



## HWA GEOSCIENCES INC.

*Geotechnical & Pavement Engineering • Hydrogeology • Geoenvironmental • Inspection & Testing*

June 25th, 2007

HWA Project No. 2007-094

Herrera Environmental Consultants, Inc.

2200 Sixth Avenue, Suite 1100

Seattle Washington 98121-1820

Attention: Mr. Mark Merkelbach

Subject: **LABORATORY TESTING REPORT  
& SOIL BEARING CAPACITY ESTIMATES  
NOOKACHAMPS PROJECT**

Dear Mr. Merkelbach:

As requested, HWA GeoSciences Inc. (HWA) performed laboratory testing for the above referenced project. Herein we present the results of our laboratory analyses, which are summarized on the attached test reports, Figures 1 through 6. The laboratory testing program was performed in general accordance with your instructions and appropriate ASTM Standards as outlined below. In addition, based upon the laboratory data developed for each soil type an estimate of the soils bearing capacity was calculated assuming the target moisture contents and densities specified by the client. The resulting bearing capacity estimates of each soil for a strip footing or a square foundation are shown on Figures 7 through 12.

**SAMPLE INFORMATION:** Four bulk soil samples were delivered to our laboratory on June 1, 2007, by Herrera personnel. The samples were delivered in four large plastic bags and were designated as TP-1A, TP-1B, TP-2B, and TP-3B. Visual inspection indicated that samples TP-1B and TP-2B were very similar and so those samples were combined for testing and designated TP-1B/2B.

**LABORATORY COMPACTION CHARACTERISTICS OF SOIL (PROCTOR TEST):** The moisture/density relationships for the three samples were determined using method ASTM D 1557 (Modified Proctor) Method C. The samples were fine grained and no correction for oversize material was required. The test results are summarized on the attached Laboratory Compaction Characteristics on Figures 1 through 3.

**SHEAR STRENGTH PARAMETERS OF SOIL:** Direct shear tests were conducted on each sample in general accordance with ASTM D-3080. Sample preparation included moisture conditioning the material to moisture content specified by the Client upon review of the Proctor test data. Three test specimens for each sample was prepared by remolding the soil into brass rings at the appropriate moisture content and target dry density as requested. Three shear trials were run at

19730 - 64th Avenue W.  
Suite 200  
Lynnwood, WA 98036.5957

Tel: 425.774.0106

Fax: 425.774.2714

[www.hwageosciences.com](http://www.hwageosciences.com)

normal stresses of 2.0, 4.0 and 6.0 ksf, respectively. The results of these tests are presented on the attached reports shown on Figures 4 through 6. The apparent cohesion and friction angle of the soils are inferred from a least-squares linear regression of the three test points.

#### **SOIL BEARING CAPACITY ESTIMATES**

Bearing Capacity estimates were based on friction angle and cohesion results obtained from Direct Shear testing. For this estimate, Terzaghi's ultimate bearing capacity equation was used. Two types of footings were considered: (1) strip footing, and, (2) square footing. The depth of the footing, in both cases, was assumed to be 2 feet. A factor of safety of 3 was used to calculate the associated allowable bearing capacity.

Figures 7 through 9 represent estimates of ultimate and allowable bearing capacity for strip footing foundations with a width dimension B, and Figures 10 through 12 represent estimates of bearing capacity for square shaped footings with a side dimension of B.

These calculations assume that the fill containing the soil in question is placed in a controlled environment at a uniform density and moisture. We estimate that, when loaded, these soils will exhibit settlements of the order of 6% to 10%. A consolidation test on these soils should be performed in order to obtain more specific values for the anticipated settlement.

Based on the shear data unconfined fill slopes should be no steeper than 3H: 1V. We expect that the material can be compacted more efficiently with a heavyweight sheep foot roller. Soil placement and compaction should be monitored on a full time basis by a licensed geotechnical engineer.



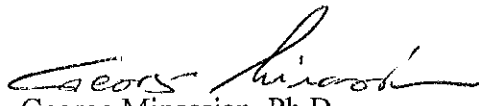
**CLOSURE:** Experience has shown that test values on soil and other natural materials vary with each representative sample. As such, HWA has no knowledge as to the extent and quantity of material the tested sample may represent. This report should not be reproduced without the expressed written consent of the Client, and then only in its entirety. The estimate contained herein are theoretical and are for use by the client for feasibility purposes only and not for final design. Additional evaluation, including seismic and/or liquefaction potential, as well as consolidation properties need to be addressed more thoroughly. Actual bearing capacity of fill will depend on field methods used and soil conditions at the time of construction.

