN AT 50% OF MAX. STRESS
q_u	= UNCONFINED COMPRESSIVE STRENGTH

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1744\14 MWT

SHEAR PILE MODEL (BETWEEN BORINGS LT-2 AND LT-7)

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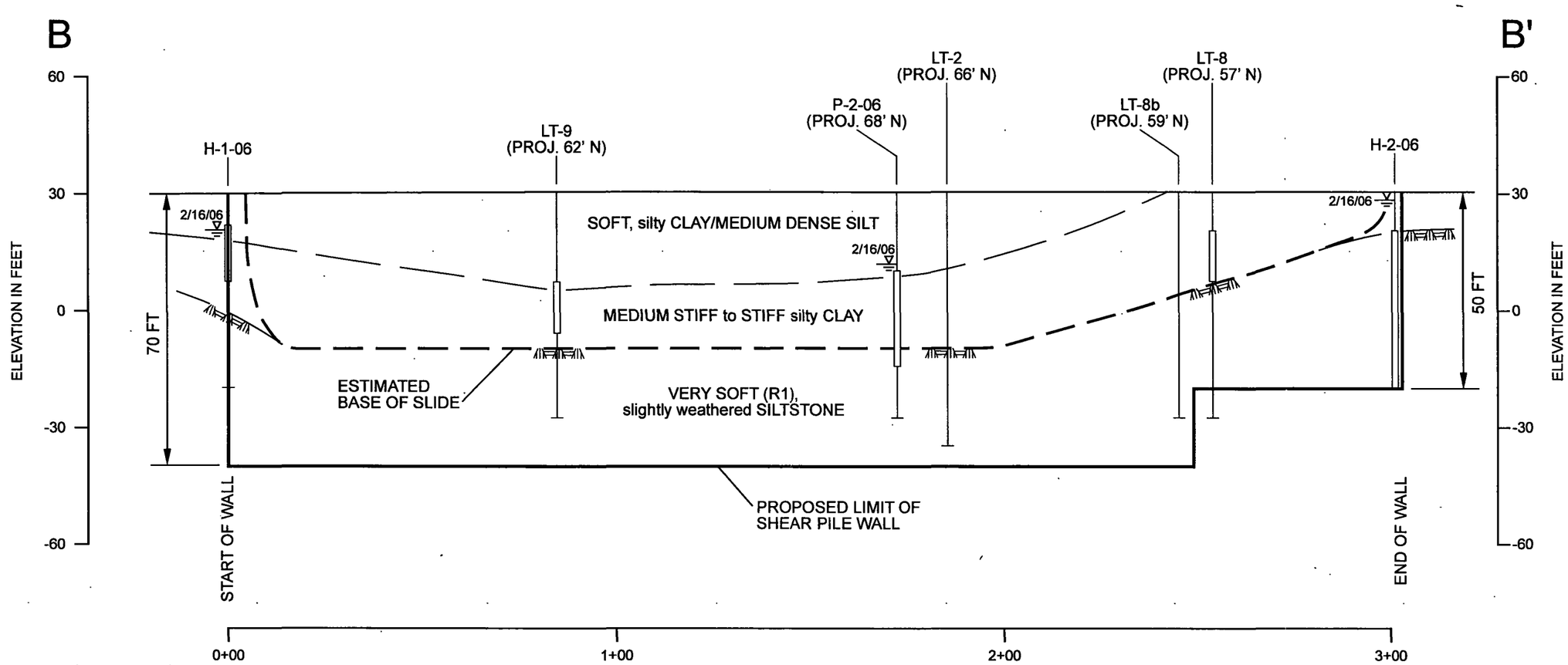
FIG. 14



LEGEND

H-1-06	BORING DESIGNATION
	APPROXIMATE GEOLOGIC CONTACT
2/16/06	OBSERVED GROUNDWATER LEVEL AND DATE
	PIEZOMETER SANDPACK SCREEN
	ESTIMATED BASE OF LANDSLIDE
	TOP OF BEDROCK
	BOTTOM OF BORING

0 30 60
SCALE IN FEET

1744\15 MWT

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SHEAR PILE WALL PROFILE
(PROFILE B-B')

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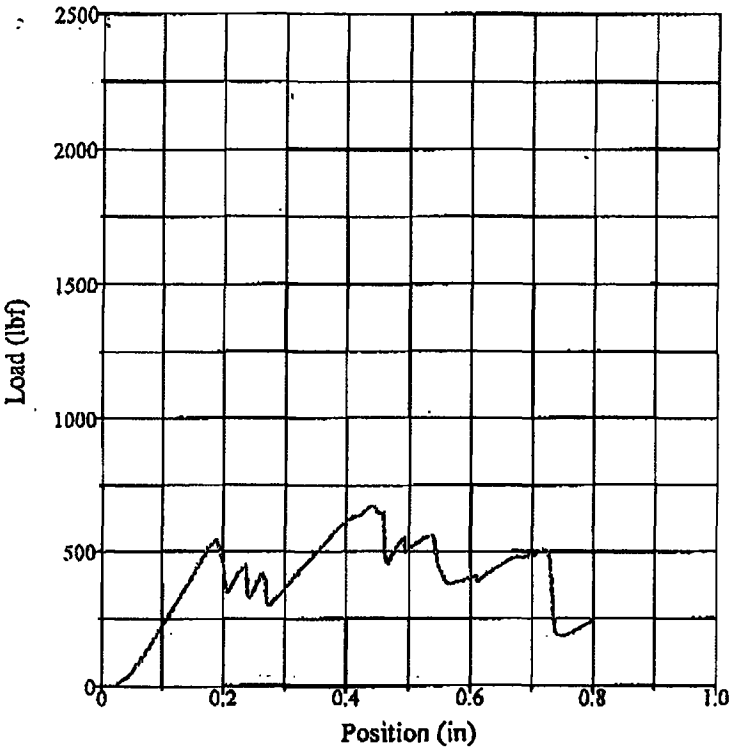
PROJ. 1744
FIG. 15

Appendix A

Rock Core Unconfined Compression Test Results

(Performed by WSDOT State Materials Laboratory, Tumwater, WA)

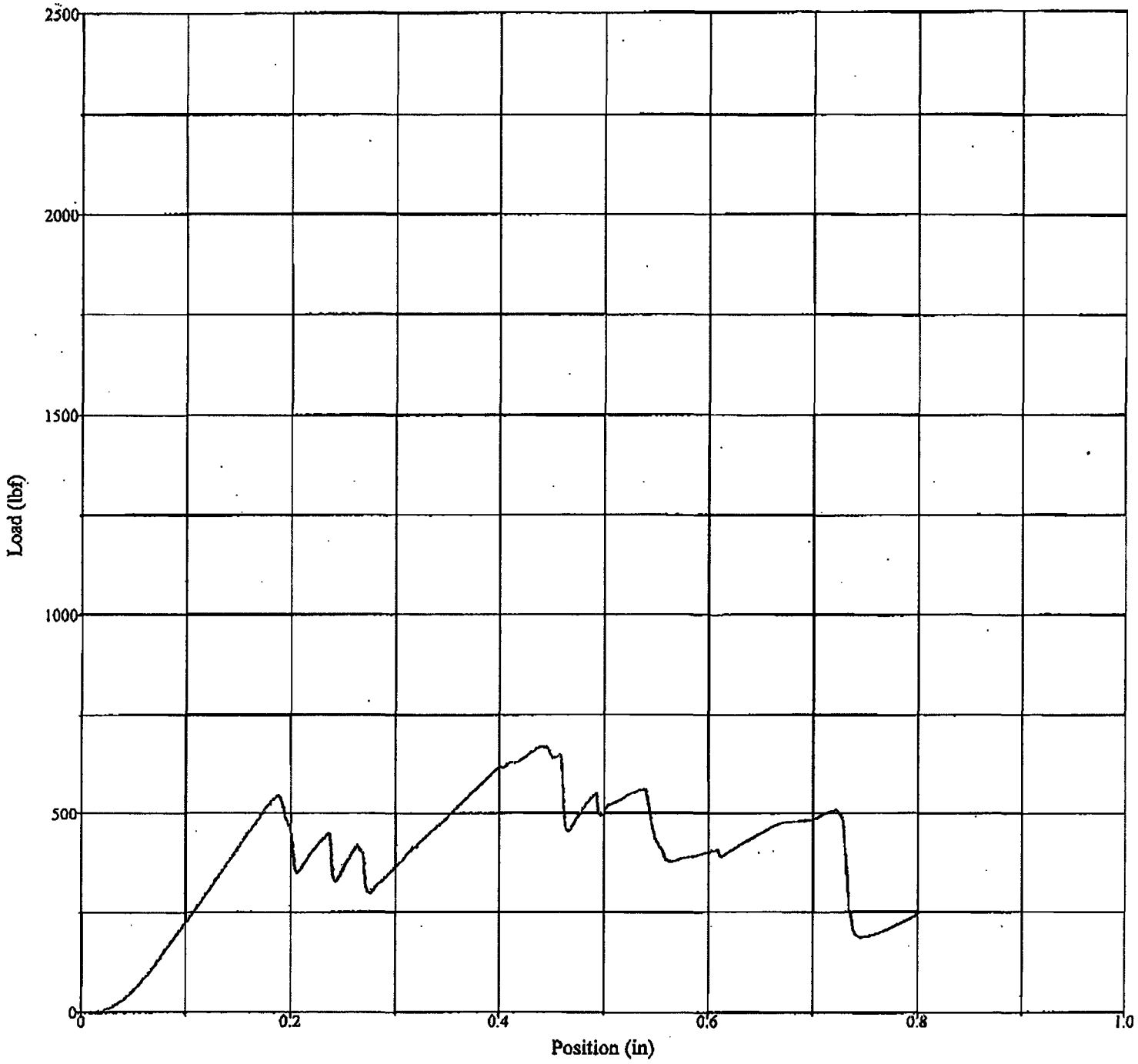


Test Results

Specimen Gage Length:	**5.2880** in
Diameter:	**2.3530** in
Area:	**4.3484** in²
Load at Break:	**240.0000** lbf
Compressive Strength:	**154.3096** psi
Stress at Break:	**55.1927** psi

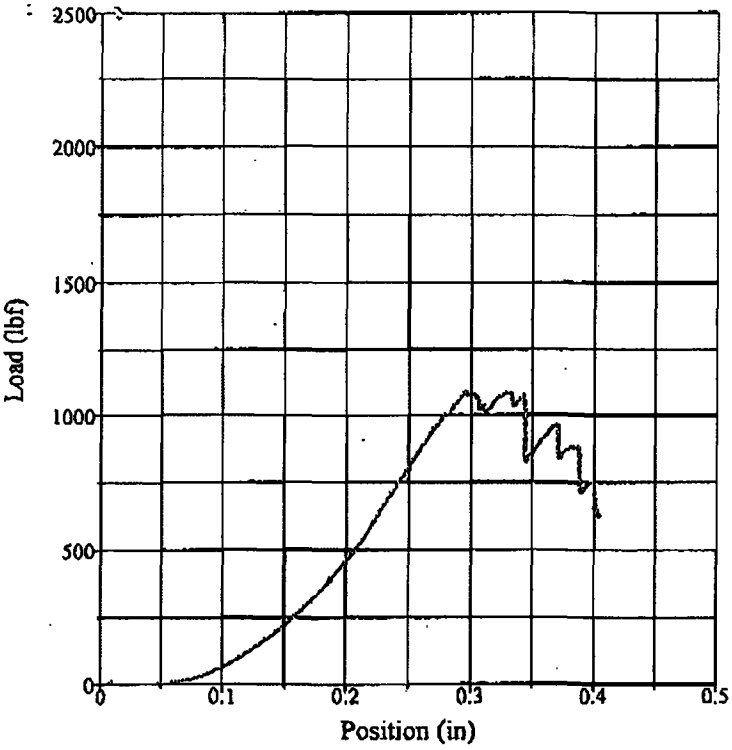
Test Summary

Counter:	**5290**
Elapsed Time:	**00:01:09**
Contract Number:	**XL2425**
Cylinder Number:	**1**
Lab ID Number:	
Procedure Name:	**STRAIN 1**
Start Date:	**5/11/2006**
Start Time:	**1:27:18 PM**
End Date:	**5/11/2006**
End Time:	**1:28:27 PM**
Workstation:	**DOTML30667**
Tested By:	**SATEC**



Test Summary

Elapsed Time:	**00:01:09**
Contract Number:	**XL2425**
Start Date:	**5/11/2006**
Start Time:	**1:27:18 PM**
End Date:	**5/11/2006**
End Time:	**1:28:27 PM**

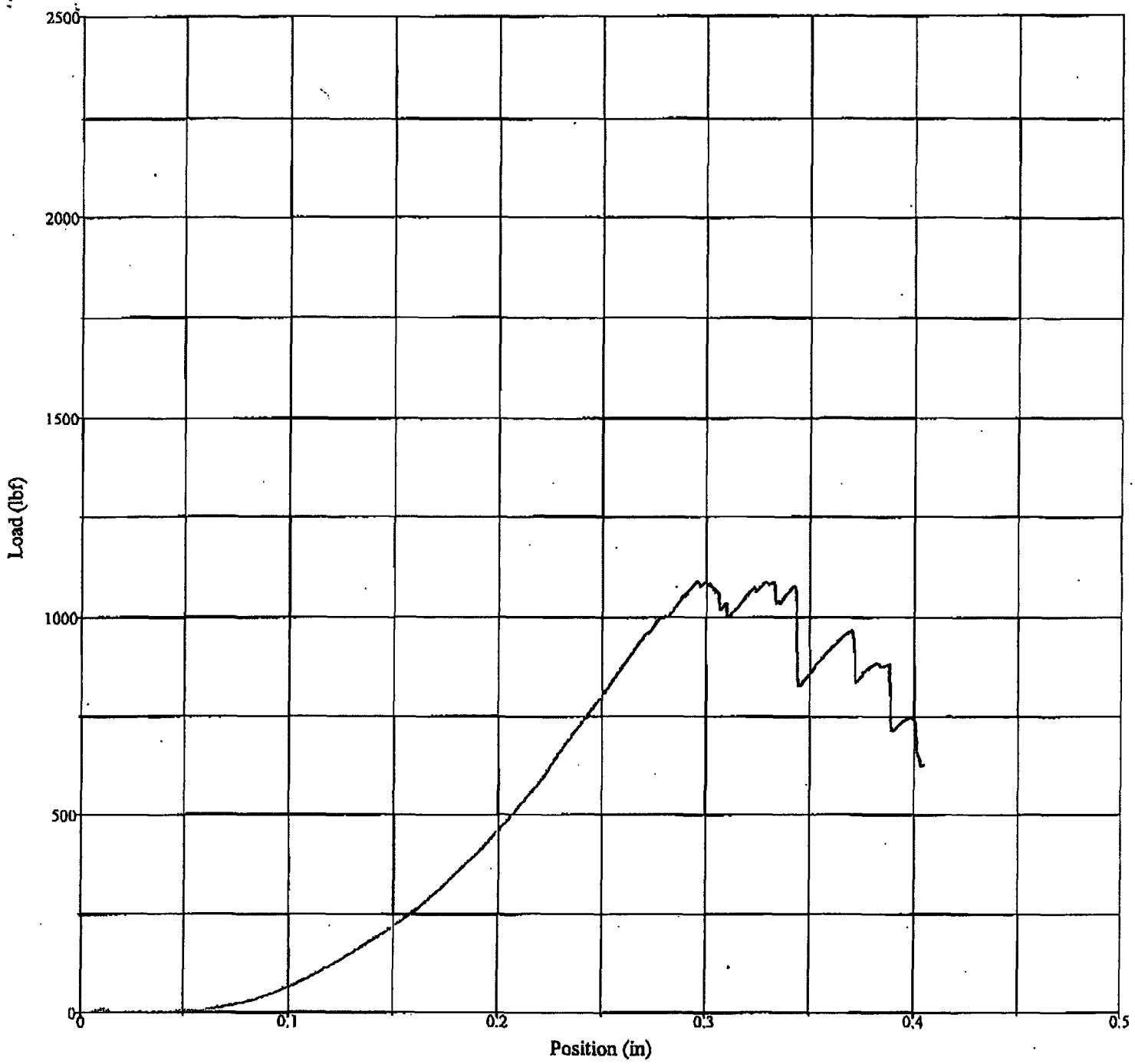


Test Results

Specimen Gage Length:	**5.8040** in
Diameter:	**2.3690** in
Area:	**4.4078** in²
Load at Break:	**628.0000** lbf
Stress at Break:	**142.4747** psi
Compressive Strength:	**247.2889** psi

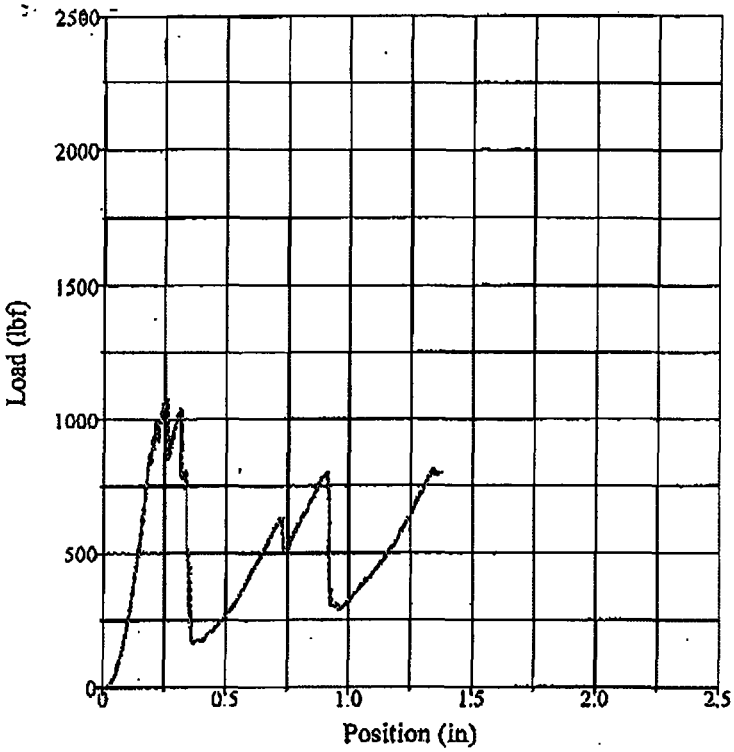
Test Summary

Counter:	**5287**
Elapsed Time:	**00:04:48**
Contract Number:	**XL2425**
Cylinder Number:	**2**
Lab ID Number:	
Procedure Name:	**strain 1**
Start Date:	**5/11/2006**
Start Time:	**11:49:20 AM**
End Date:	**5/11/2006**
End Time:	**11:54:08 AM**
Workstation:	**DOTML30667**
Tested By:	**SATEC**



Test Summary

Elapsed Time:	**00:04:48**
Contract Number:	**XL2425**
Start Date:	**5/11/2006**
Start Time:	**11:49:20 AM**
End Date:	**5/11/2006**
End Time:	**11:54:08 AM**

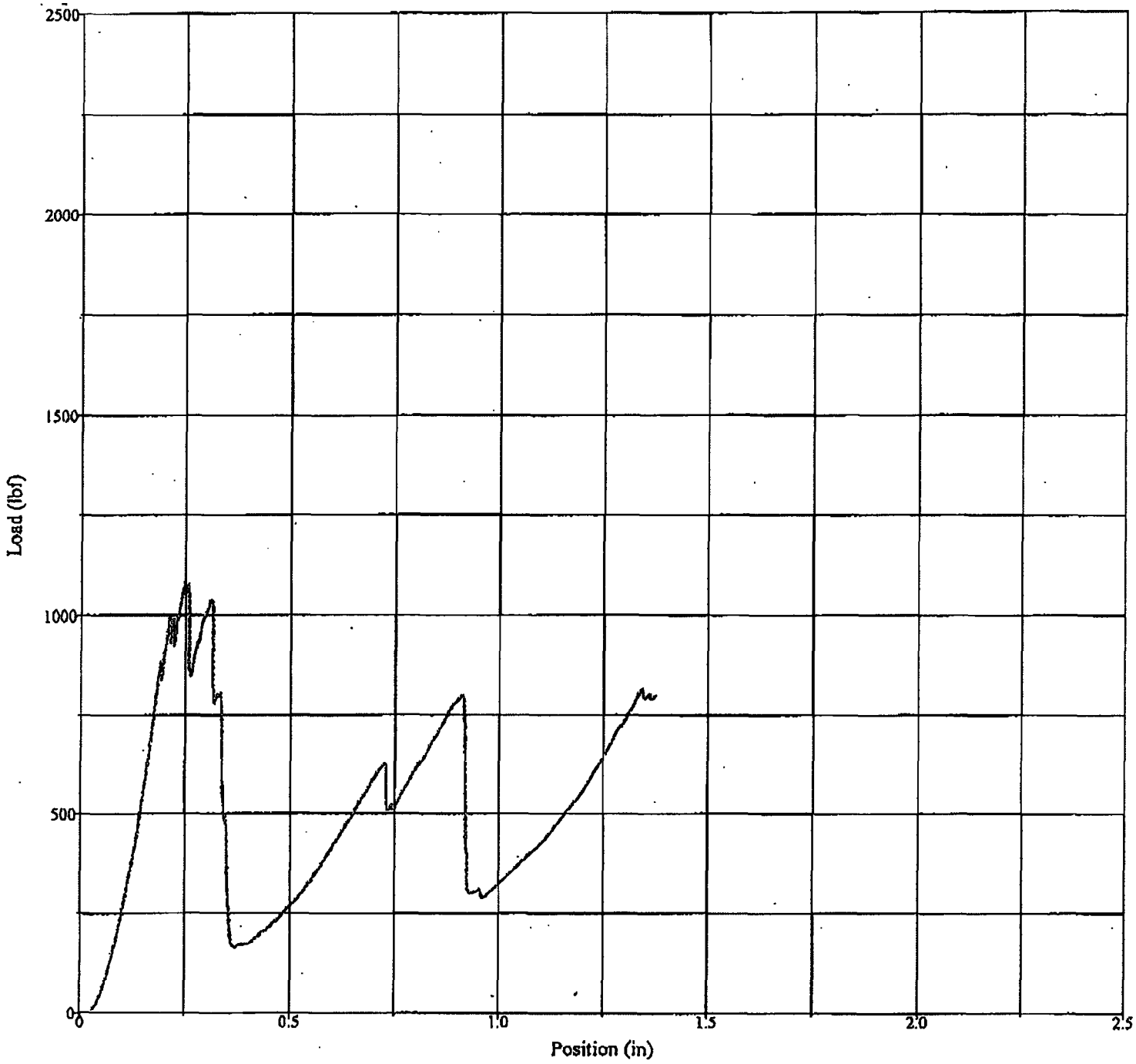


Test Results

Specimen Gage Length:	**5.9510** in
Diameter:	**2.3720** in
Area:	**4.4190** in²
Compressive Strength:	**245.3044** psi
Load at Break:	**799.0000** lbf
Stress at Break:	**180.8101** psi

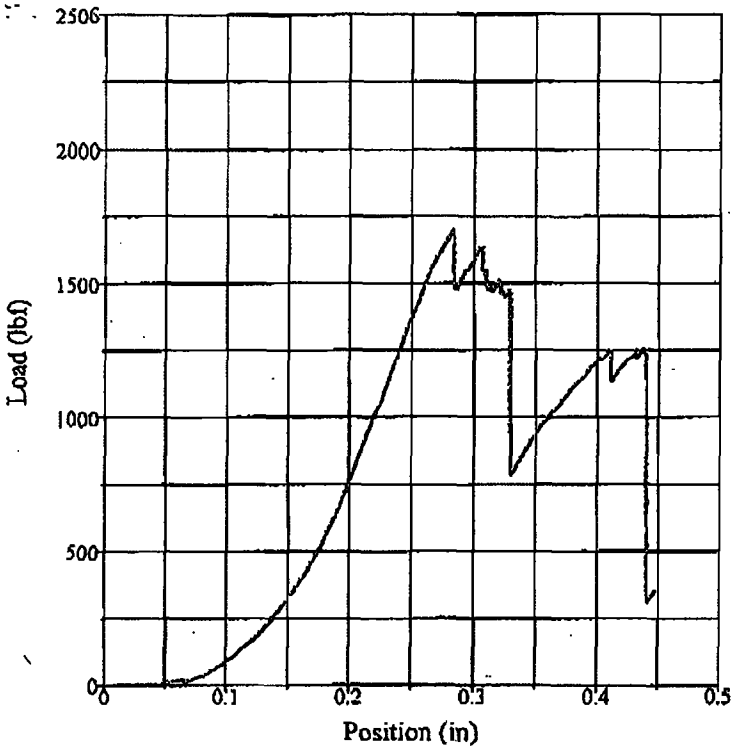
Test Summary

Counter:	**5288**
Elapsed Time:	**00:15:31**
Contract Number:	**XL2425**
Cylinder Number:	**3**
Lab ID Number:	
Procedure Name:	**Proc3**
Start Date:	**5/11/2006**
Start Time:	**12:50:03 PM**
End Date:	**5/11/2006**
End Time:	**1:05:34 PM**
Workstation:	**DOTML30667**
Tested By:	**SATEC**



Test Summary

Elapsed Time:	**00:15:31**
Contract Number:	**XL2425**
Start Date:	**5/11/2006**
Start Time:	**12:50:03 PM**
End Date:	**5/11/2006**
End Time:	**1:05:34 PM**

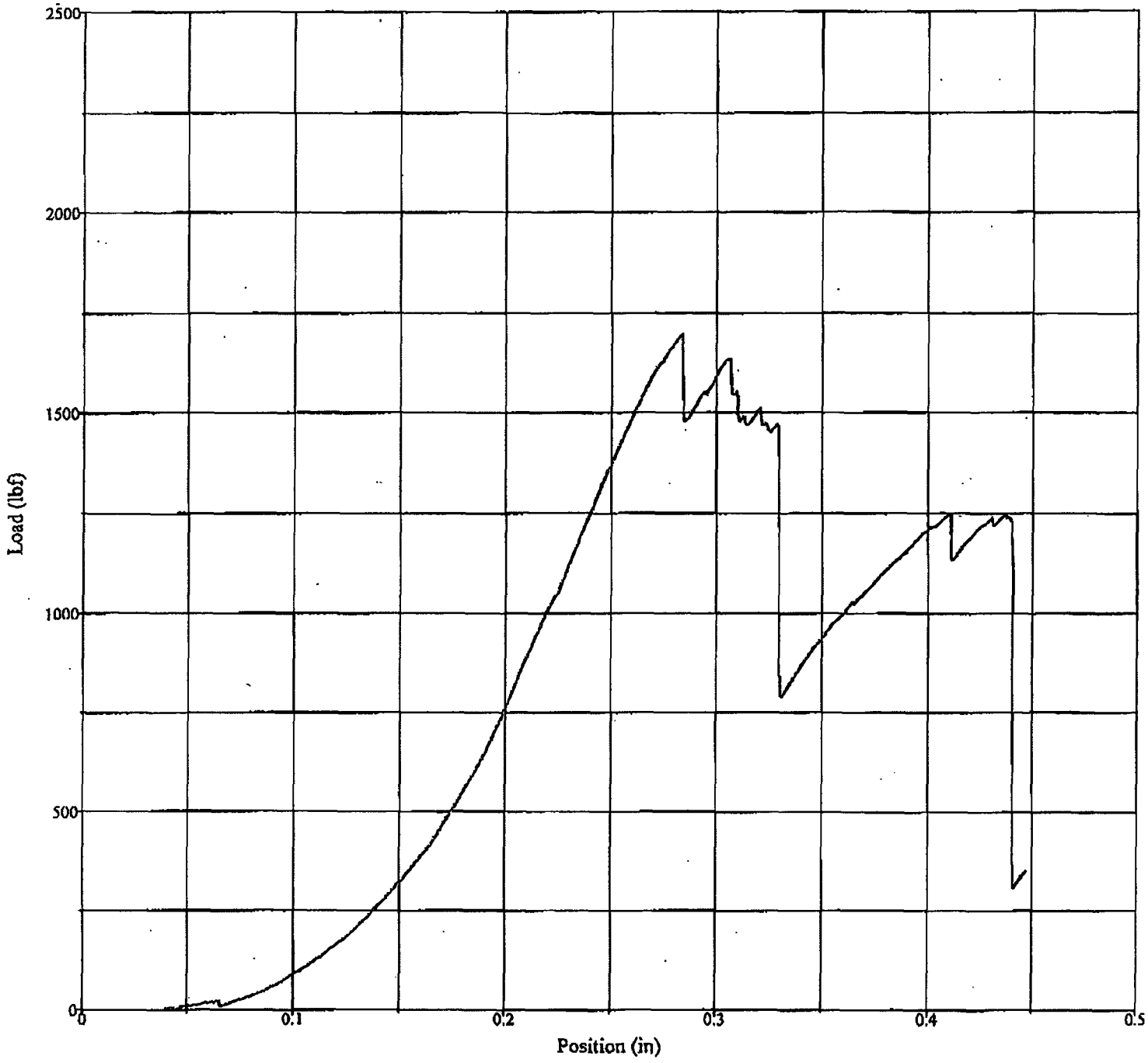


Test Results

Specimen Gage Length:	**5.4920** in
Diameter:	**2.3830** in
Area:	**4.4600** in²
Compressive Strength:	**380.4933** psi
Load at Break:	**351.0000** lbf

Test Summary

Counter:	**5289**
Elapsed Time:	**00:05:56**
Contract Number:	**XL2425**
Cylinder Number:	**4**
Lab ID Number:	
Procedure Name:	**STRAIN 4**
Start Date:	**5/11/2006**
Start Time:	**1:15:12 PM**
End Date:	**5/11/2006**
End Time:	**1:21:08 PM**
Workstation:	**DOTML30667**
Tested By:	**SATEC**



Test Summary

Elapsed Time:	**00:05:56**
Contract Number:	**XL2425**
Start Date:	**5/11/2006**
Start Time:	**1:15:12 PM**
End Date:	**5/11/2006**
End Time:	**1:21:08 PM**

Appendix B

Material Property Determinations
and
Rock p-y Curve

LANDSLIDE TECHNOLOGY

PROJ. NO. 1744

SHEET 1 OF

PROJECT SR 107, MP 4.7 SLIDE

q_u of rock mass

BY KY

CK

DATE 5-20-06

DATE

Use symbols in Wyllie (1999), Foundations on Rock.

$\sigma_{u(r)}$ = uniaxial compressive strength of intact rock

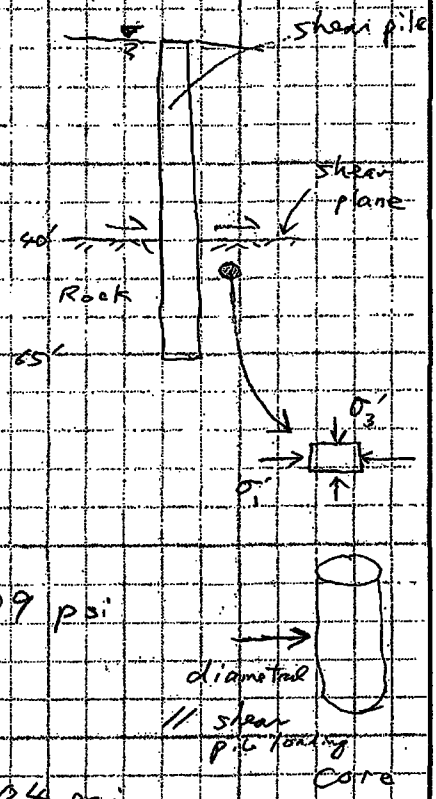
$\sigma_{u(m)}$ = uniaxial compressive strength of rock mass

m, s = Hoek-Brown rock mass strength factors

$$\sigma_1' = \sigma_3' + (m\sigma_{u(r)}\sigma_3' + s\sigma_{u(r)}^2)^{\frac{1}{2}} \qquad \text{Eq. (3.8)}$$

In the shear pile loading condition for the rock below the shear plane,

$\sigma_3' = \sigma_v'$ = vertical effective stress



Interpret $\sigma_{u(r)}$ to be the uniaxial compressive strength estimated from the diametral point load tests.

Table 4.3

Boring LT-8

Mean of diametral test results = 809 psi

Boring LT-9

Ignore LT-9-1 ∵ sandstone

Mean of diametral test results = 704 psi

Take the mean of the above.

$$\sigma_{u(r)} = \frac{809 + 704}{2} = \underline{756 \text{ psi}}$$

Set GWL at the ground surface, which is the level used to estimate the unfactored shear pile force (water level = 10 ft higher than 2/16/06 level)

LANDSLIDE TECHNOLOGY

PROJ. NO. 1744

SHEET 2 OF

PROJECT SR 107, MP 47 SLIDE BY KY DATE 5-20-06

q_u of rock mass CK DATE

Use depth of 50 ft to estimate $\sigma_3' = \sigma_v$

$\sigma_3 = (120\ pcf)(50\ ft) = 6000\ psf$

$u = (62.4\ pcf)(50\ ft) = 3120\ psf$

$\sigma_3' = 6000 - 3120 = 2880\ psf = 20.0\ psi$ ←

m, s constants

Table 3.7 Lithified Argillaceous Rocks

"Intact Rock Samples" $m = 10.00$ $s = 1.00$

"Very Good Quality Rock Mass" $m = 3.43$ $s = 0.082$

"Good Quality Rock Mass" $m = 0.821$ $s = 0.00293$

Estimate $\sigma_{u(m)}' = \sigma_1'$

$$\sigma_{u(m)}' = \sigma_1' = \sigma_3' + \left(m\sigma_{u(r)}\sigma_3' + s\,\sigma_{u(r)}^2\right)^{\frac{1}{2}}$$

If "Very Good Quality Rock Mass"

$$\sigma_{u(m)}' = 20.0 + \left[(3.43)(756)(20.0) + (0.082)(756)^2\right]^{\frac{1}{2}}$$

$$= 20.0 + \left[51{,}861.6 + 46{,}865.952\right]^{\frac{1}{2}}$$

$$= 20.0 + 314.2 = \underline{334\ psi}$$ ◁

If "Intact Rock Samples"

$$\sigma_{u(m)}' = 20.0 + \left[(10.00)(756)(20.0) + (1.00)(756)^2\right]^{\frac{1}{2}}$$

$$= 20.0 + \left[151{,}200 + 571{,}536\right]^{\frac{1}{2}}$$

$$= 20.0 + 850.1 = \underline{870\ psi}$$ ◁

Since the rock is rather "massive", take the mean and estimate $\sigma_{u(m)}'$ to be

$$\sigma_{u(m)}' \approx \frac{334 + 870}{2} = 602\ psi \text{ Say } \underline{600\ psi}$$ ◁

Table 3 Summary of Point Load Tests

Boring No.	Depth (ft)	Test Type*	$Is_{(50)}$	Estimated Unconfined Compressive Strength (psi)
LT-8-1	42	D	0.25	883
LT-8-2	40.4	D	0.26	919
LT-8-3	37.5	D	0.23	819
LT-8-4	34.6	D	0.22	790
LT-8-5	26.3	D	0.20	697
LT-8-6	27.5	D	0.20	702
LT-8-7	27	D	0.22	795
LT-8-8	28.5	D	0.24	866
LT-8-9	28.9	A	0.32	1,125
LT-8-10	26	A	0.29	1,041
			Mean Diametral LT-8	809
			Mean Axial LT-8	1,083
LT-9-1	57.5	D	0.34	1,201 → Ignore ∵ sandstone
LT-9-2	55.2	D	0.22	787
LT-9-3	53	D	0.21	749
LT-9-4	50.2	D	0.20	721
LT-9-5	39.5	D	0.21	744
LT-9-6	41	D	0.20	697
LT-9-7	41.5	D	0.18	628
LT-9-8	42.5	D	0.17	604
LT-9-9	42.8	A	0.27	964
LT-9-10	39.9	A	0.21	733
			Mean Diametral LT-9	766
			Mean Axial LT-9	849

*D = diametral test, along the bedding plane

A = axial test, perpendicular to the bedding plane

LANDSLIDE TECHNOLOGY

PROJ. NO. 1744

SHEET 1 OF

PROJECT SR 107, MP 4.7 Slide — BY KY — DATE 5-20-06

Unit Weights, Soil Shear Strength — CK — DATE

Unit Weights (Rock below shear plane)

LT-8	C-1	$\gamma_m = 117$ pcf	γ_m = moist unit wt.
	C-2	$\gamma_m = 130$ pcf	
LT-9	C-3	$\gamma_m = 121$ pcf	
	C-4	$\gamma_m = 123$ pcf	
	Mean	$\bar{\gamma}_m = 122.8$ pcf	

Estimate $\gamma_{sat} \approx 125$ pcf

Unit Weight (Soil above the shear plane)				Shear Strength
LT-8b	19.5'	UU	$\gamma_m = 120$ pcf	$S_u = 2,730$ psf
	21.6'	UU	$\gamma_m = 113$ pcf	$S_u = 1,880$ psf
LT-9	16.1'	UU	$\gamma_m = 103$ pcf	$S_u = 490$ psf ← ignore
	23.2'	UU	$\gamma_m = 110$ pcf	$S_u = 1,620$ psf

Ignore LT-9, 16.1'. Too high up above the shear plane and is in the soft zone.

Take the mean of the remaining three values.

Mean $\gamma_m = \frac{120 + 113 + 110}{3} = 114.3$ pcf

Estimate $\gamma_{sat} \approx 117$ pcf

Mean S_u: Ignore LT-8b, 19.5', 2,730 psf (influenced by block of stronger siltstone?)