June 25<sup>th</sup>, 2007  
HWA Project No. 2007-094

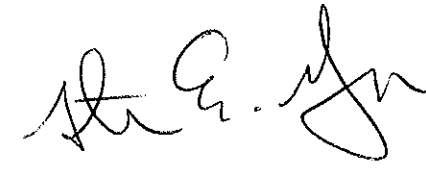
We appreciate the opportunity to provide laboratory testing services on this project. Should you have any questions or comments, or if we may be of further service, please call.

Sincerely,

HWA GEOSCIENCES INC.



George Minassian, Ph.D.  
Geotechnical Engineer



Steven E. Greene, L.E.G.  
Vice-President

SEG:GM:seg

Attachments:

Figures 1-3    Laboratory Compaction Characteristics of Soil  
Figures 4-6    Direct Shear Test of Soils under Consolidated Drained Conditions Report  
Figures 7-9    Bearing Capacity Estimates for Strip Footings  
Figures 10-12    Bearing Capacity Estimates for Square Footings

# LABORATORY COMPACTION CHARACTERISTICS OF SOIL



HWA GEOSCIENCES INC.

CLIENT: Herrera Environmental Consultants Inc.

PROJECT: Nookachamps

SAMPLE ID: TP-1A

PROJECT NO: 2007094

Sampled By: Client

Tested By: EJB

Date Sampled: \_\_\_\_\_

Date Received: 06/07/2007

Date Tested: 06/07/2007

## MATERIAL TYPE OR DESCRIPTION:

Gray brown CLAY with organics

## MATERIAL SOURCE, SAMPLE LOCATION AND DEPTH:

On site: TP-1A

Designation: ☐ ASTM D 698

☒ ASTM D 1557

Natural Moisture Content: 41.6 %

Method: ☐ A

☐ B

☒ C

Oversize: 0 % retained on: 3/4 in.

Preparation: ☐ Dry

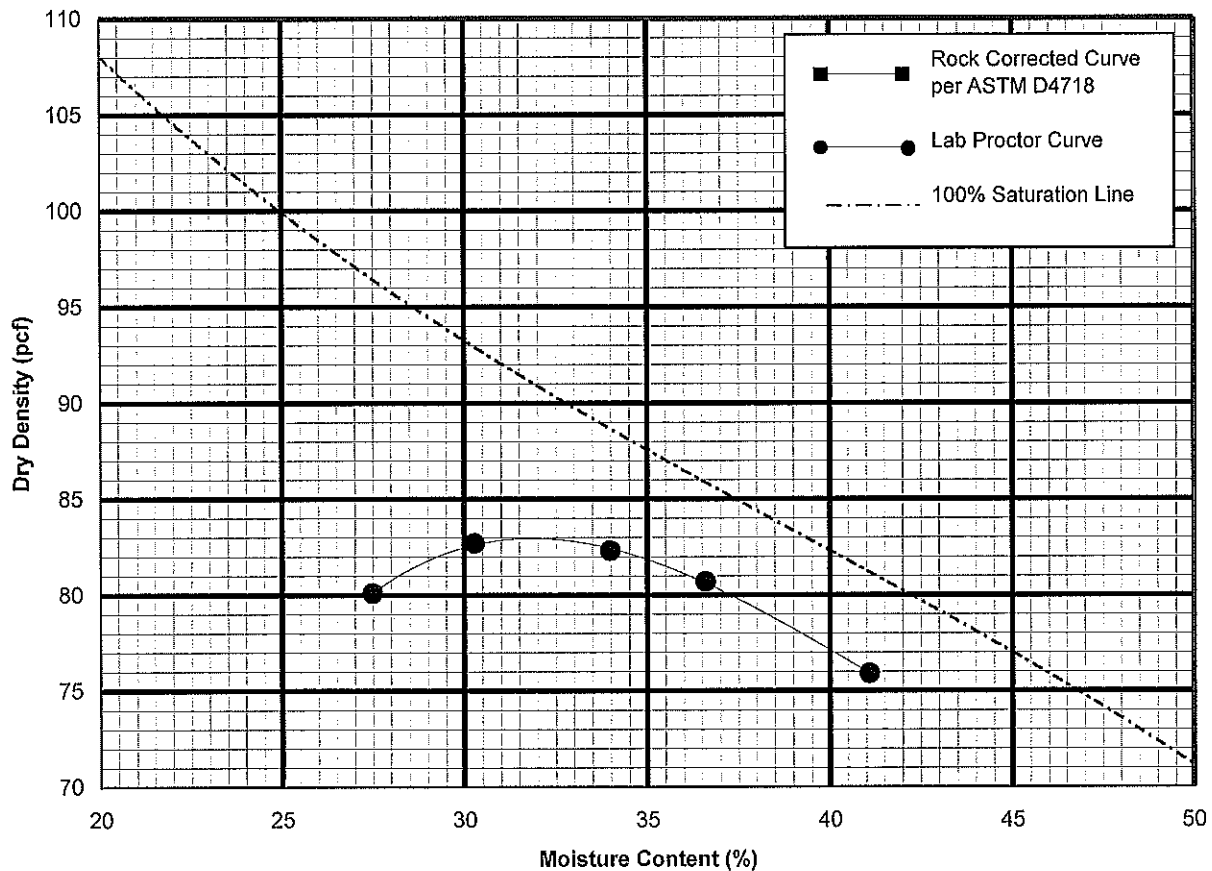
☒ Moist

Rammer: ☒ Auto ☐ Manual

Assumed S.G.: 2.65

## Test Data

Dry Density (pcf)	82.7	80.7	75.9	82.3	80.1
Moisture Content (%)	30.3	36.6	41.1	34.0	27.5



## Data Summary\*

Percent Oversize	<5%
Max. Dry Density (pcf)*	83.0
Optimum Moisture (%)*	32.0

## Test Values At Other Oversize Percentages

0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%
83.0	85.1	87.4	89.7	92.2	94.8	97.6
32.0	30.5	28.9	27.4	25.8	24.3	22.7

\* values corrected for oversize material per ASTM D4718, using assumed Specific Gravity shown and oversize moisture content of 1%

Reviewed By: \_\_\_\_\_

FIGURE 1

# LABORATORY COMPACTION CHARACTERISTICS OF SOIL



HWA GEOSCIENCES INC.

CLIENT: Herrera Environmental Consultants Inc.

PROJECT: Nookachamps

SAMPLE ID: TP-1B & TP-2B

PROJECT NO: 2007094

Sampled By: Client

Tested By: EJB

Date Sampled: \_\_\_\_\_

Date Received: 06/07/2007

Date Tested: 06/07/2007

## MATERIAL TYPE OR DESCRIPTION:

Brown SILT

## MATERIAL SOURCE, SAMPLE LOCATION AND DEPTH:

On site TP-1B & TP-2B

Designation: ☐ ASTM D 698

☒ ASTM D 1557

Natural Moisture Content: 33.8/35.2 %

Method: ☐ A

☐ B

☒ C

Oversize: 0 % retained on: 3/4 in.