Estimate $S_u = \frac{1,880 + 1,620}{2} = 1,750$ psf

This value is in the upper "STIFF" range. The unit is logged as "MED STIFF" in LT-9 and "MED DENSE" in LT-2, the two closest borings. ∴ Adjust to 1,250 psf

p-y Curves for Siltstone 5-22-06 KY

Based on: Frantzen, J. and Stratton, F.W. (1987). "p-y Curve Data for Laterally Loaded Piles in Shale and Sandstone." *Report No. FHWA-KS-87-2.* Kansas DOT.

y_1 = 0 p_1 = 0

y_2 = 0.007*b p_2 = 0.28*q_u*b

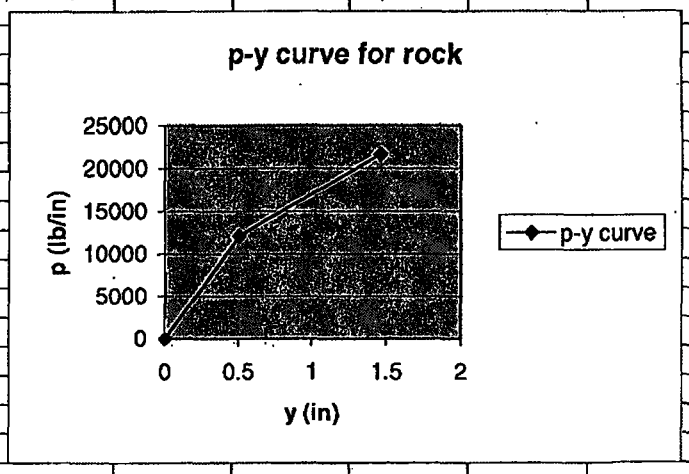
y_3 = 0.0203*b p_3 = 0.5*q_u*b

b = diameter of pile

q_u = unconfined compressive strength of rock

b =	72	in
q_u =	600	psi

Pt	y (in)	p (lb/in)
1	0	0
2	0.504	12096
3	1.4616	21600



Appendix C

LPILE Analysis Results for Shear Pile

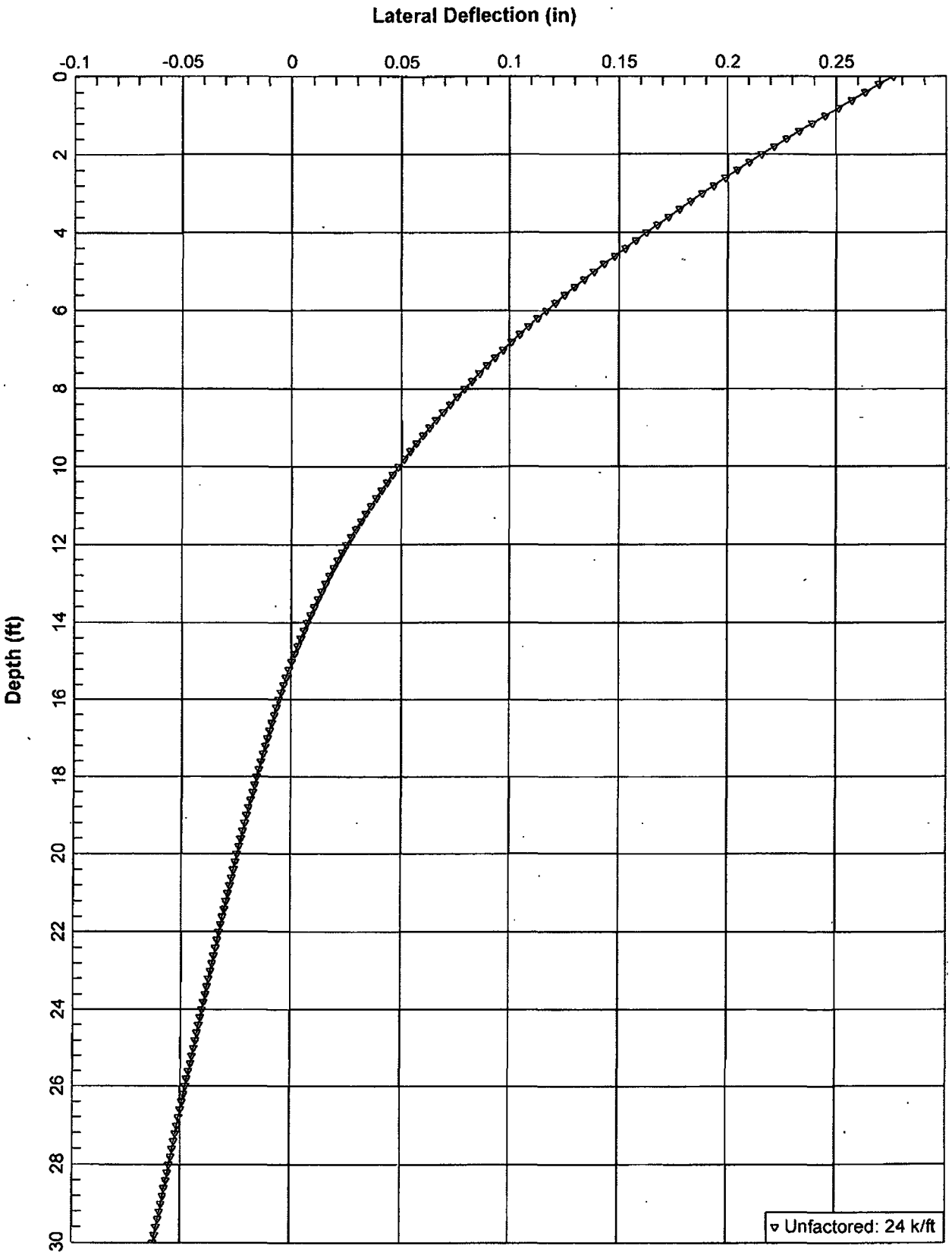
1744 SR 107, MP 4.7 Slide

5-24-06 KY

Spreadsheet to calculate pile head shear and bending moment

Assume 3-ft thick shear zone above shear plane.

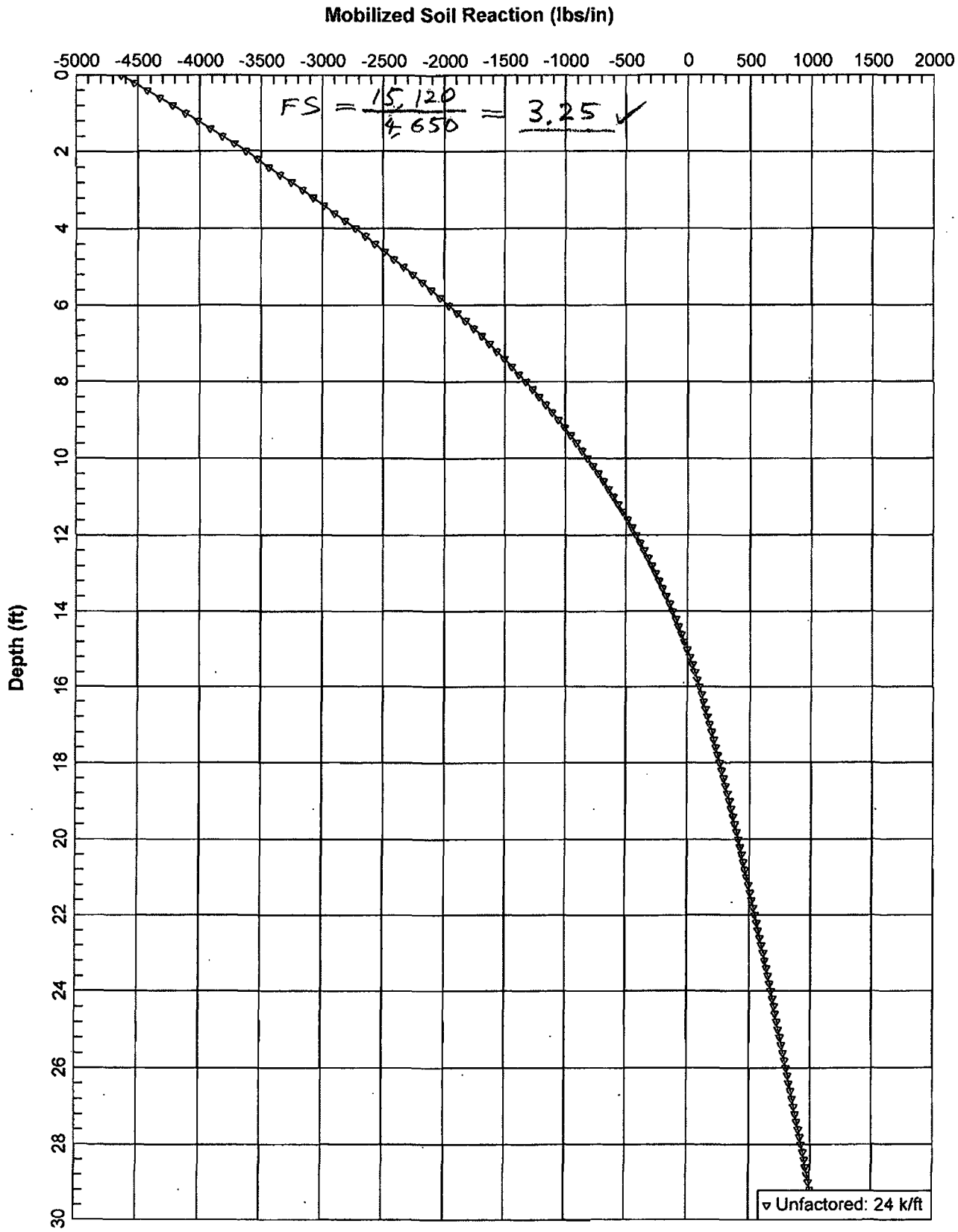
Pile Diameter b (ft)	Pille Spacing Ratio s/b	Pile Spacing s (ft)	P-multiplier p	m=9*p	Loading Soil s_u (psf)	Shear Pile Force Calculated from Slope Stability Analysis F_sp (lb/ft)	Height over which slide force acts h=(F_sp*s)/(m*s_u*b) (ft)	arm for bending moment (ft)	Pile head Shear F_t (lb)	Pile head Bending Moment M_t (lb-in)
6	1.5	9	0.7	6	1,250	24,000	4.80	5.40	216,000	13,997,000
6	1.5	9	0.7	6	1,250	52,000	10.40	8.20	468,000	46,051,000
		0		0	1,250	38,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	25,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	25,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	24,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	24,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	69,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	52,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	12,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	26,500	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	35,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0.0	1,250	24,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0.0	1,250	52,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0.0	1,250	69,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	52,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	24,000	#DIV/0!	#DIV/0!	0	#DIV/0!
		0		0	1,250	52,000	#DIV/0!	#DIV/0!	0	#DIV/0!



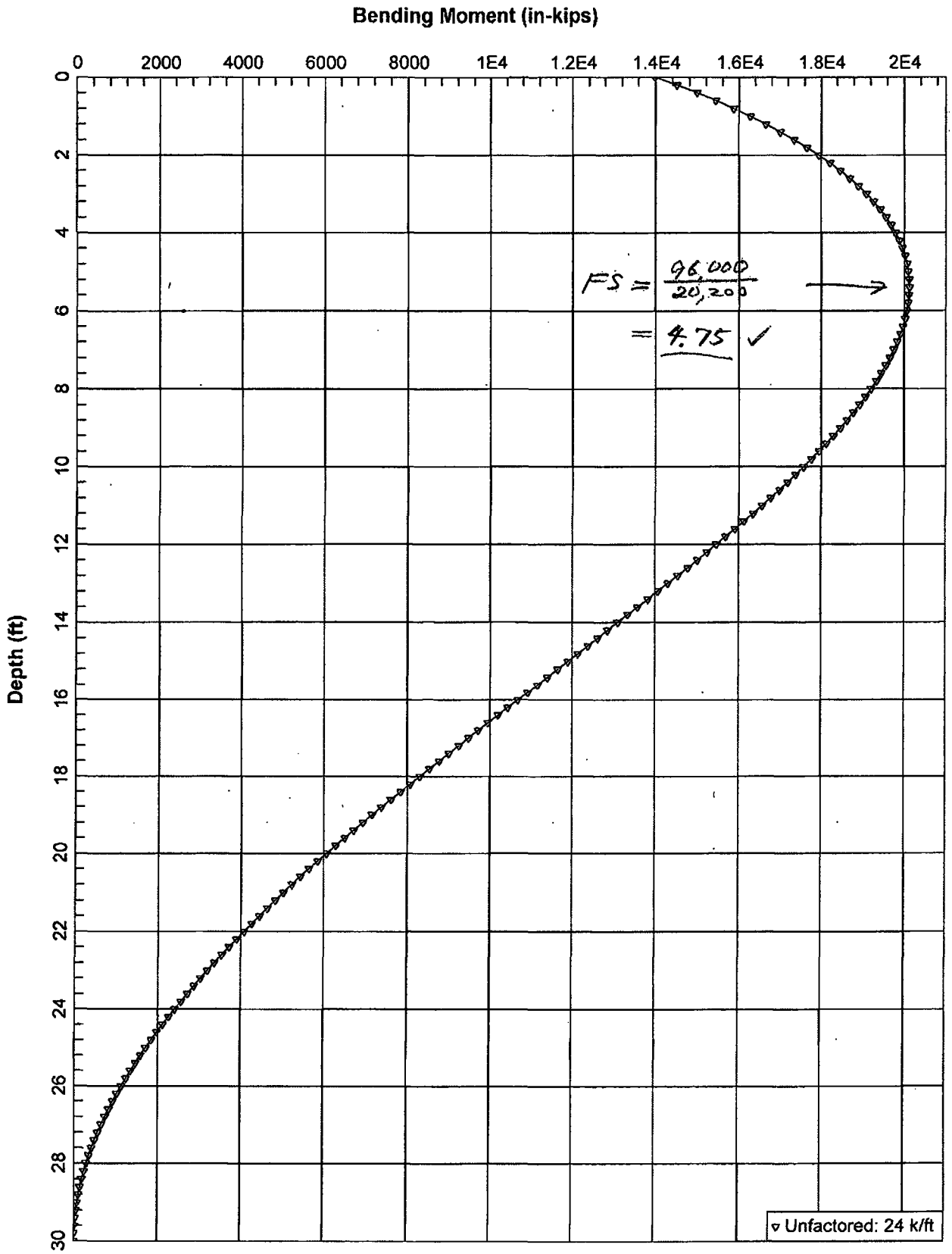
b=6', s=9', a=1.5% KS DOT p-y curve

$P_{max} = (21{,}600)(0.7) = 15{,}120$ lb/in

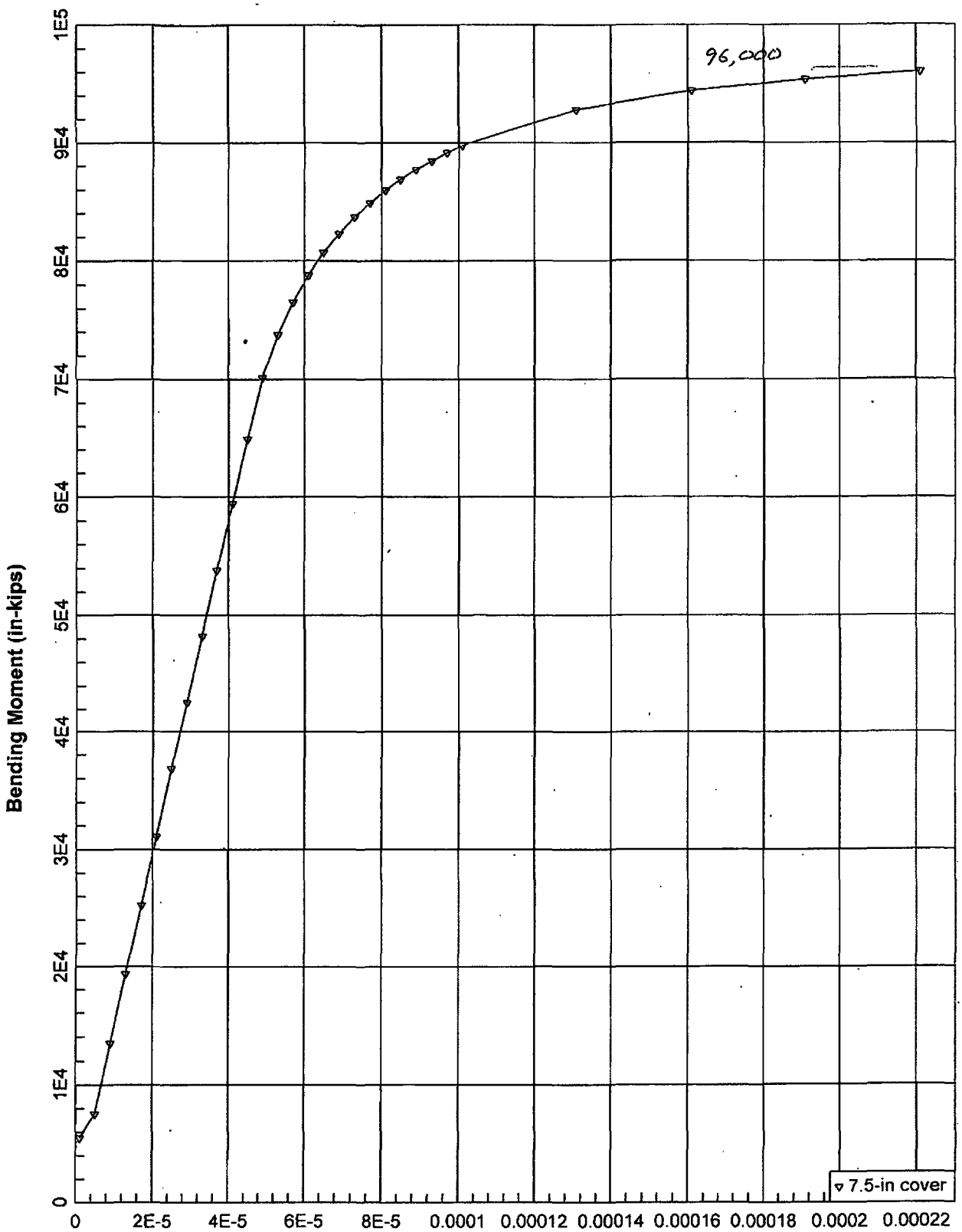
p-mult.



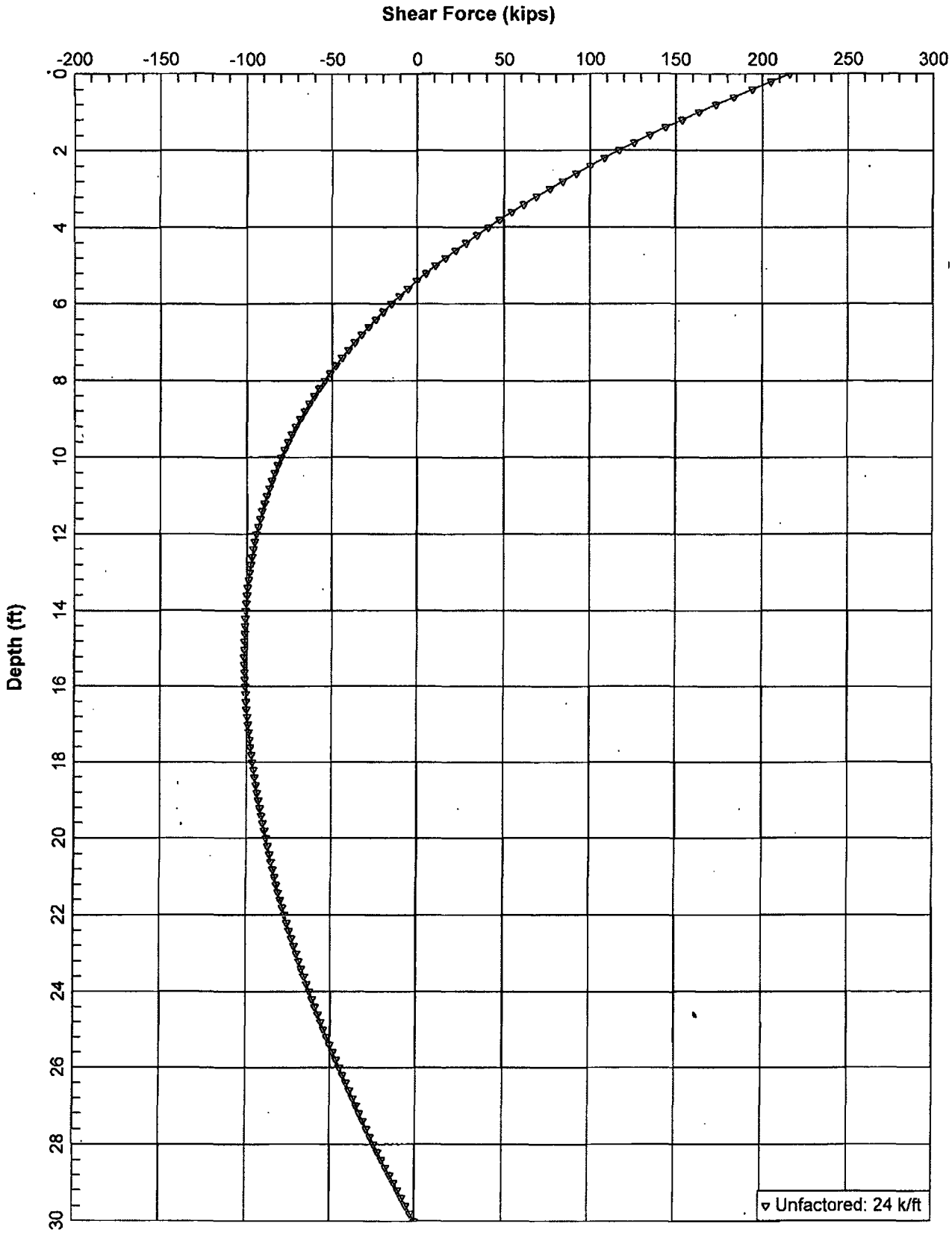
b=6', s=9', a=1.5% KS DOT p-y curve



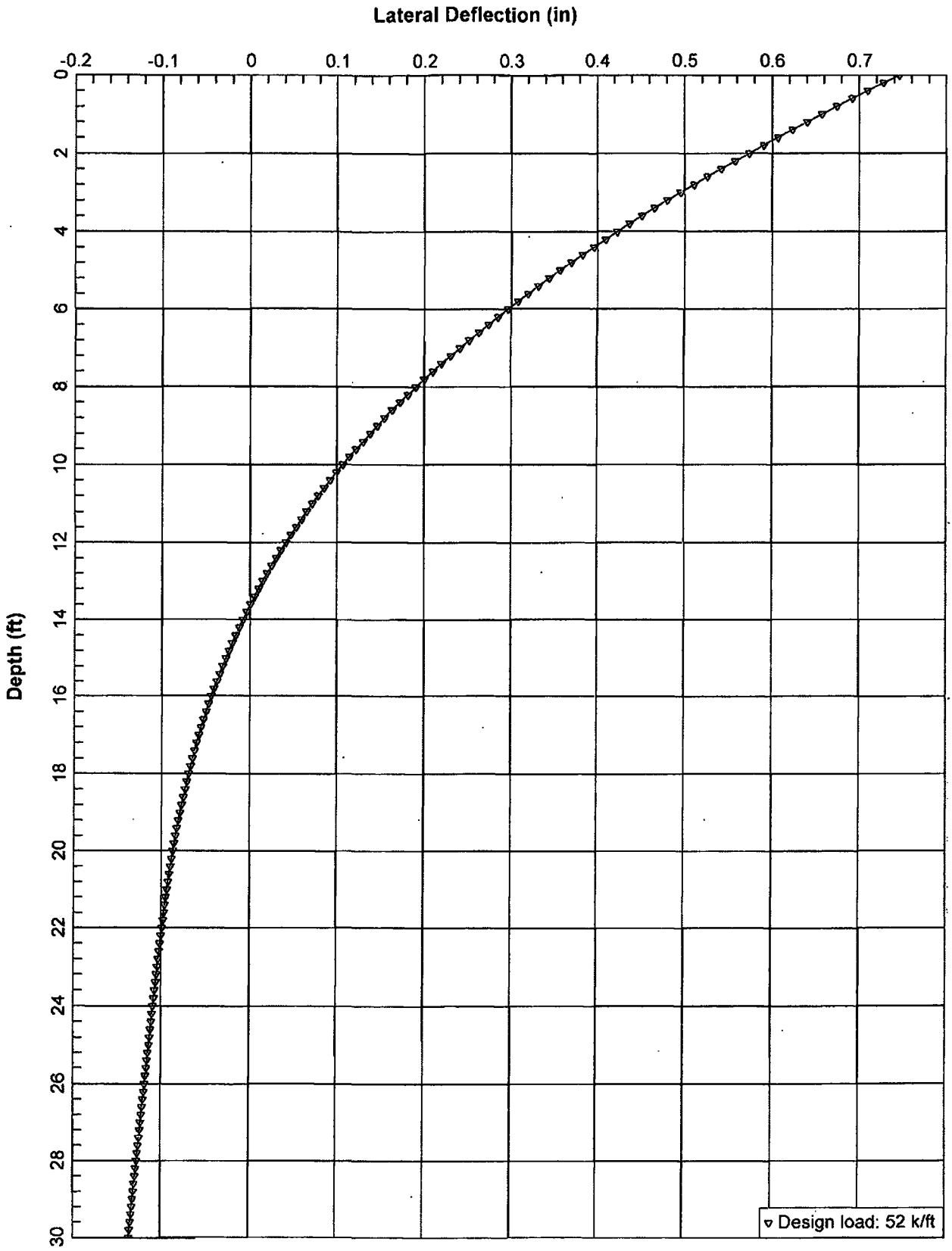
b=6', s=9', a=1.5% KS DOT p-y curve



b=6', s=9', a=1.5% KS DOT p-y curve



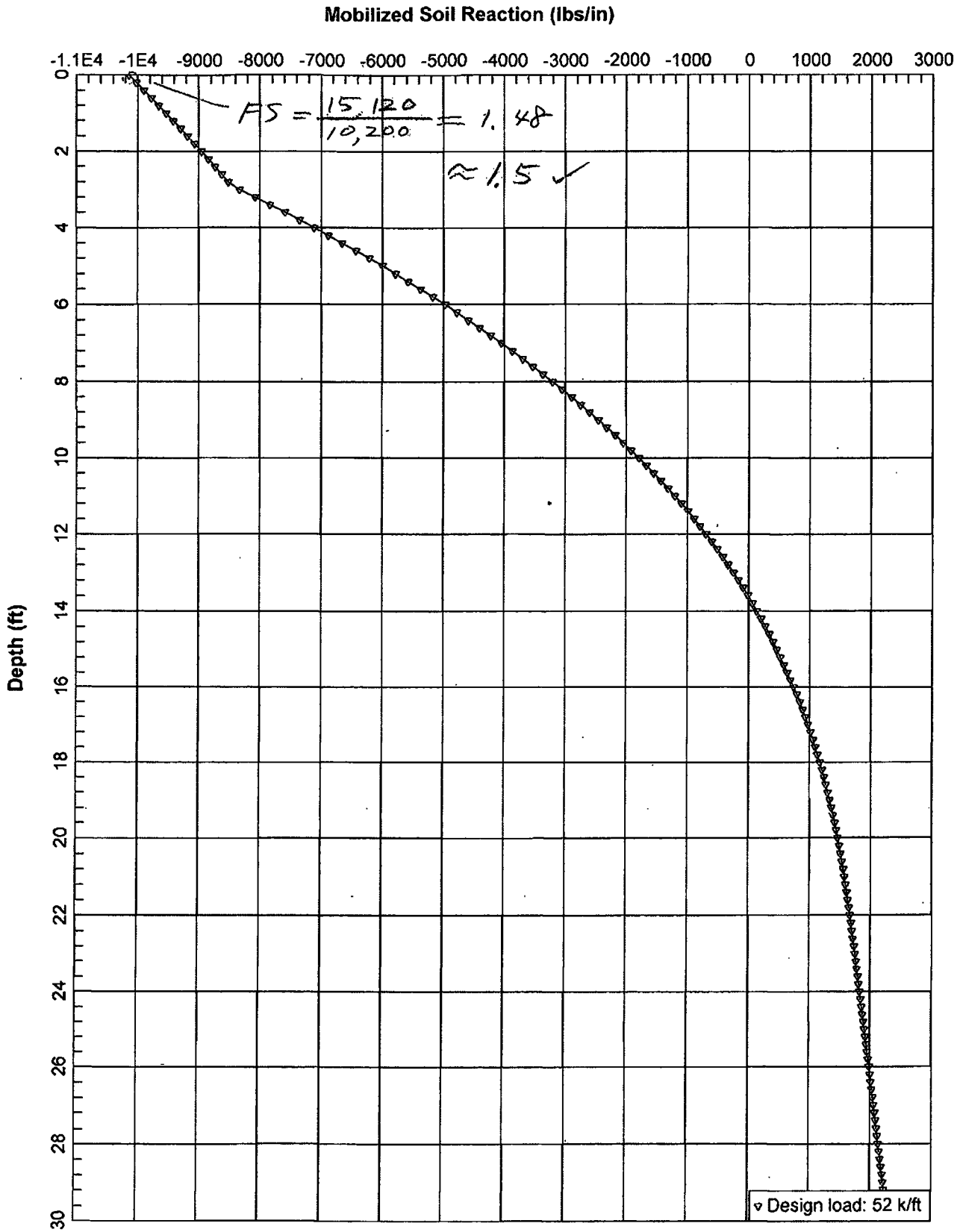
b=6', s=9', a=1.5% KS DOT p-y curve



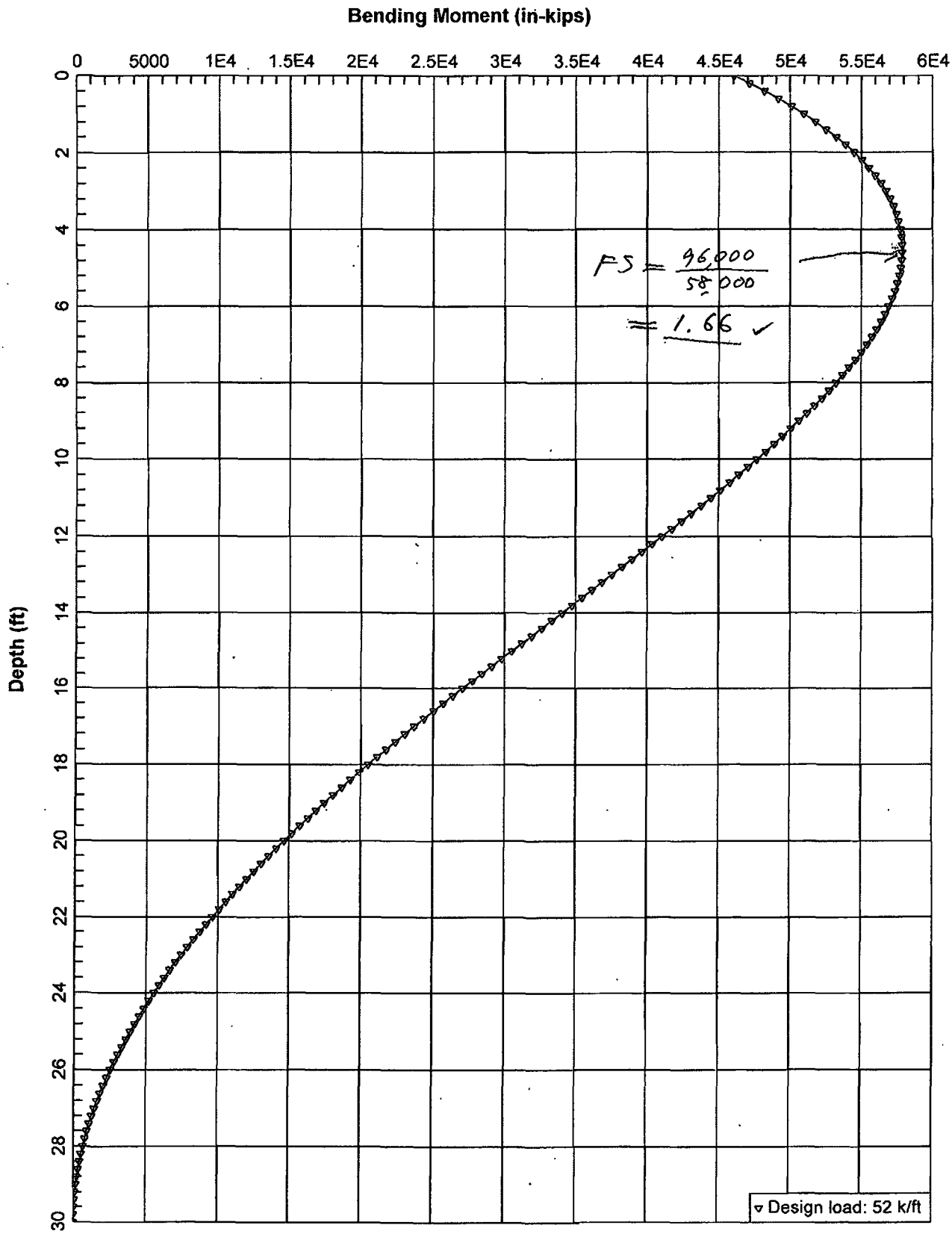
b=6', s=9', a=1.5% KS DOT p-y curve

$P_{max} = (21,600)(0.7) = 15,120$ lb/in

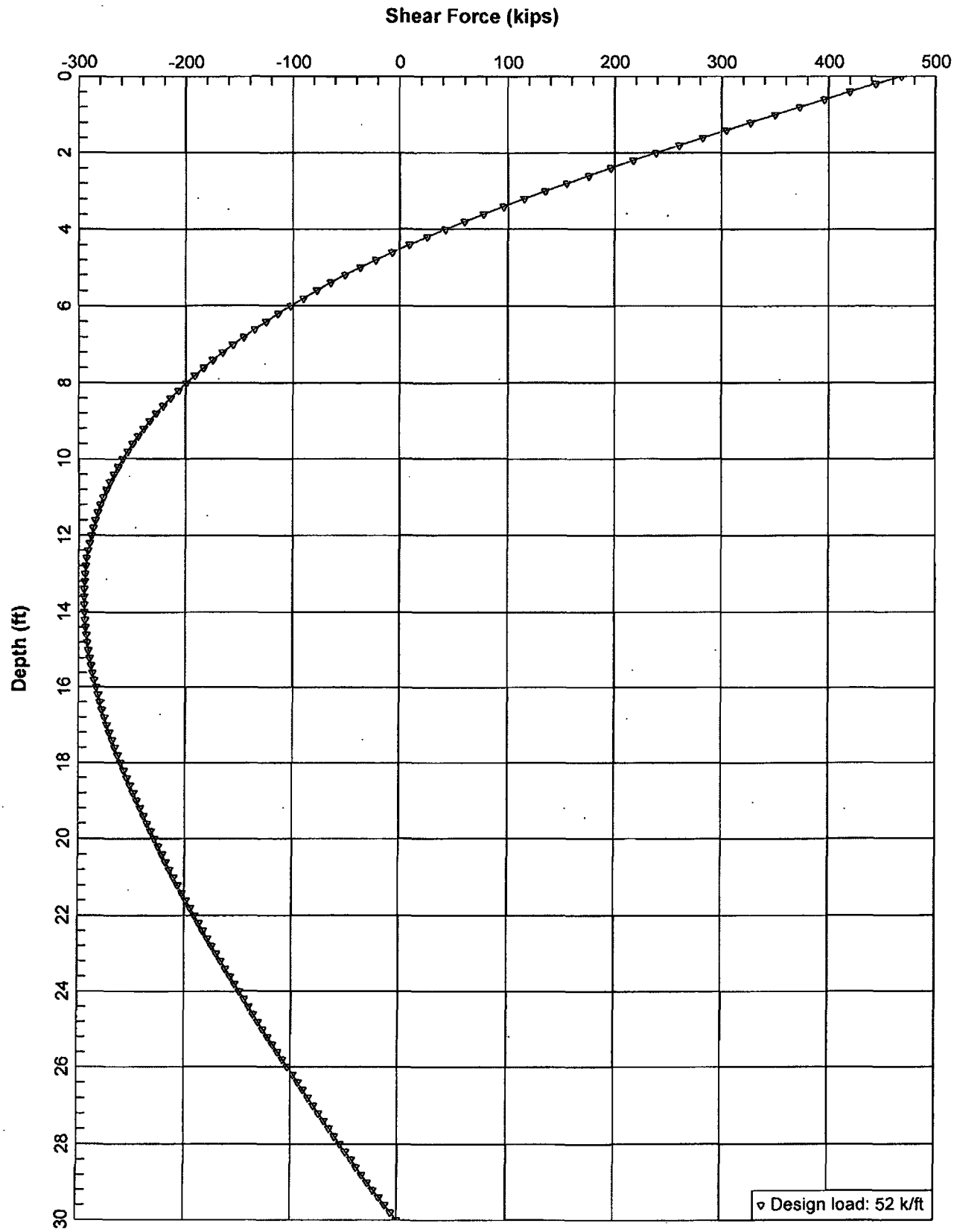
p-mult.