Preparation: ☐ Dry

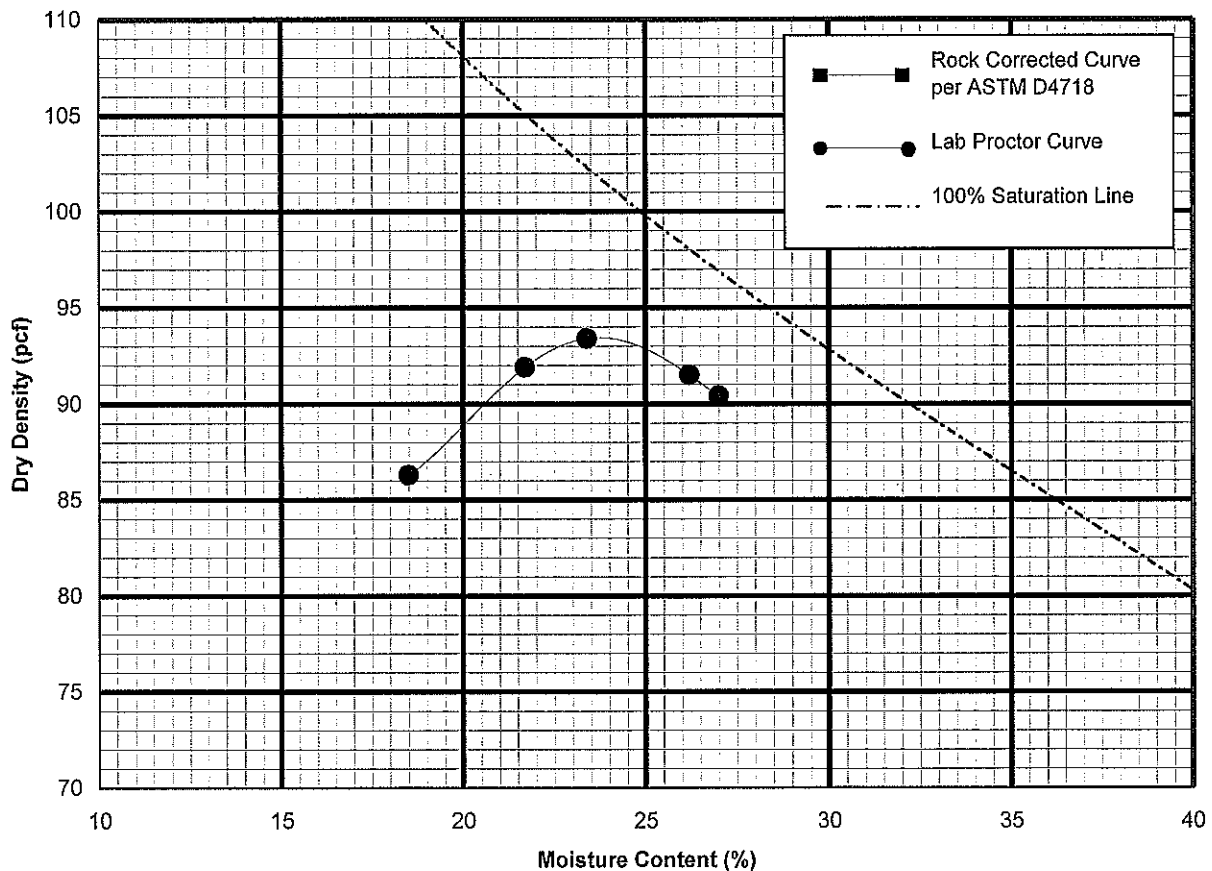
☒ Moist

Rammer: ☒ Auto ☐ Manual

Assumed S.G.: 2.65

## Test Data

Dry Density (pcf)	86.3	91.9	93.4	91.5	90.4
Moisture Content (%)	18.5	21.7	23.4	26.2	27.0



## Data Summary\*

Percent Oversize	<5%
Max. Dry Density (pcf)*	93.4
Optimum Moisture (%)*	24.0

## Test Values At Other Oversize Percentages

0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%
93.4	95.5	97.7	99.9	102.3	104.8	107.4
24.0	22.9	21.7	20.6	19.4	18.3	17.1

\* values corrected for oversize material per ASTM D4718, using assumed Specific Gravity shown and oversize moisture content of 1%

Reviewed By: \_\_\_\_\_

FIGURE 2

# LABORATORY COMPACTION CHARACTERISTICS OF SOIL



HWA GEOSCIENCES INC.

CLIENT: Herrera Environmental Consultants Inc.