b=6', s=9', a=1.5% KS DOT p-y curve

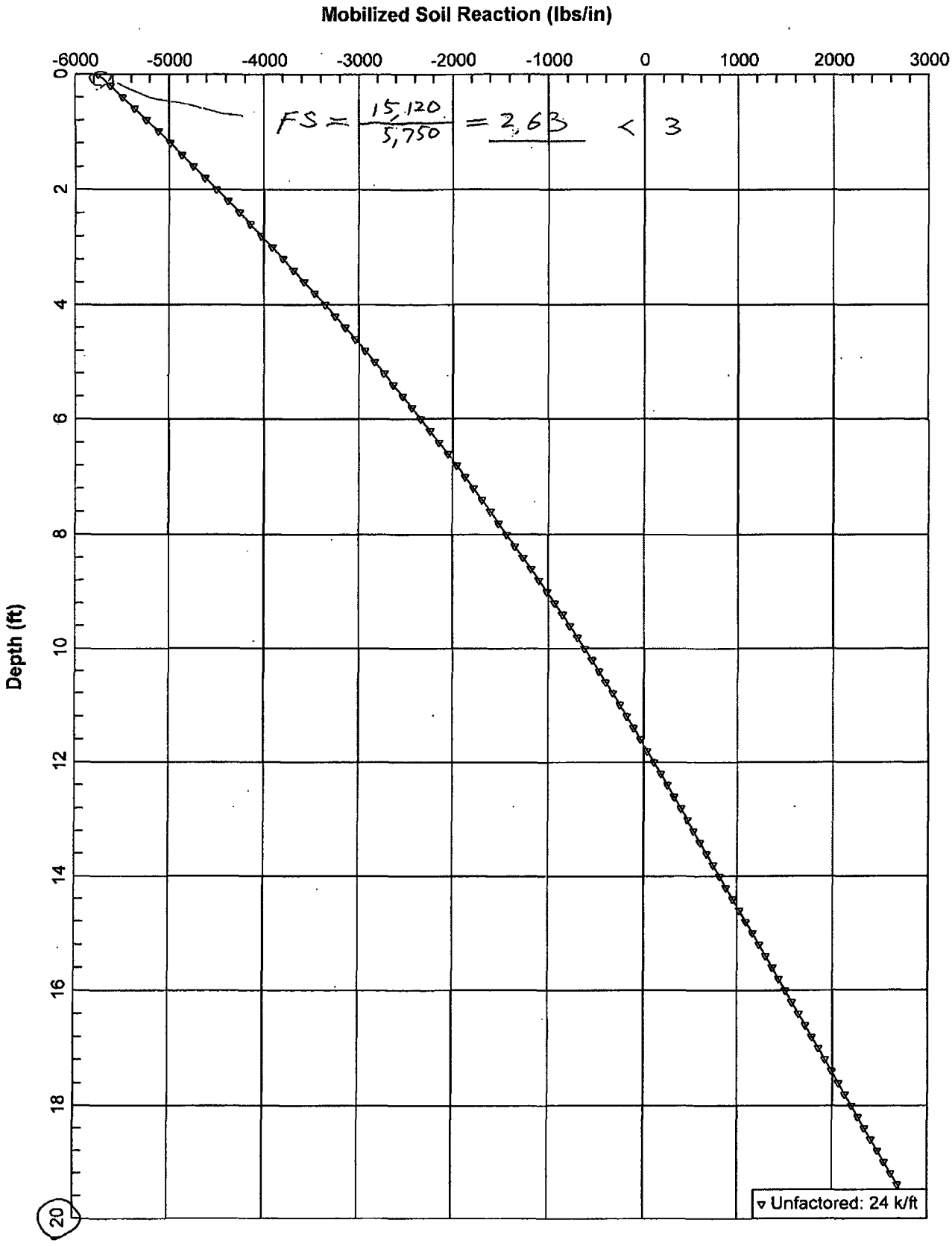


b=6', s=9', a=1.5% KS DOT p-y curve

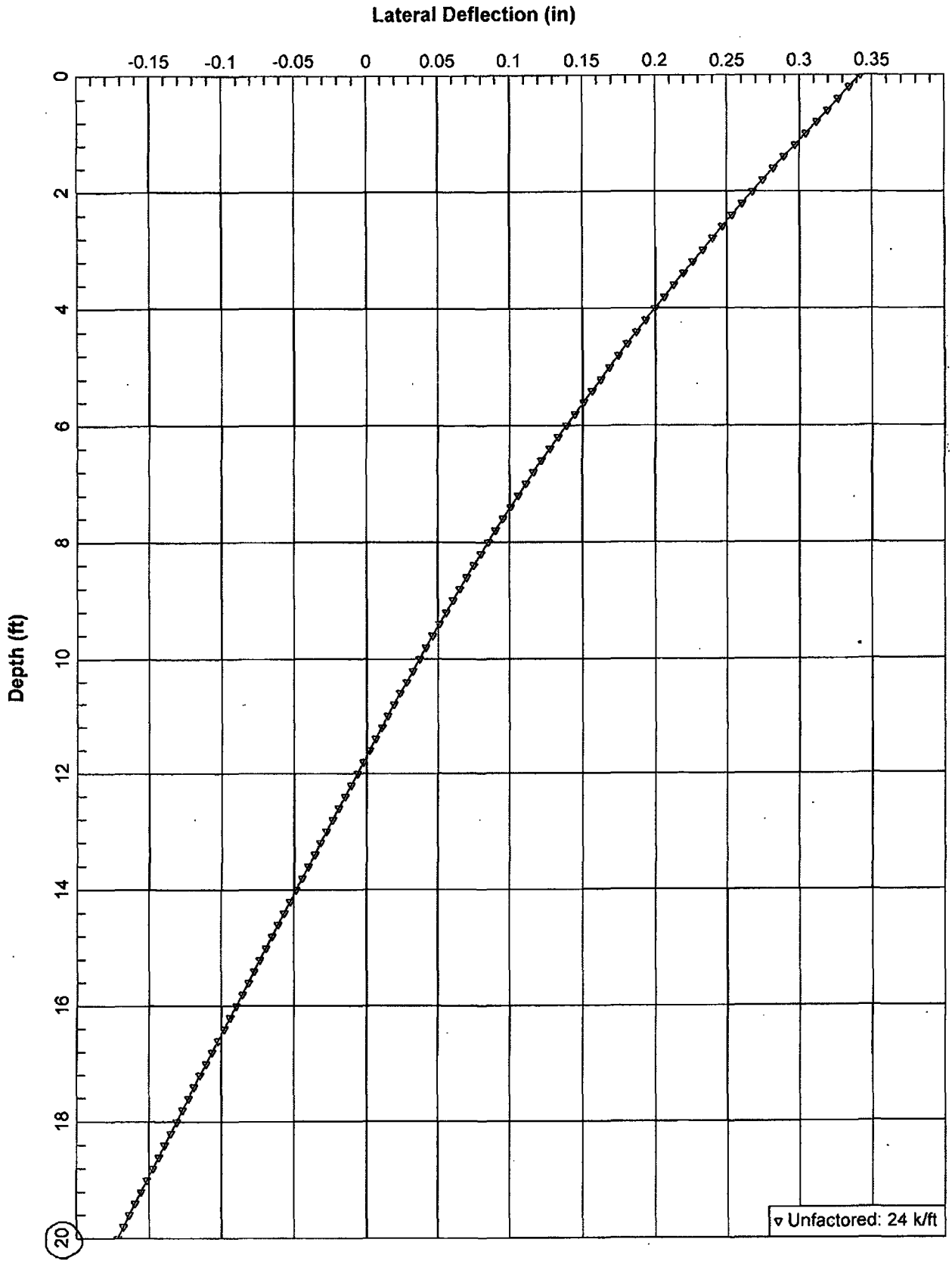


b=6', s=9', a=1.5% KS DOT p-y curve

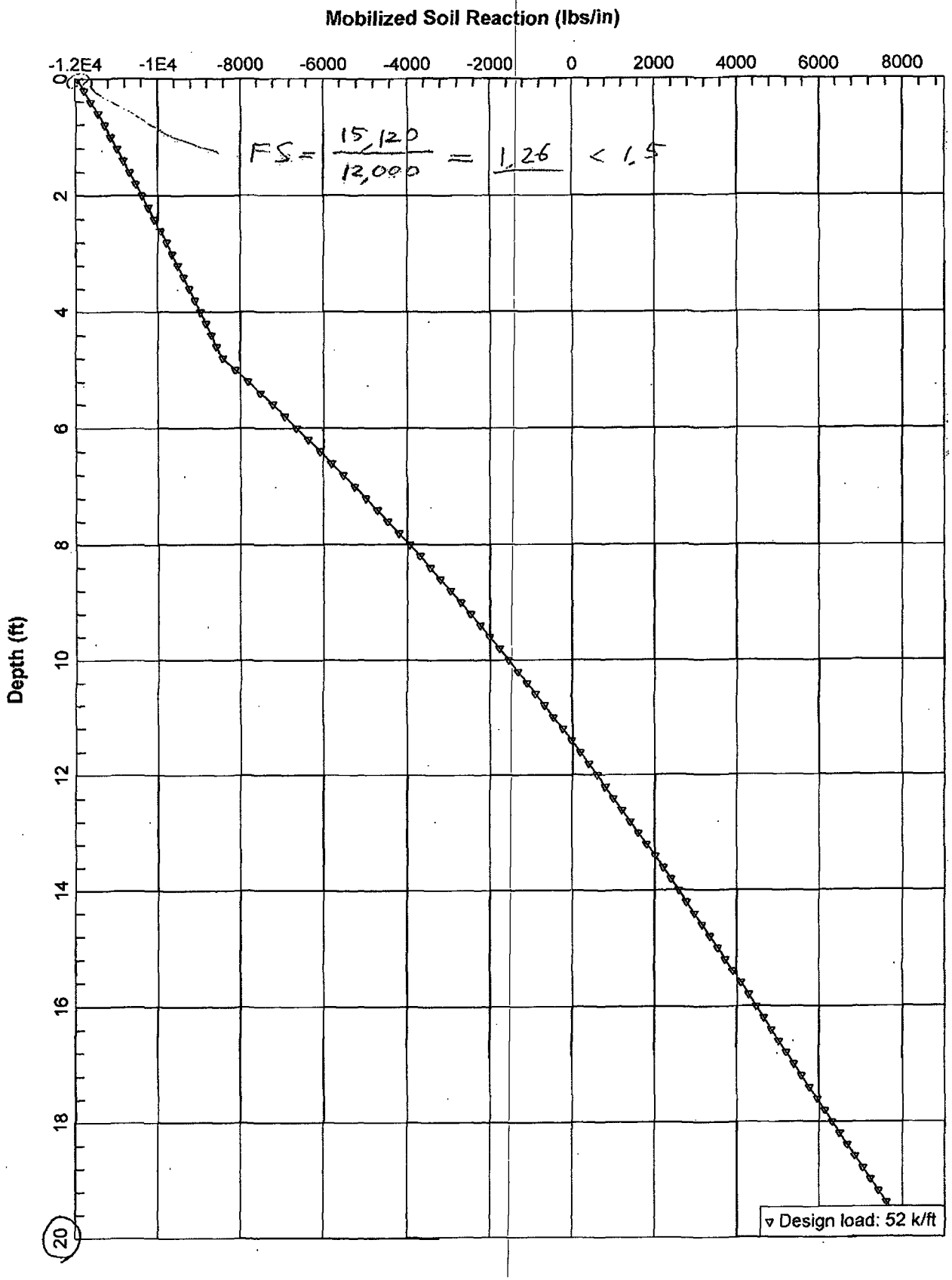
$P_{max} = (21,600)(0.7) = 15,120$ lb/in.



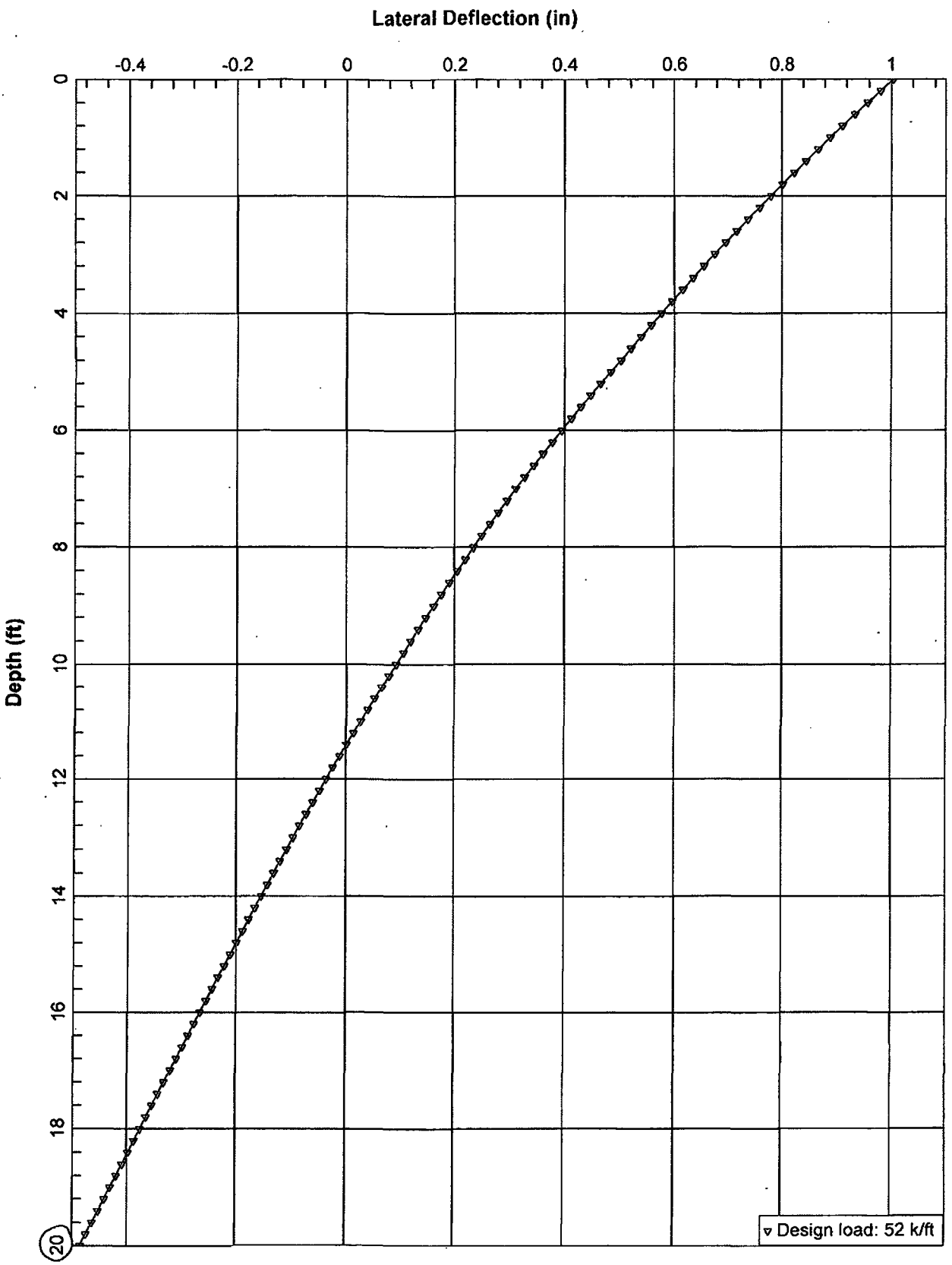
b=6', s=9', a=1.5%, emb=20' KS DOT p-y curve



b=6', s=9', a=1.5%, emb=20' KS DOT p-y curve



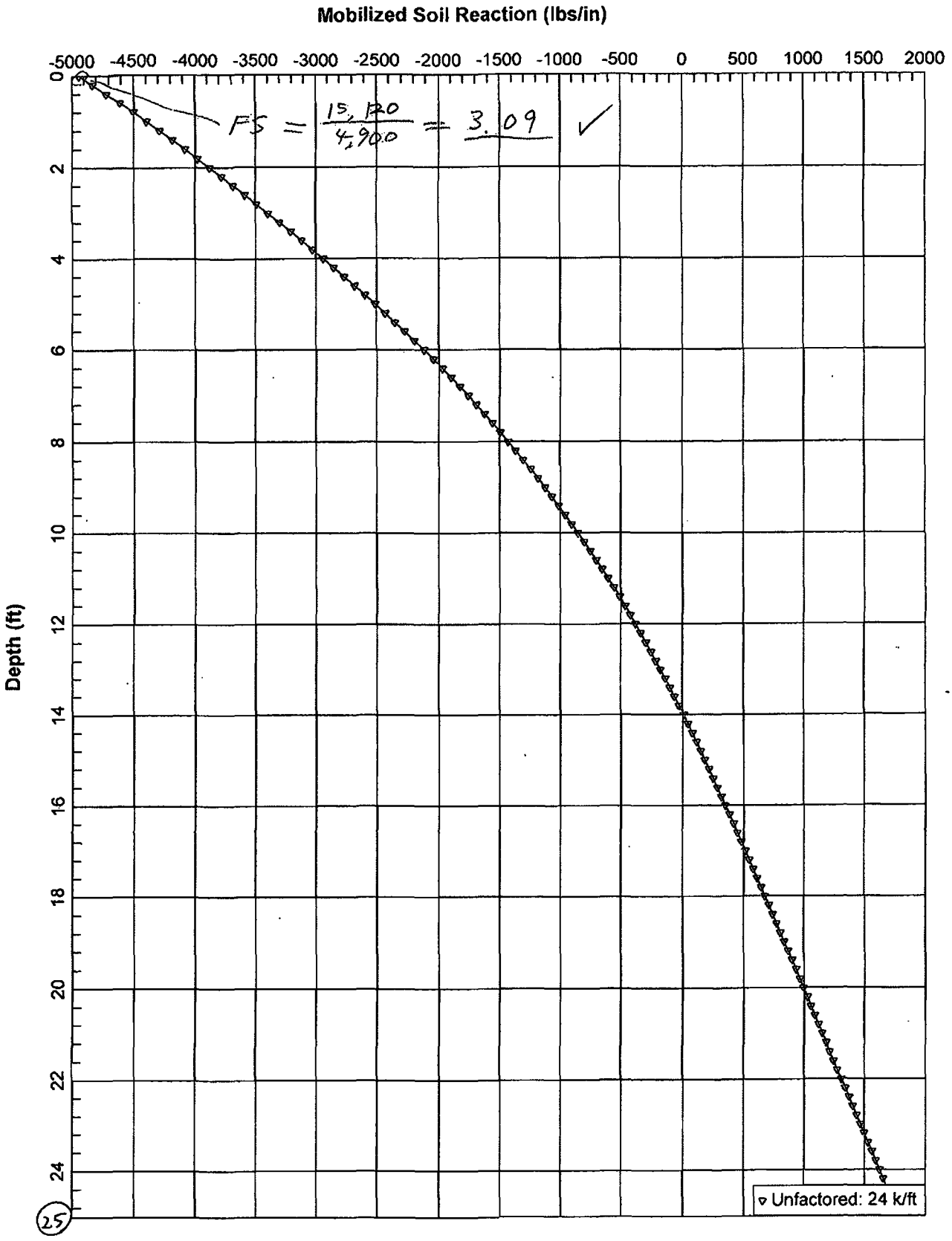
b=6', s=9', a=1.5%, emb=20' KS DOT p-y curve



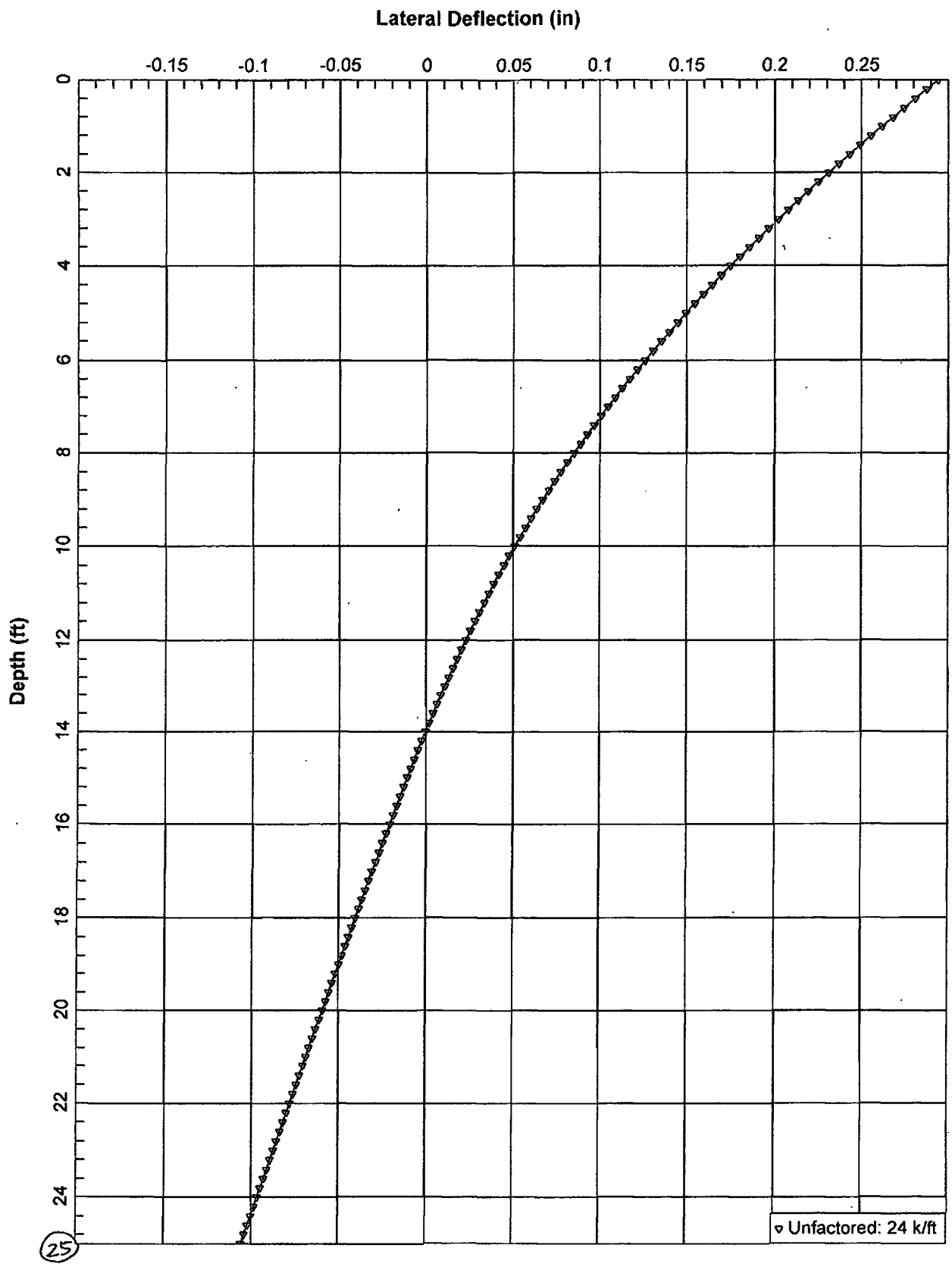
b=6', s=9', a=1.5%, emb=20' KS DOT p-y curve

$P_{max} = (21{,}600)(0.7) = 15{,}120$ lb/in

p-mult.



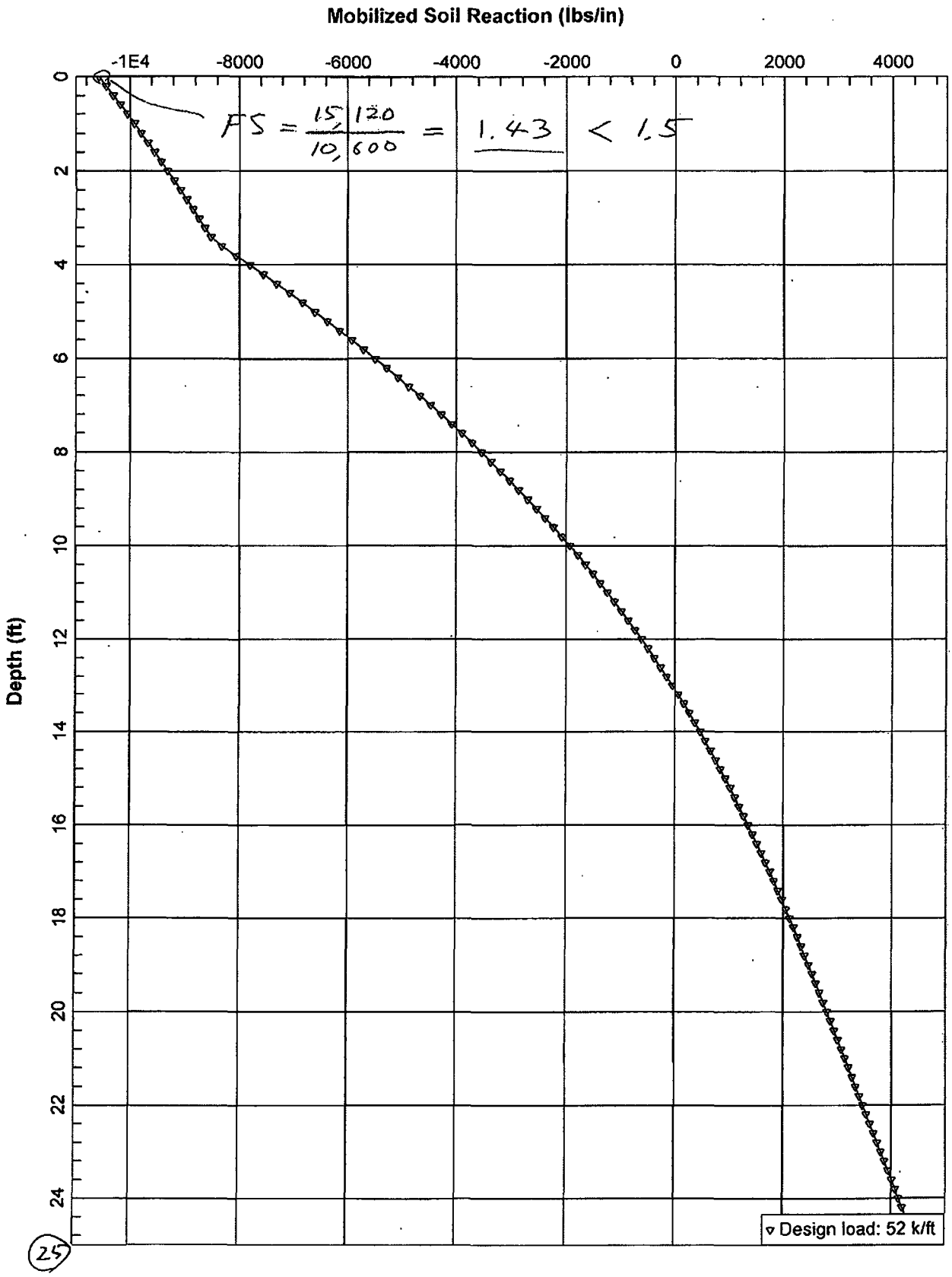
b=6', s=9', a=1.5%, emb-25' KS DOT p-y curve



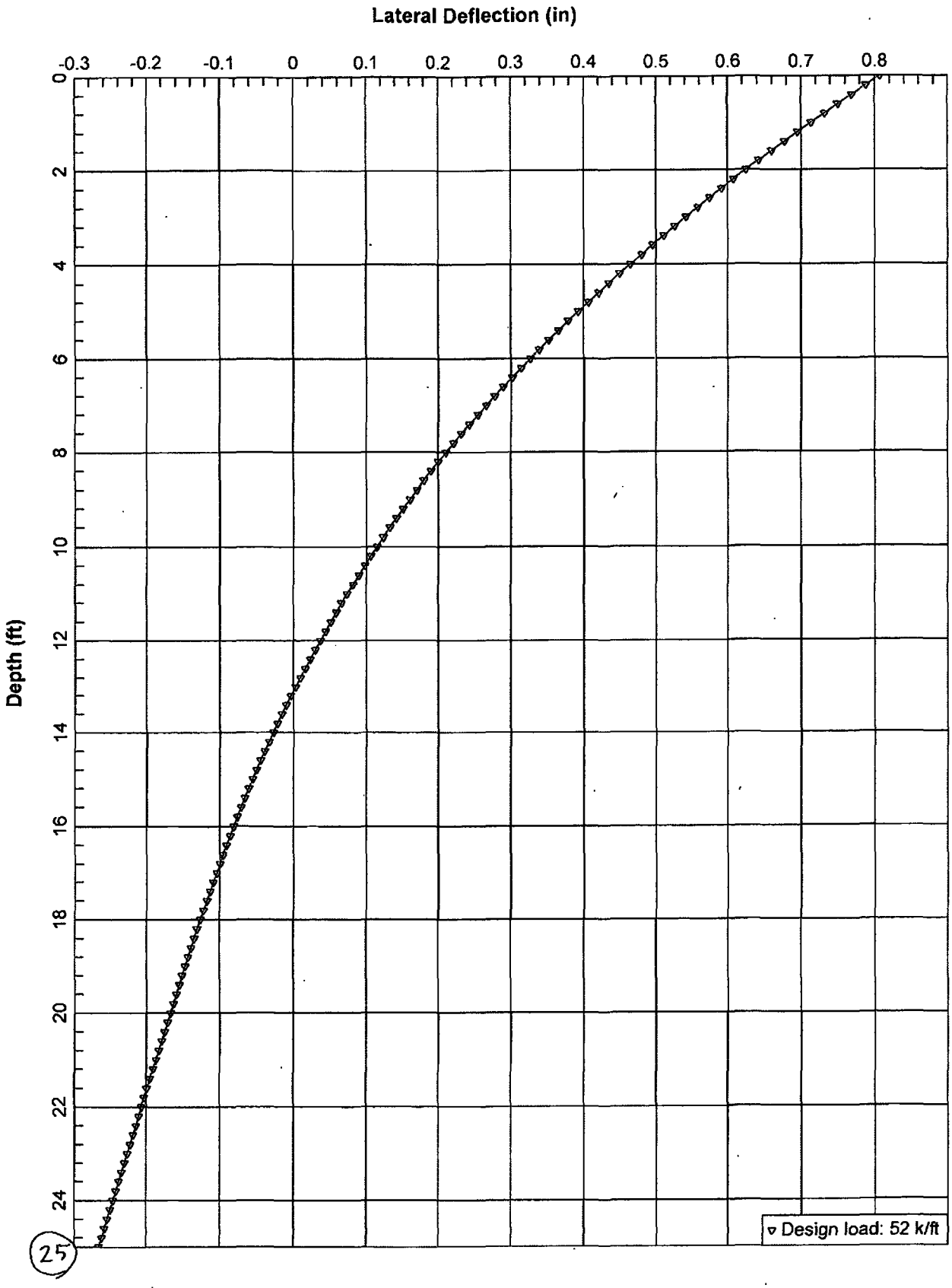
b=6', s=9', a=1.5%, emb=25' KS DOT p-y curve

$P_{max} = (21,600)(0.7) = 15,120$ lb/in

p-mult.



b=6', s=9', a=1.5%, emb-25' KS DOT p-y curve



b=6', s=9', a=1.5%, emb=25' KS DOT p-y curve

Appendix D

Use of LRFD for Shear Pile Design

Use of LRFD for Shear Pile Design

The following could be used as an approach for applying the LRFD for Bridge Design to the design of shear piles. Please refer to Table 3.4.1-1 of *AASHTO LRFD Bridge Design Specifications*, 2nd Ed, 1998.

1. The unfactored landslide force of F_{SP} = 24 kips/ft (see the paragraphs under Shear Pile Forces on page 6 of the report) is a best estimate of actual landslide loading on the shear pile under "normal landslide conditions." (Landslide is by no means normal, however.) To analyze this condition, Strength-I Limit State should be used. Landslide loading could be considered to be somewhere between Permanent Loads (EH, etc.) and Transient Loads (LL, IM, etc.), so the load factor to use would be $\gamma = (1.5 + 1.75)/2 = \underline{1.65}$. To obtain the geotechnical FS of 3 (see Table 4 of the report), the resistance factor would be $\phi = \gamma/FS = 1.65/3 = \underline{0.55}$.

2. The design landslide force of F_{SP} = 52 kips/ft is an "already factored" landslide loading on the shear pile to provide a global FS = 1.25. This condition would be somewhere between the Strength Limit State and the Extreme Event Limit State. (As a side note, we are not designing for any seismic loading conditions.) This condition may be referred to as "Unusual Event" Limit State. The load factor to use would be $\gamma = \underline{1.00}$ (similar to IC and CV). To obtain the geotechnical FS of 1.5, the resistance factor would be $\phi = 1.00/1.5 = \underline{0.65}$.

To summarize, the shear pile should be designed for the following two load combinations.

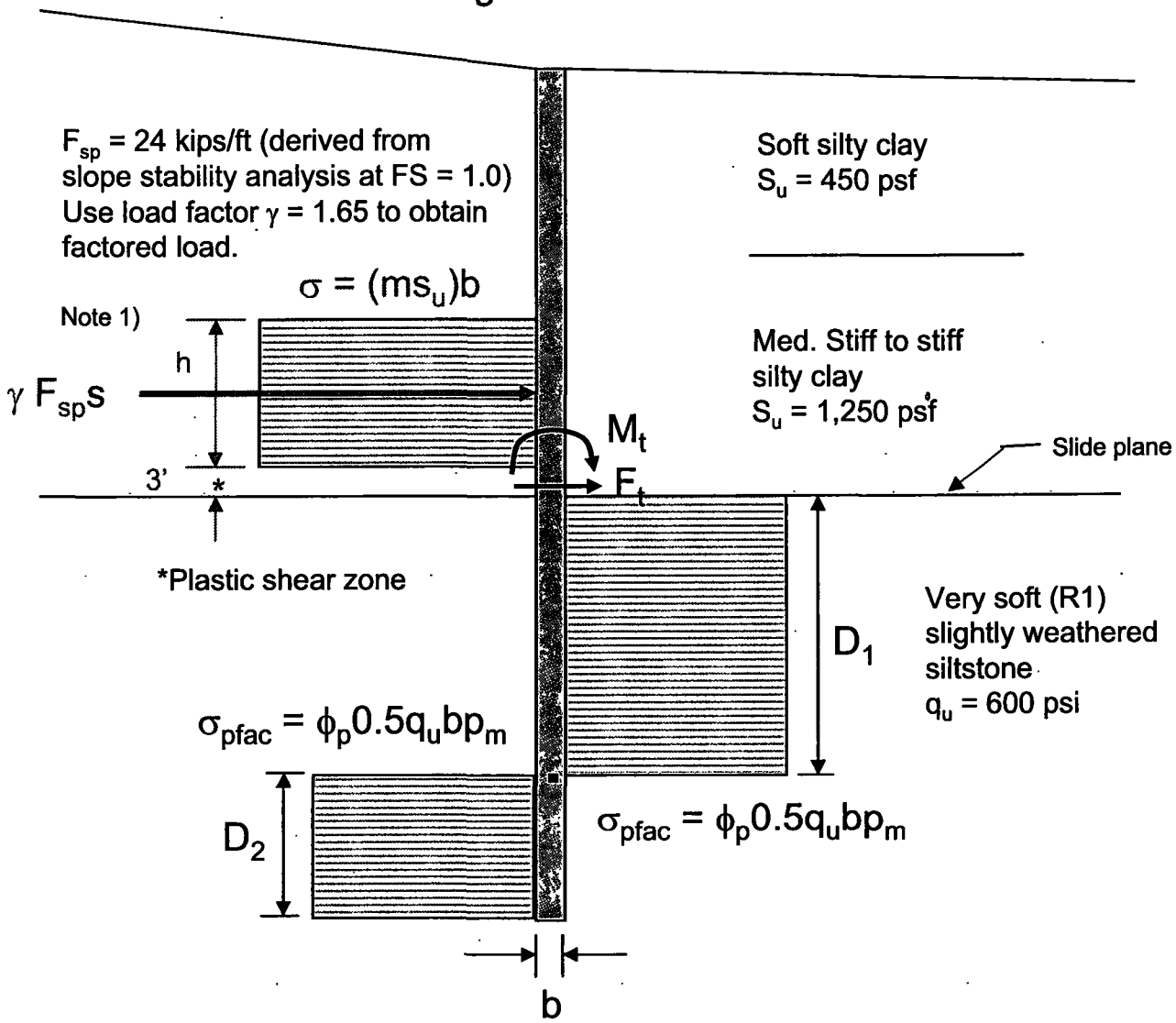
(1) Strength-I Limit State with $\gamma = 1.65$ and $\phi = 0.55$: nominal F_{SP} = 24 kips/ft

(2) "Unusual Event" Limit State with $\gamma = 1.00$ and $\phi = 0.65$: nominal F_{SP} = 52 kips/ft

The rectangular slide force loading in Figure 14 of the report is the nominal load and can be used for both load combinations.

The load diagrams for the two conditions are attached. These load diagrams are based on conventional soldier-pile type analyses and can be used to perform a check of the maximum bending moment in the shear pile and the required embedment depth. However, we do not recommend these diagrams be used for the final design of the shear piles, because the rock reaction distribution below the slide plane is too simplistic.

Strength Limit State

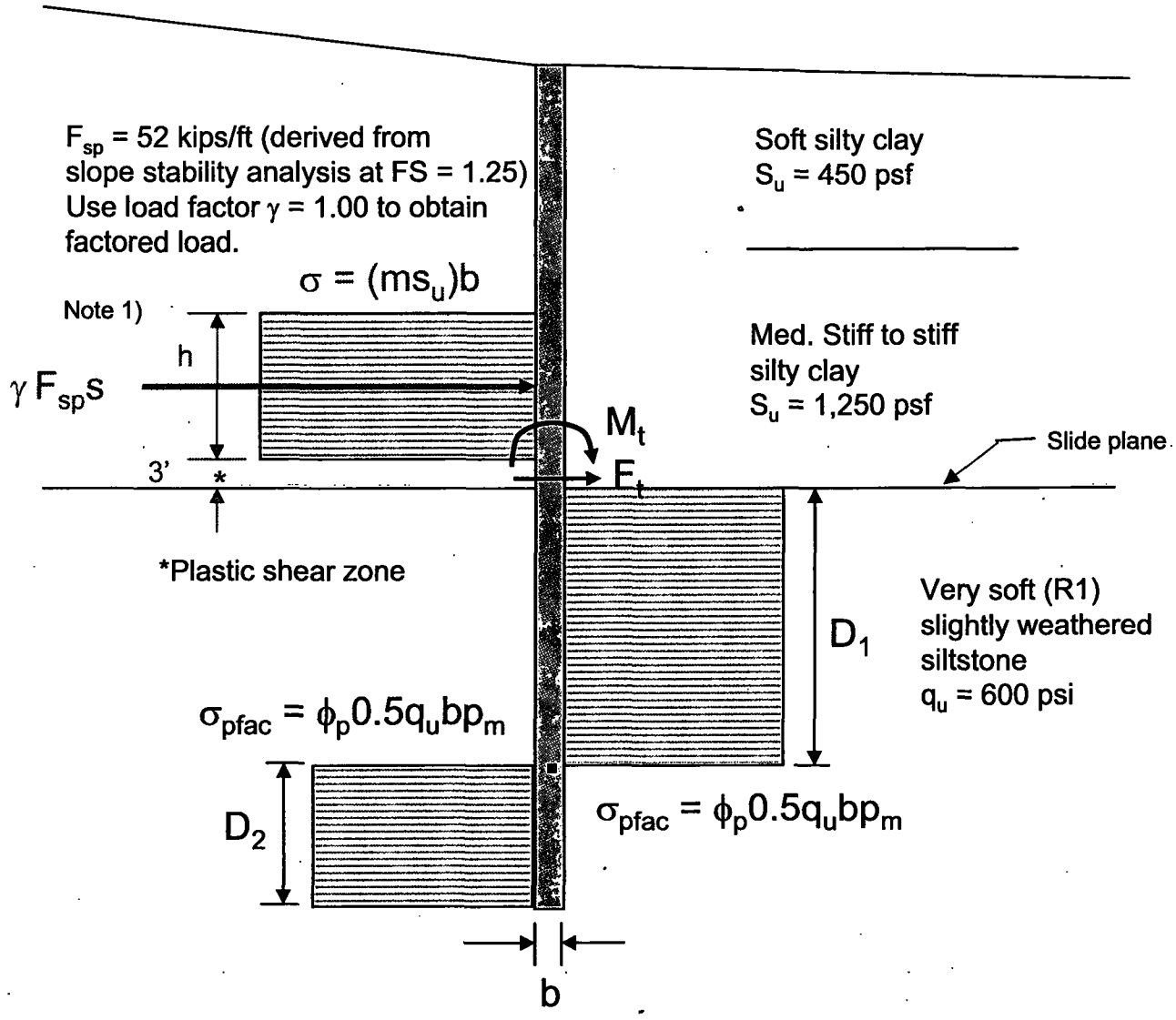


Note 1): The rectangular landslide loading should be converted to F_t and M_t and applied at the slide plane as shown above.