PROJECT: Nookachamps

SAMPLE ID: TP-3B

PROJECT NO: 2007094

Sampled By: Client

Tested By: EJB

Date Sampled: \_\_\_\_\_

Date Received: 06/07/2007

Date Tested: 06/07/2007

## MATERIAL TYPE OR DESCRIPTION:

Brown, SILT with fine sand

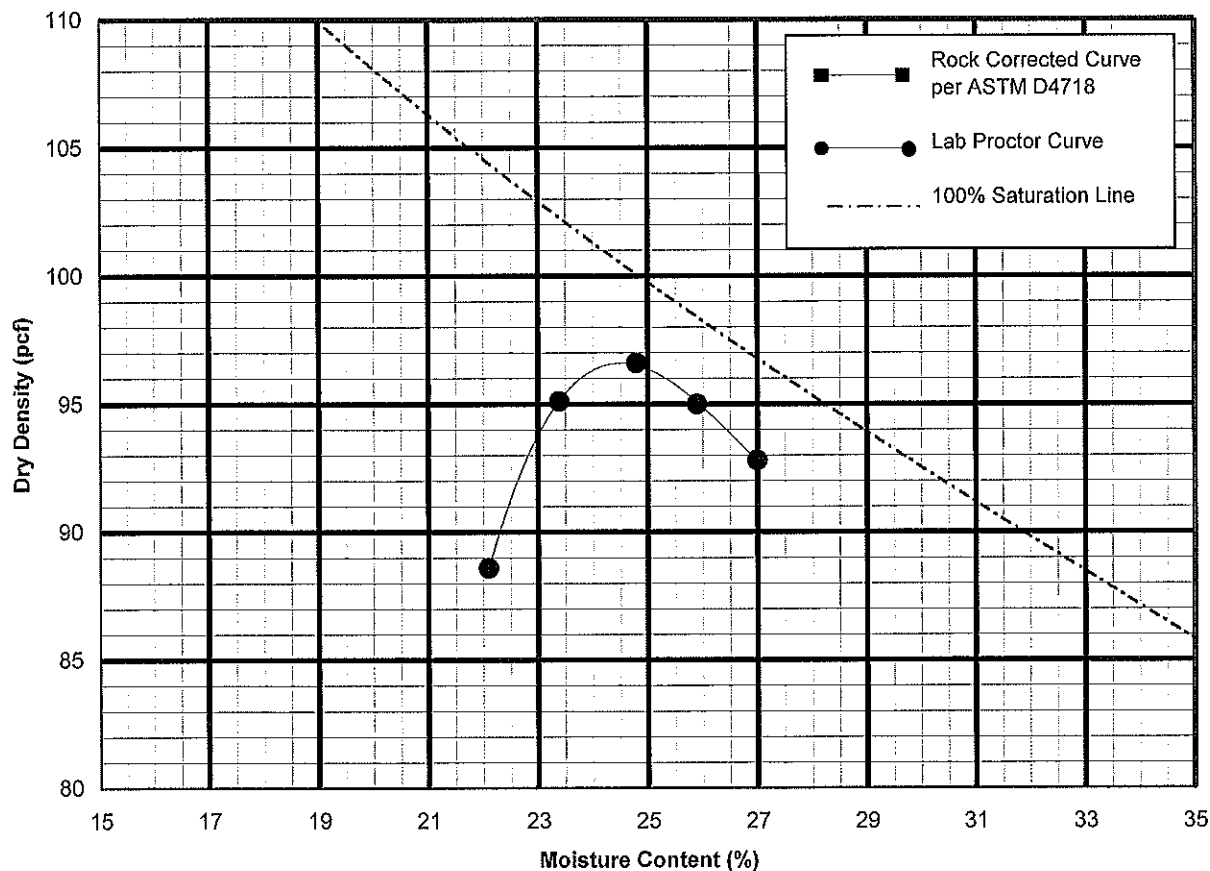
## MATERIAL SOURCE, SAMPLE LOCATION AND DEPTH:

On site TP-3B

Designation: ☐ ASTM D 698 ☒ ASTM D 1557 Natural Moisture Content: 42.2 %  
 Method: ☐ A ☐ B ☒ C Oversize: 0 % retained on: 3/4 in.  
 Preparation: ☐ Dry ☒ Moist Rammer: ☒ Auto ☐ Manual Assumed S.G.: 2.65

## Test Data

Dry Density (pcf)	88.6	95.1	96.6	95.0	92.8
Moisture Content (%)	22.1	23.4	24.8	25.9	27.0