Use resistance factor, ϕ_p = 0.55 multiplied to passive resistance σ_p to obtain factored passive resistance, σ_{pfac}.

Note: p_m is the p-multiplier and are 0.8 for s/b=2, 0.7 for s/b=1.5, and 0.65 for s/b=1.3.

"Unusual Event" Limit State



Note 1): The rectangular landslide loading should be converted to F_t and M_t and applied at the slide plane as shown above.

Use resistance factor, ϕ_p = 0.65 multiplied to passive resistance σ_p to obtain factored passive resistance, σ_{pfac}.

Note: p_m is the p-multiplier and are 0.8 for s/b=2, 0.7 for s/b=1.5, and 0.65 for s/b=1.3.

Shear Pile Design
Notes to Conventional Method Load Diagram

Symbols

b = shear pile diameter
s = shear pile spacing on centers
s_u = undrained shear strength of cohesive soil
p_m = p-multiplier
$m = 9 * p_m$
= 7 for s/b=2
= 6 for s/b=1.5
= 5.9 for s/b=1.3
F_{sp} = shear pile force (slide force) per unit width of slide
h = height over which slide force acts
q_u = unconfined compressive strength of rock
F_t = shear in pile at the slide plane (factored)
M_t = bending moment in pile at the slide plane (factored)
γ = load factor
ϕ = resistance factor

Equations

$F_t = \gamma F_{sp} s = \gamma(ms_u)bh$
$M_t = F_t$ (arm)
Where arm = 3 ft + h/2

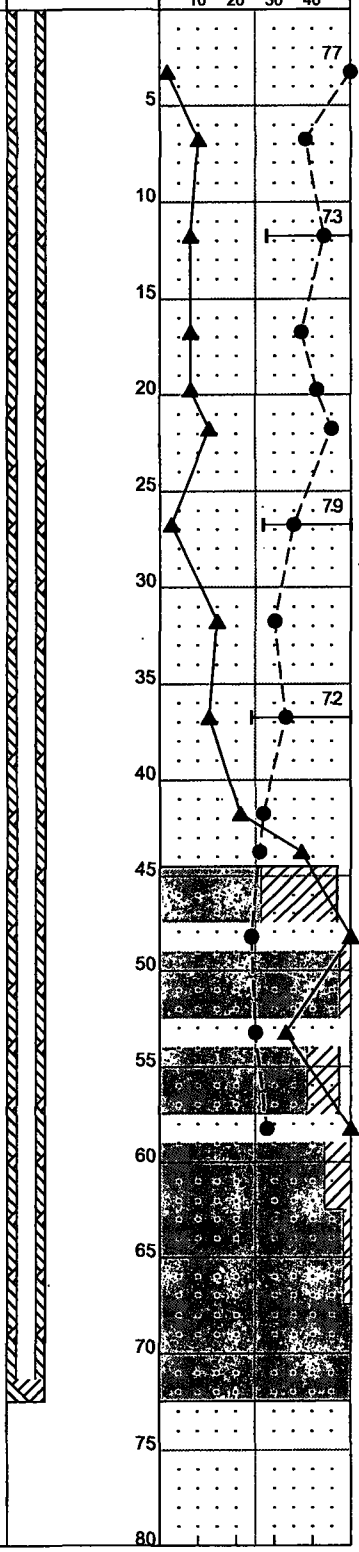
3 ft is the thickness of the plastic shear zone at the slide plane where there is no net loading on the pile. This is typically estimated from inclinometer deflection plots.

Appendix E

Logs of Borings Drilled in January 2006

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION SURFACE ELEVATION: 55.0 FT.	RUN NO.	SAMPLE NO.	PEN. DATA
		STIFF, brown and light gray, silty CLAY; trace sand, blocky, relic rock texture, medium sand sized siltstone fragments (DECOMPOSED SILTSTONE/SLIDE DEBRIS)		S-1	0 1 1
		...top 4' jumbled and VERY SOFT, brown, slightly clayey SILT; numerous organics, rootlets and wood fragments		S-2	6 5 5
				S-3	3 3 5
		...siltstone fragments coarse gravel-sized from 16 to 27.5 feet.		S-4	4 3 5
				S-5	6 4 4
				S-6	4 5 8
27.5	27½	...becomes MEDIUM STIFF at 26 to 27.5 feet.		S-7	1 1 2
		STIFF to VERY STIFF, gray, slightly sandy, silty CLAY; coarse gravel sized siltstone fragments, scattered shell fragments, blocky (HIGHLY WEATHERED SILTSTONE)		S-8	5 7 8
				S-9	4 5 8
12.5	42½	VERY SOFT (R1), gray slightly weathered, SILTSTONE; moderately jointed, scattered shell fragments, occasional sandstone lenses. (LINCOLN CREEK FORMATION)		S-10	7 10 11
				S-11	15 18 19
			R-1		
				S-12	19 30 50/5"
			R-2		
				S-13	12 13 20
		...becomes VERY SOFT to SOFT (R1-R2) and fresh at approximately 54.5 feet	R-3		
				S-14	26 43 50/5"
			R-4		
			R-5		
			R-6		
-17.5	72½	Bottom of Boring: 72.5 FT			

GROUND WATER/ INSTRUMENT INSTALLATION



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. START CARD NO: R68284
3. HOLE NO: LT-1-06
4. SITE ADDRESS: SR 107 VIC MP 4.7
5. WELL ID NO: AKK-274
6. GRAYS HARBOR COUNTY
7. NE 1/4, SE 1/4, SECTION 23, T17, R8 - WWM
8. DRILLER: MIKE HARVEY, LIC NO. 2599

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: AWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 4.5 INCH

DRILLER: WA DOT
DATE START: 1/24/2006 FINISH: 1/25/2006
DRILLING TECHNIQUE: HWT Casing Advancer/HQ3 Coring

LANDSLIDE TECHNOLOGY
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1200 Fax 503-452-1528

SUMMARY BORING LOG LT-1

SR 107, MP 4.7 LANDSLIDE
MONTESANO, WASHINGTON

JUN 2006
PROJ 1744
FIG. 4

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION SURFACE ELEVATION: 55.0 FT.	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION	PENETRATION TEST (BLOWS PER FOOT) / WATER CONTENT (%) 10 20 30 40
		Quick drilled piezometer. One sample attempted.				
			S-1 *		01/28/06	
13.0	42	Bottom of Boring: 42 FT				

Depth scale: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80

20 40 60 80
RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. START CARD NO: R68284
3. HOLE NO: P-1-06
4. SITE ADDRESS: SR 107 VIC MP 4.7
5. WELL ID NO: AKK-275
6. GRAYS HARBOR COUNTY
7. NE 1/4, SE 1/4, SECTION 23, T17, R8 - WWM
8. DRILLER: MIKE HARVEY, LIC NO. 2599

HAMMER ASSEMBLY: NOT APPLICABLE SPT SAMPLER: NOT APPLICABLE
DRILL ROD USED: NOT APPLICABLE BOREHOLE DIAM.: 4.5 INCH

DRILLER: WA DOT
DATE START: 1/25/2006 FINISH: 1/25/2006
DRILLING TECHNIQUE: HWT Casing Advancer

LANDSLIDE TECHNOLOGY
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1200 Fax 503-452-1528

SUMMARY BORING LOG
P-1-06

SR 107, MP 4.7 LANDSLIDE
MONTESANO, WASHINGTON

JUN 2006
PROJ 1744
FIG. 5

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION SURFACE ELEVATION: 55.0 FT.	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION	PENETRATION TEST (BLOWS PER FOOT) / WATER CONTENT (%) 10 20 30 40
		Quick drilled piezometer. No sampling.				
44.0	11	Bottom of Boring: 11 FT				

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

20 40 60 80
RECOVERY/RQD (%)

LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- ▲ STANDARD PENETRATION TEST (BLOWS/FT.)
- ● WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. START CARD NO: R68284
3. HOLE NO: P-1A-06
4. SITE ADDRESS: SR 107 VIC MP 4.7
5. WELL ID NO: AKK-283
6. GRAYS HARBOR COUNTY
7. NE 1/4, SE 1/4, SECTION 23, T17, R8 - WWM
8. DRILLER: MIKE HARVEY, LIC NO. 2599
9. PIEZOMETER DRY ON 1/26 AND 1/28/06

HAMMER ASSEMBLY: NOT APPLICABLE SPT SAMPLER: NOT APPLICABLE
DRILL ROD USED: NOT APPLICABLE BOREHOLE DIAM.: 4.5 INCH

DRILLER: WA DOT
DATE START: 1/25/2006 FINISH: 1/25/2006
DRILLING TECHNIQUE: HWT Casing Advancer

LANDSLIDE TECHNOLOGY
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1200 Fax 503-452-1528

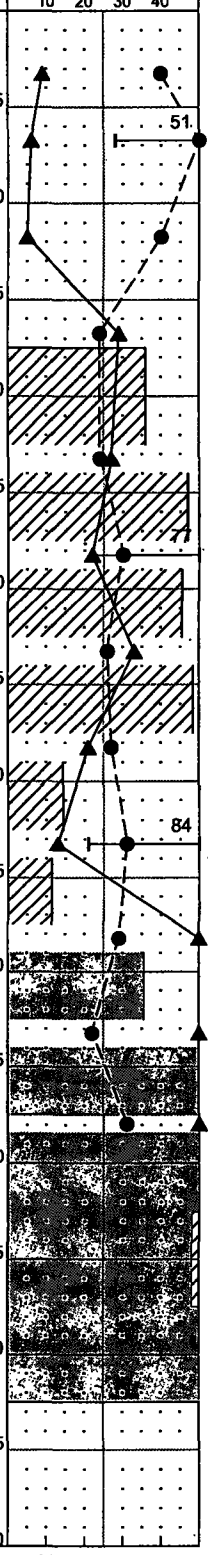
SUMMARY BORING LOG P-1A-06

SR 107, MP 4.7 LANDSLIDE
MONTESANO, WASHINGTON

JUN 2006
PROJ 1744
FIG. 6

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION SURFACE ELEVATION: 44.0 FT.	RUN NO.	SAMPLE NO.	PEN. DATA
		SOFT, light brown, slightly sandy, silty CLAY; scattered organics, relic rock texture, disturbed (DECOMPOSED SILTSTONE / SLIDE DEBRIS)		S-1	3 4 5
		...becomes brown-gray at approx. 6.5 feet		S-2	1 3 3
		...becomes gray at approx. 11 feet		S-3	1 2 3
29.0	15	VERY STIFF to HARD, gray, slightly sandy, silty CLAY; relic rock texture, locally distrubed, siltstone blocks boulder sized, coarse gravel sized sandstone fragments, fine sand sized mica, occasional shell fragments (HIGHLY WEATHERED SILTSTONE / SLIDE DEBRIS)		S-4	11 14 15
			R-1		
				S-5	7 13 14
			R-2		
				S-6	8 8 14
			R-3		
				S-7	11 15 18
			R-4		
				S-8	13 11 10
5.0	39	STIFF, gray, slightly sandy silty CLAY; disturbed, coarse gravel sized sandstone inclusions, fine sand sized mica, scattered shell fragments. (HIGHLY WEATHERED SILTSTONE)	R-5		
				S-9	3 6 7
			R-6		
-4.0	48	VERY SOFT (R1), gray, slightly weathered, SILTSTONE; moderately jointed, scattered shell fragments, occasional sandstone lenses (LINCOLN CREEK FORMATION)		S-10	12 36 38
			R-7		
				S-11	5 15 38
			R-8		
				S-12	32 50/5"
			R-9		
			R-10		
			R-11		
-28.5	72½	Bottom of Boring: 72.5 FT			

GROUND WATER/ INSTRUMENT INSTALLATION



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- ▲ STANDARD PENETRATION TEST (BLOWS/FT.)
- ● WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. START CARD NO: R68284
3. HOLE NO: LT-7-06
4. SITE ADDRESS: SR 107 VIC MP 4.7
5. WELL ID NO: AKK-284
6. GRAYS HARBOR COUNTY
7. NE 1/4, SE 1/4, SECTION 23, T17, R8 - WWM
8. DRILLER: MIKE HARVEY, LIC NO. 2599

HAMMER ASSEMBLY: AUTO TRIP
DRILL ROD USED: AWJ
SPT SAMPLER: NO LINER - RECESSED ID
BOREHOLE DIAM.: 4.5 INCH

DRILLER: WA DOT
DATE START: 1/26/2006 FINISH: 1/27/2006
DRILLING TECHNIQUE: HWT Casing Advancer/HQ3 Coring

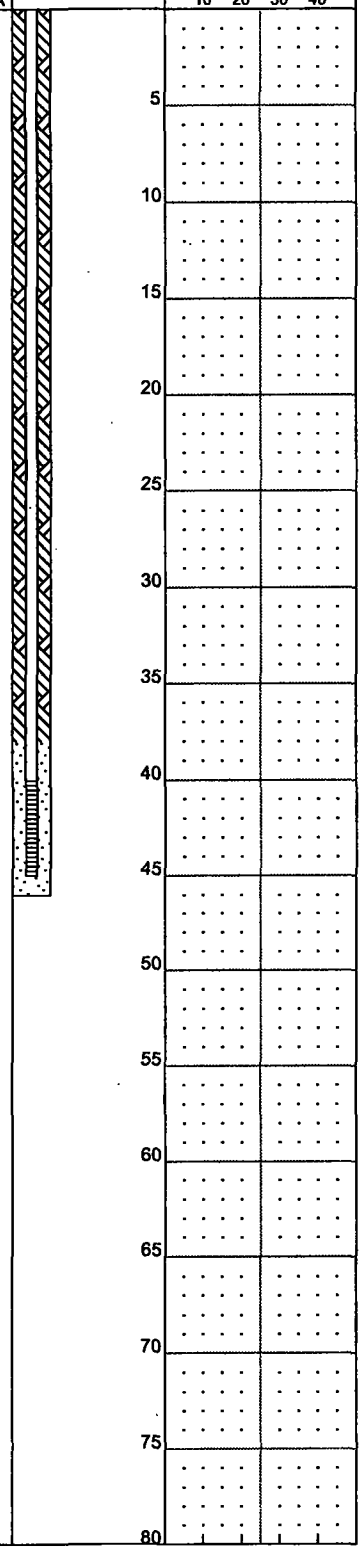
LANDSLIDE TECHNOLOGY
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1200 Fax 503-452-1328

SUMMARY BORING LOG LT-7

SR 107, MP 4.7 LANDSLIDE
MONTESANO, WASHINGTON

JUN 2006
PROJ 1744
FIG. 7

ELEVATION IN FEET	DEPTH IN FEET	MATERIAL DESCRIPTION SURFACE ELEVATION: 44.0 FT.	SAMPLE NO.	SAMPLE PEN. DATA	GROUND WATER/ INSTRUMENT INSTALLATION	PENETRATION TEST (BLOWS PER FOOT) / WATER CONTENT (%) 10 20 30 40
		Quick drilled piezometer. No sampling.				
-2.0	46	Bottom of Boring: 46 FT				



LEGEND

- 2-INCH O.D. SPLIT SPOON
- 3-INCH O.D. SPLIT SPOON
- 3-INCH O.D. THIN WALL SAMPLER
- 3-INCH O.D. PITCHER TUBE SAMPLER
- * NO SAMPLE RECOVERY
- 12/5/2005 GROUND WATER LEVEL AND DATE OBSERVED
- LIQUID LIMIT
- WATER CONTENT
- PLASTIC LIMIT
- STANDARD PENETRATION TEST (BLOWS/FT.)
- WATER CONTENT IN PERCENT
- CORE RECOVERY IN PERCENT
- RQD IN PERCENT
- PT-1 PACKER TEST INTERVAL

NOTES

1. MATERIAL DESCRIPTIONS AND INTERFACES ARE INTERPRETIVE AND ACTUAL CHANGES MAY BE GRADUAL.
2. START CARD NO: R68284
3. HOLE NO: P-2A-06
4. SITE ADDRESS: SR 107 VIC MP 4.7
5. WELL ID NO: AKK-276
6. GRAYS HARBOR COUNTY
7. NE 1/4, SE 1/4, SECTION 23, T17, R8 - WWM
8. DRILLER: MIKE HARVEY, LIC NO. 2599

HAMMER ASSEMBLY: NOT APPLICABLE SPT SAMPLER: NOT APPLICABLE
DRILL ROD USED: NOT APPLICABLE BOREHOLE DIAM.: 4.5 INCH

DRILLER: WA DOT
DATE START: 1/27/2006 FINISH: 1/28/2006
DRILLING TECHNIQUE: HWT Casing Advancer

LANDSLIDE TECHNOLOGY
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1200 Fax 503-452-1528

SUMMARY BORING LOG P-3-06

SR 107, MP 4.7 LANDSLIDE
MONTESANO, WASHINGTON

JUN 2006
PROJ 1744
FIG. 8

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-1-06

Sheet 1 of 3

Job No. XL-2425 SR 107 Elevation ft (m)

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Site Address SR-107 Vic. MP 4.7

Inspector Bill Hanning

Start January 4, 2006 Completion January 4, 2006 Well ID# AKK-381

Equipment CME 850 w/ autohammer

Station Offset Casing 5"

Method Wet Rotary

Northing Easting Latitude Longitude

County Grays Harbor Subsection SE/NW Section 23 Range 8 WWM Township 17 N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
5	1			1 2 2 (4)		D-1		SILT, with sand, some gravel and sand stone., very loose, yellowish brown, moist, Blocky,Disrupted, no HCl reaction Length Recovered 0.5 ft, Length Retained 0.5 ft		
10	2 3			3 3 4 (7)		D-2		SILT, with trace sand and sandstone fragments, loose, dark gray, moist, Blocky,Disrupted, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
15	4 5			3 5 6 (11)		D-3		Elastic SILT, stiff, dark gray, moist, Disrupted, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
20	6			3 10		D-4		SILT, with shell fragments, dense, very dark gray, moist, Stratified,Disrupted, strong HCl reaction, Note rock		