## Data Summary\*

Percent Oversize	<5%
Max. Dry Density (pcf)*	96.7
Optimum Moisture (%)*	24.5

## Test Values At Other Oversize Percentages

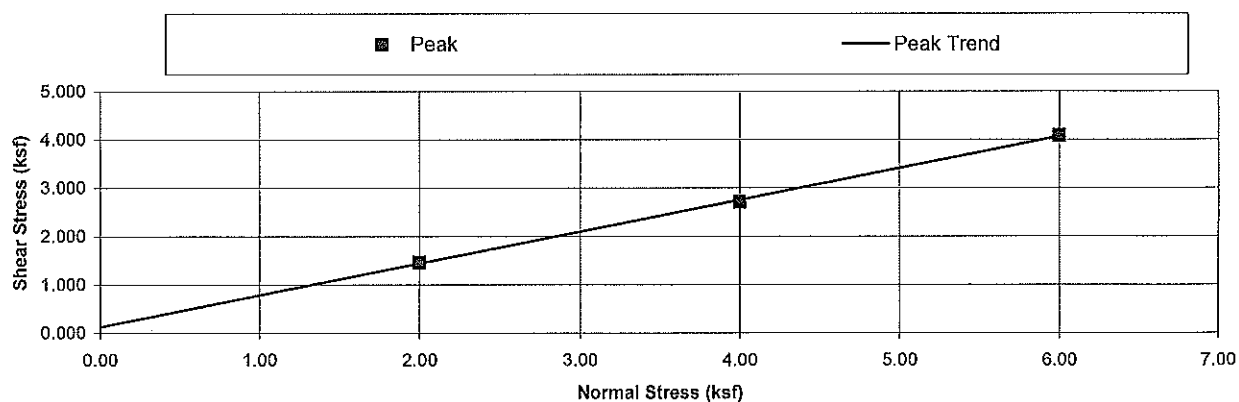
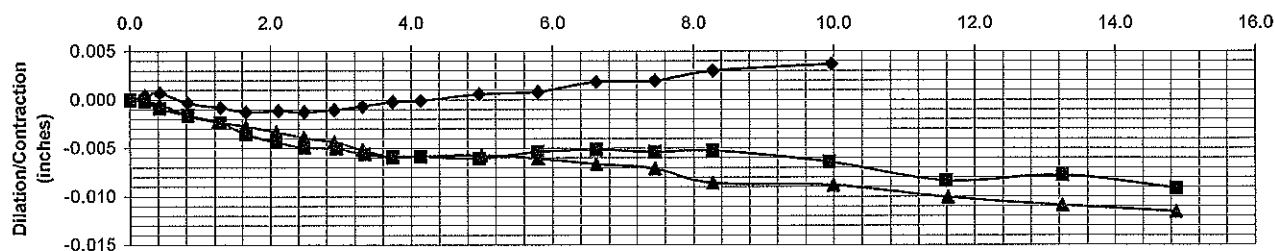
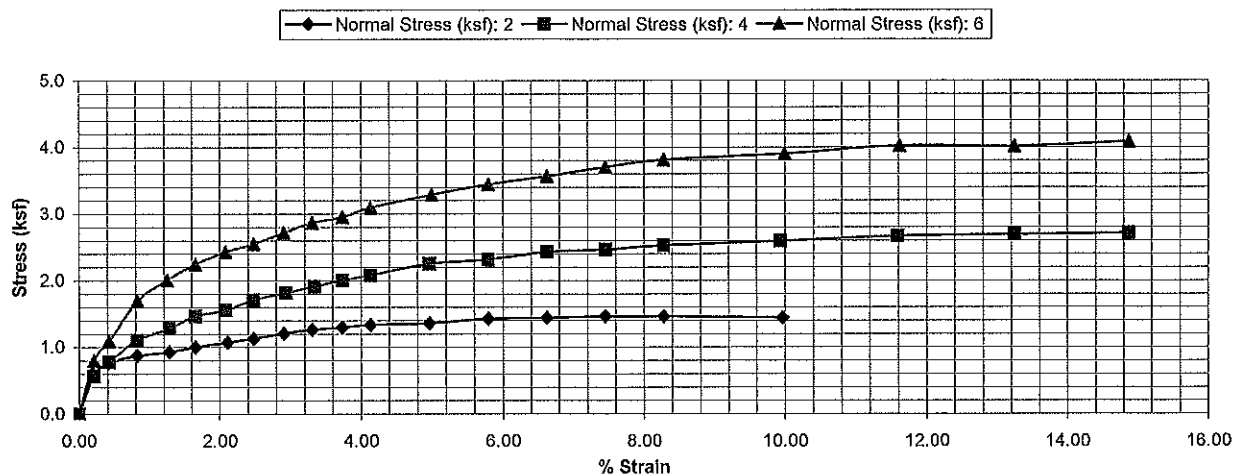
0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%
96.7	98.8	100.9	103.1	105.5	107.9	110.5
24.5	23.3	22.2	21.0	19.8	18.6	17.5

\* values corrected for oversize material per ASTM D4718, using assumed Specific Gravity shown and oversize moisture content of 1%

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FIGURE 3

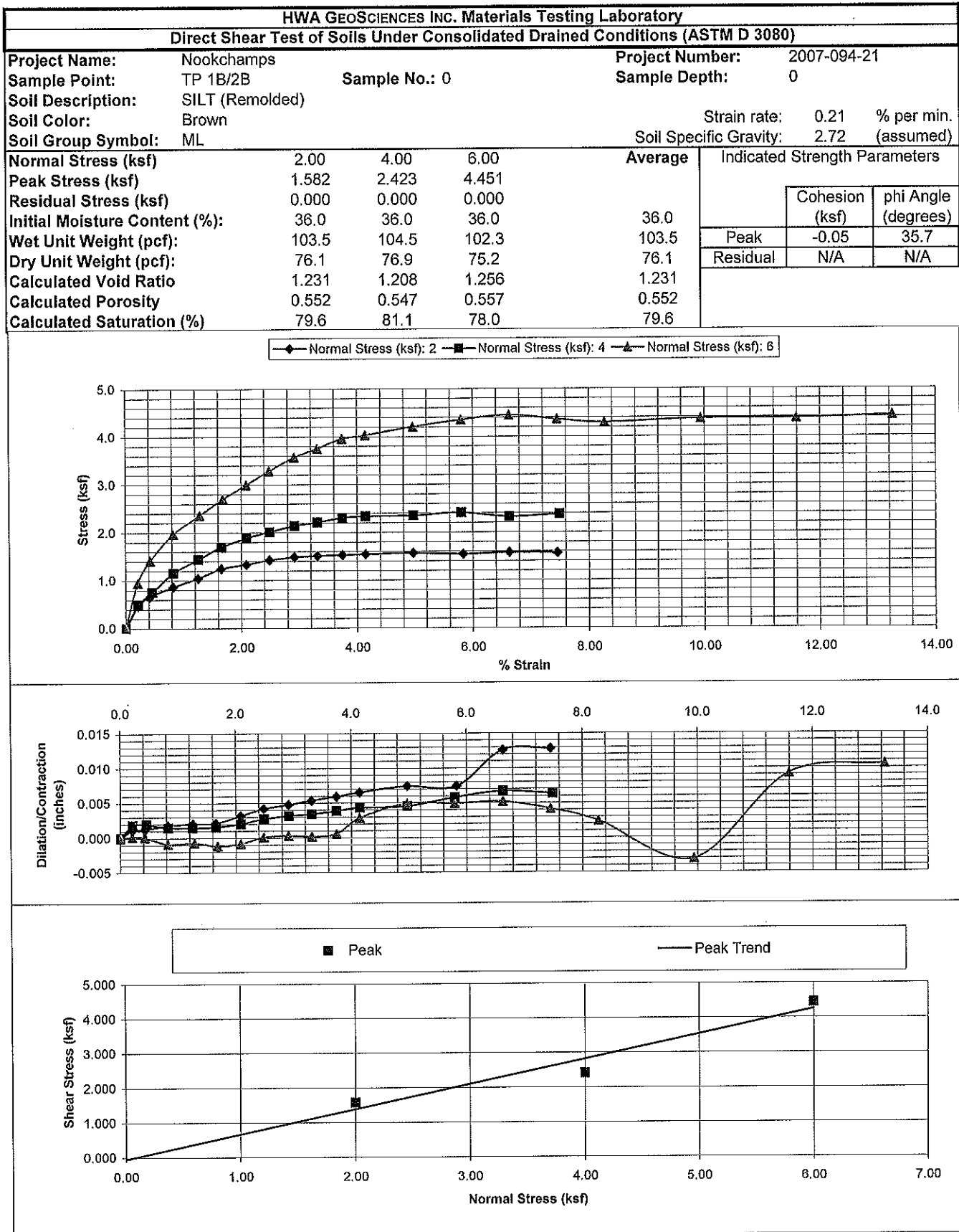
HWA GEOSCIENCES INC. Materials Testing Laboratory															
Direct Shear Test of Soils Under Consolidated Drained Conditions (ASTM D 3080)															
Project Name:	Nookchamps			Project Number:	2007-094-21										
Sample Point:	TP 1A	Sample No.: 0		Sample Depth:	0										
Soil Description:	CLAY (Remolded)														
Soil Color:	Gray Brown				Strain rate:	0.21 % per min.									
Soil Group Symbol:	CL				Soil Specific Gravity:	2.72 (assumed)									
Normal Stress (ksf)	2.00	4.00	6.00	Average	Indicated Strength Parameters										
Peak Stress (ksf)	1.460	2.712	4.087												
Residual Stress (ksf)	0.000	0.000	0.000												
Initial Moisture Content (%):	42.0	42.0	42.0	42.0											
Wet Unit Weight (pcf):	105.9	106.1	105.7	105.9											
Dry Unit Weight (pcf):	74.6	74.7	74.4	74.6											
Calculated Void Ratio	1.275	1.271	1.281	1.276	<table><tr><td></td><td>Cohesion (ksf)</td><td>phi Angle (degrees)</td></tr><tr><td>Peak</td><td>0.13</td><td>33.3</td></tr><tr><td>Residual</td><td>N/A</td><td>N/A</td></tr></table>			Cohesion (ksf)	phi Angle (degrees)	Peak	0.13	33.3	Residual	N/A	N/A
	Cohesion (ksf)	phi Angle (degrees)													
Peak	0.13	33.3													
Residual	N/A	N/A													
Calculated Porosity	0.561	0.560	0.562	0.561											
Calculated Saturation (%)	89.6	89.8	89.2	89.5											