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/11/06 8:24:59 AM

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-1-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 2 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				15 (25) RQD 12 FF 20		C-5		contact at 19.5. Top 0.5 dirupted, remainder of sample is SILTSTONE. Length Recovered 1.5 ft, Length Retained 1.5 ft SILTSTONE, very dark gray, fine grained, moderately weathered, very weak rock, no HCl reaction. Discontinuities are very closely spaced and in poor condition, Material looks disrupted., Percent Recovered 72.0%		
	7									
25				7 4 15 (19)		D-6		SILT, with some shell fragments, medium dense, very dark gray, moist, Homogeneous, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
	8			RQD 60 FF 2		C-7		SILTSTONE, very dark gray, fine grained, slightly weathered, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	9									
30				RQD 92 FF 1		C-8		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in fair condition, Note to fractures washed clean. Picture taken., Percent Recovered 100.0%		
	10									
35			>>	14 26 45 (71)		D-9		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition Length Recovered 1.0 ft, Length Retained 1.0 ft		
	11			RQD 98 FF .2		C-10		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	12									
40				RQD 90 FF .5		C-11		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	13									
45										

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-1-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 3 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14			34 50/2" (50) RQD 100 FF .5		D-12 C-13		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition Length Recovered 0.5 ft, Length Retained 0.5 ft SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	15									
50								End of test hole boring at 50 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Bailed. Water reading before bail was 10.6ft. Reading after bail was 48.8ft. Reading after 5 Minutes at 42.9ft. 10 Min. 34.6ft. Reading in piezometer after install was 5.0ft. will need to bail instrument.		
	16									
55										
	17									
	18									
60										
	19									
65										
	20									
	21									
70										

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/00 8:57:58 A

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-2-06

Sheet 1 of 3

Job No. XL-2425 SR 107 Elevation ft (m)

Project SR 107 M.P. 4.7 Landslide Driller Vince Johnson Lic# 2532

Site Address SR-107 MP 4.7 Inspector Bill Hanning

Start January 11, 2006 Completion January 11, 2006 Well ID# AKK-362 Equipment CME 850 w/ autohammer

Station Offset Casing 5" Method Wet Rotary

Northing Easting Latitude Longitude

County Grays Harbor Subsection SE/NW Section 23 Range 8 WWM Township 17 N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
5	1			3 3 3 (6)		D-1		Elastic SILT, with trace sand and fine gravel, soft, dark gray, moist, Blocky,Homogeneous, no HCl reaction Length Recovered 0.8 ft, Length Retained 0.8 ft		
10	2 3		>>	15 23 30 (53)		D-2		SILT, with trace sand and shell fragments, very dense, dark grayish brown, moist, Laminated, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
				RQD 100 FF .2		C-3		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction.. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
15	4 5			11 19 27 (46)		D-4		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition Length Recovered 1.5 ft, Length Retained 1.5 ft		
				RQD 100 FF 0		C-5		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
20	6									

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/06 8:56:03 AM

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-2-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 2 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				RQD 100 FF .2		C-6		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	7									
25			>>	18 28 44 (72)		D-7		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition Length Recovered 1.0 ft, Length Retained 1.0 ft		
	8			RQD 100 FF .2		C-8		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	9									
30				RQD 100 FF .6		C-9		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	10									
35			>>	19 32 50/4" (82)		D-10		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition Length Recovered 1.4 ft, Length Retained 1.4 ft		
	11			RQD 100 FF 0		C-11		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	12									
40				RQD 100 FF .2		C-12		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	13									
45			>>							

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/06 8:44:43 AM

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-2-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 3 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14			20 32 50 (82) RQD 100 FF .2		D-13 C-14		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition Length Recovered 1.5 ft, Length Retained 1.5 ft SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	15									
50										
	16							End of test hole boring at 50 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Bailed to 48.2 ft. Recarged to 9.2 feet in 30 minutes. Bailed again before installing piezo.		
55										
	17									
	18									
60										
	19									
65										
	20									
	21									
70										

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/06 8:58:03 AT

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3-06

Sheet 1 of 6

Job No. XL-2425 SR 107 Elevation ft (m)

Project SR 107 M.P. 4.7 Landslide Driller Vince Johnson Lic# 2532

Site Address SR-107 M.P. 4.7 Inspector Bill Hanning

Start January 5, 2006 Completion January 9, 2006 Well ID# AKK-383 Equipment CME 850 w/ autohammer

Station Offset Casing 3.5" Method Wet Rotary

Northing Easting Latitude Longitude

County Grays Harbor Subsection SE/NW Section 23 Range 8 WWM Township 17 N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
5	1			0 2 1 (3)		D-1		SILT, with some fine sand trace oganics, very loose, olive brown, wet, Blocky,Disrupted, no HCl reaction, Iron stains throughout. 100% Drill fluid loss starting at 2.0ft. Length Recovered 0.6 ft, Length Retained 0.6 ft		
10	2 3			1 1 2 (3)		D-2		SILT, with some fine sand, organics and sandstone fragments., very loose, dark grayish brown, wet, Blocky,Disrupted, no HCl reaction Length Recovered 0.9 ft, Length Retained 0.9 ft		
15	4 5			3 3 3 (6)		D-3		SILT, with some fat clay, fine sand and sand stone fragments, loose, grayish brown, moist, Blocky,Disrupted, strong HCl reaction, Some iron staining. Length Recovered 1.2 ft, Length Retained 1.2 ft		
20	6			2 1		D-4		SILT, with trace organics, very loose, yellowish browm/grayish brown, moist, Disrupted, no HCl reaction,		

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/06 8:36:06 AM

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 2 of 6

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				2 (3)				25% Mottled. Iron staining throughout. Length Recovered 0.8 ft, Length Retained 0.8 ft		
	7									
25				6 9 15 (24)		D-5		SILT, with SILTSTONE fragments, medium dense, yellowish brown/very dark gray, moist, Stratified,Blocky,Disrupted, no HCl reaction, Note drill behavior change, indicating soil change at 21.0ft. Note bottom 0.5ft of sample to be SILTSTONE. Length Recovered 1.5 ft, Length Retained 1.5 ft		
	8			RQD 36 FF 20		C-6		SILTSTONE, very dark gray, fine grained, highly weathered, very weak rock, no HCl reaction. Discontinuities are very closely spaced and in poor condition, Note silty iron stained fractures., Percent Recovered 85.0%		
	9									
30				RQD 40 FF 20		C-7		SILTSTONE, very dark gray, fine grained, moderately weathered, very weak rock, no HCl reaction. Discontinuities are very closely spaced and in poor condition, Note iron stained fractures., Percent Recovered 100.0%		
	10									
35				3 8 15 (23)		D-8		SILT, medium dense, very dark gray, moist, Homogeneous, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
	11			RQD 70 FF 1		C-9		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in fair condition, Note all fractures to be in the top 0.9ft of sample., Percent Recovered 100.0%		
	12									
40				RQD 95 FF 2		C-10		SILTSTONE, very dark gray, fine grained, slightly weathered, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	13									
45										

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 3 of 6

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14			11 16 22 (38)		D-11		SILT, dense, very dark gray, moist, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
				RQD 28 FF 20		C-12		SILTSTONE, very dark gray, fine grained, moderately weathered, very weak rock, no HCl reaction. Discontinuities are very closely spaced and in poor condition, Percent Recovered 85.0%		
	15									
50				RQD 38 FF 20		C-13		SILTSTONE, very dark gray, fine grained, highly weathered, very weak rock, no HCl reaction. Discontinuities are very closely spaced and in poor condition, Percent Recovered 100.0%		
	16									
55			>>	14 23 33 (56)		D-14		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition Length Recovered 1.5 ft, Length Retained 1.5 ft		
	17			RQD 83 FF .5		C-15		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in fair condition, Percent Recovered 100.0%		
	18									
60				RQD 88 FF .6		C-16		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	19									
65				27 50/6" (50)		D-17		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition Length Recovered 0.9 ft, Length Retained 0.9 ft		
	20			RQD 87 FF .5		C-18		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	21									
70										

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 11/16/06 8:50:07 AM

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 4 of 6

Project SR 107 M.P. 4.7 Landslide Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				RQD 86 FF 2		C-19		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	22									
75										
	23		>>	21 28 48 (76)		D-20		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition Length Recovered 1.5 ft, Length Retained 1.5 ft		
				RQD 100 FF 0		C-21		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in execellent condition, Percent Recovered 100.0%		
	24									
80				RQD 90 FF .8		C-22		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	25									
85										
	26		>>	10 34 50/4" (84)		D-23		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition Length Recovered 1.3 ft, Length Retained 1.3 ft		
				RQD 100 FF .5		C-24		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	27									
90										
				RQD 92 FF 1.2		C-25		SILTSTONE, very dark gray, fine grained, slightly weathered, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	28									
95										

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 5 of 6

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	29			35 50/5" (50) RQD 97 FF .2		D-26 C-27		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition Length Recovered 0.9 ft, Length Retained 0.9 ft SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in fair condition, Percent Recovered 100.0%		
	30									
100				RQD 86 FF 2		C-28		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in fair condition, Percent Recovered 100.0%		
	31									
105	32			26 50/6" (50) RQD 85 FF .5		D-29 C-30		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition Length Recovered 0.8 ft, Length Retained 0.8 ft SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	33									
110				RQD 72 FF 1.5		C-31		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	34									
115	35			RQD 91 FF 1.6		C-32		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	36									
120										

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE GPJ SOILGD1 (r1706,8,2007 A)

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 6 of 6

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				35 50/6" (50) RQD 97 FF .5		D-33		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition Length Recovered 1.0 ft, Length Retained 1.0 ft		
	37					C-34		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	38									
125				RQD 73 FF 2		C-35		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	39									
130				RQD 95 FF .6		C-36		SILTSTONE, very dark gray, fine grained, fresh, very weak rock, no HCl reaction. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
	40									
	41									
135								End of test hole boring at 135.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	42									
140										
	43									
	44									
145										

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3A-06

Sheet 1 of 4

Job No. XL-2425 SR 107 Elevation ft (m)

Project SR 107 M.P. 4.7 Landslide Driller Vince Johnson Lic# 2532

Site Address SR-107 Vic. MP 4.7 Inspector Bill Hanning

Start January 10, 2006 Completion January 10, 2006 Well ID# AKK-384 Equipment CME 850 w/ autohammer

Station Offset Casing 5" Method Wet Rotary

Northing Easting Latitude Longitude

County Grays Harbor Subsection SE/NW Section 23 Range 8 WWM Township 17 N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				0 0 0 0 (0)		D-1		No Recovery		
	1									
5										
	2									
10	3									
	4									
15	5									
	6									
20										

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3A-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 2 of 4

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	7									
25										
	8									
	9									
30										
	10									
35										
	11									
	12									
40										
	13									
45										

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOILSGDT 1/17/08 8:38:13 AM

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3A-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 3 of 4

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14									
	15									
50										
	16									
55										
	17									
	18									
60										
	19									
65										
	20									
	21									
70										

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68317

HOLE No. H-3A-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 4 of 4

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	22									
75	23									
	24									
80	25									
85	26									
	27									
90	28							End of test hole boring at 89.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
95										

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68275

HOLE No. H-3B-06

Sheet 1 of 3

Job No. XL-2425 SR 107 Elevation ft (m)

Project SR 107 M.P. 4.7 Landslide Driller Vince Johnson Lic# 2532

Site Address SR-107 Vic. MP 4.7 Inspector Bill Hanning

Start January 11, 2006 Completion January 11, 2006 Well ID# AKK-269 Equipment CME 850 w/ autohammer

Station Offset Casing 5" Method Wet Rotary

Northing Easting Latitude Longitude

County Grays Harbor Subsection SE/NW Section 23 Range 8 WWM Township 17 N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				0 0 0 0 (0)		D-1		No Recovery		
	1									
5										
	2									
10	3									
	4									
15	5									
20	6									

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/06 8:58:17 AM

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68275

HOLE No. H-3B-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 2 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	7									
25										
	8									
	9									
30										
	10									
35										
	11									
	12									
40										
	13									
45										

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/06 8:58:17 AM

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68275

HOLE No. H-3B-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 3 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14									
	15									
50								End of test hole boring at 49.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	16									
55										
	17									
	18									
60										
	19									
65										
	20									
	21									
70										

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/06 8:56:17 AT

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68276

HOLE No. LT-2-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 1 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Thomas Harvey Lic# 2599

Site Address SR-107 Vic. MP 4.7

Inspector James Fetterly

Start January 12, 2006 Completion January 13, 2006 Well ID# AKK-270

Equipment CME 850 w/ autohammer

Station Offset Casing 6" X 69'

Method Wet Rotary

Northing Easting Latitude Longitude

County Grays Harbor Subsection SE/NW Section 23 Range 8 WWM Township 17 N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	1									
5	2			6 8 9 (17)		D-1 C-2		SILT, with trace sand and shell fragments, medium dense, yellowish brown, moist, Disrupted,Homogeneous, HCl reaction not tested, FEO stains throughout Length Recovered 1.5 ft, Length Retained 1.5 ft SILT, with trace shell fragments and sand, medium dense, yellowish brown, moist, Disrupted,Homogeneous, HCl reaction not tested, color changes from yellowish brown to grey Length Recovered 3.5 ft, Length Retained 3.5 ft		
10	3			6 7 8 (15)		D-3 C-4		SILT, with trace sand, medium dense, dark olive grey, moist, Blocky,Disrupted,Homogeneous, HCl reaction not tested Length Recovered 1.5 ft, Length Retained 1.5 ft SILT, to SILTSTONE, medium dense, dark olive grey, moist, Blocky,Disrupted,Homogeneous, HCl reaction not tested, FEO stained joints Length Recovered 3.0 ft, Length Retained 3.0 ft		
	4									
15	5			5 6 5 (11)		D-5 C-6		SILT, with trace sand, medium dense, dark olive grey, moist, Blocky,Disrupted,Homogeneous, HCl reaction not tested, FEO stains throughout Length Recovered 1.4 ft, Length Retained 1.4 ft 01/13/2006 SILT, with trace sand, medium dense, dark yg, moist, Blocky,Disrupted,Homogeneous, HCl reaction not tested, FEO stained joints Length Recovered 1.7 ft, Length Retained 1.7 ft	▽	
20	6			4 8		D-7		SILT, with trace sand, medium dense, dark olive grey, moist, Blocky,Disrupted,Homogeneous, HCl reaction not		

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68276

HOLE No. LT-2-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 2 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Thomas Harvey Lic# 2599

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				11 (19)		C-8		tested Length Recovered 1.5 ft, Length Retained 1.5 ft SILT, with SILTSTONE, medium dense, dark olive grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 2.0 ft, Length Retained 2.0 ft		
	7									
25				9 10 11 (21)		D-9		SILT, medium dense, dark olive grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 1.5 ft, Length Retained 1.5 ft		
	8					C-10		SILT, with SILTSTONE, medium dense, dark olive grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 2.0 ft, Length Retained 2.0 ft		
30	9			4 5 6 (11)		D-11		SILT, with trace sand and shell fragments, medium dense, dark olive grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 1.5 ft, Length Retained 1.5 ft		
						C-12		SILT, with SILTSTONE, medium dense, dark olive grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 2.5 ft, Length Retained 2.5 ft		
	10									
35				4 4 5 (9)		D-13		SILT, with shell fragments and sand, loose, dark olive grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 1.2 ft, Length Retained 1.2 ft		
	11			RQD 100 FF 0		C-14		SILTSTONE, dark grey, fine grained, slightly weathered, very weak rock, HCl reaction not tested. Discontinuities are very widely spaced and in good condition, Percent Recovered 100.0%		
40	12		>>	11 24 29 (53)		D-15		Sandy SILT, with trace shell fragments, very dense, dark olive grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 1.5 ft, Length Retained 1.5 ft		
				RQD 100 FF 0		C-16		SILTSTONE, brownish grey, fine grained, slightly weathered, very weak rock, HCl reaction not tested. Discontinuities are very widely spaced and in good condition, Percent Recovered 100.0%		
	13									
45			>>	11 31		D-17		SILT, very dense, dark grey, moist, Blocky,Homogeneous, HCl reaction not tested		

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/08 8:58:20 AM

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R-68276

HOLE No. LT-2-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 3 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Thomas Harvey Lic# 2599

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				46 (77) RQD 100 FF 0		C-18		Length Recovered 1.2 ft, Length Retained 1.2 ft SILTSTONE, brownish grey, fine grained, slightly weathered, very weak rock, HCl reaction not tested. Discontinuities are very widely spaced and in good condition, Percent Recovered 100.0%		
	14									
	15			15 34 50/5" (50) RQD 100 FF 0		D-19 C-20		SILT, with trace sand, very dense, dark grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 1.4 ft, Length Retained 1.4 ft SILTSTONE, brownish grey, fine grained, slightly weathered, very weak rock, HCl reaction not tested. Discontinuities are very widely spaced and in good condition, Percent Recovered 100.0%		
50										
	16									
				20 50/6" (50) RQD 100 FF 0		D-21 C-22		SILT, very dense, dark grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 1.0 ft, Length Retained 1.0 ft SILTSTONE, brownish grey, fine grained, slightly weathered, very weak rock, HCl reaction not tested. Discontinuities are very widely spaced and in good condition, Percent Recovered 100.0%		
55										
	17									
	18			16 50/6" (50) RQD 80 FF 0.8		D-23 C-24		SILT, very dense, grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 1.0 ft, Length Retained 1.0 ft SILTSTONE, brownish grey, fine grained, slightly weathered, very weak rock, HCl reaction not tested. Discontinuities are very widely spaced and in good condition, Percent Recovered 100.0%		
60										
	19									
				21 50/6" (50)		D-25		SILT, very dense, dark grey, moist, Blocky,Homogeneous, HCl reaction not tested Length Recovered 1.0 ft, Length Retained 1.0 ft		
65										
	20							End of test hole boring at 65 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	21									
70										

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/17/06,8:58:20 AM

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68276

HOLE No. P-2-06

Sheet 1 of 3

Job No. XL-2425 SR 107 Elevation ft (m)

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Site Address SR-107 Vic, MP 4.7

Inspector Bill Hanning

Start January 12, 2006 Completion January 12, 2006 Well ID# AKK-271

Equipment CME 850 w/ autohammer

Station Offset Casing 5"

Method Wet Rotary

Northing Easting Latitude Longitude

County Grays Harbor Subsection SE/NW Section 23 Range 8 WWM Township 17 N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				0 0 0 0 (0)		D-1		No Recovery		
	1									
5										
	2									
10	3									
	4									
15										
	5								01/12/2006	
20	6									

SOIL XL-2425 SR-107 MP 4.7 LANDSLIDE.GPJ SOIL.GDT 1/11/06 8:06:24 AM

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68276

HOLE No. P-2-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 2 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	7									
25										
	8									
	9									
30										
	10									
35										
	11									
	12									
40										
	13									
45										

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card R-68276

HOLE No. P-2-06

Job No. XL-2425 SR 107 Elevation ft (m)

Sheet 3 of 3

Project SR 107 M.P. 4.7 Landslide

Driller Vince Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								End of test hole boring at 44.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	14									
	15									
50										
	16									
55										
	17									
	18									
60										
	19									
65										
	20									
	21									
70										