Checked By:

George Minassian

Figure 4



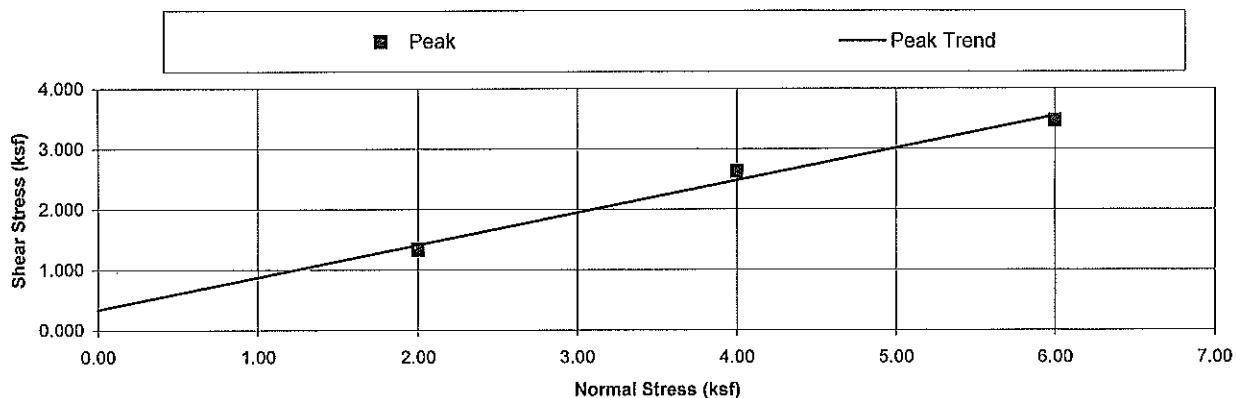
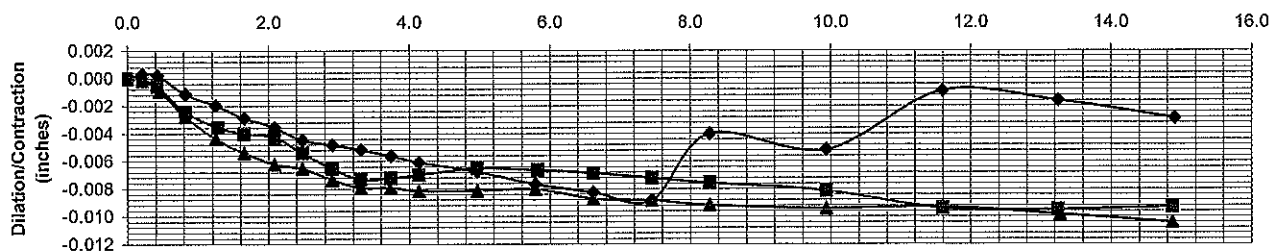
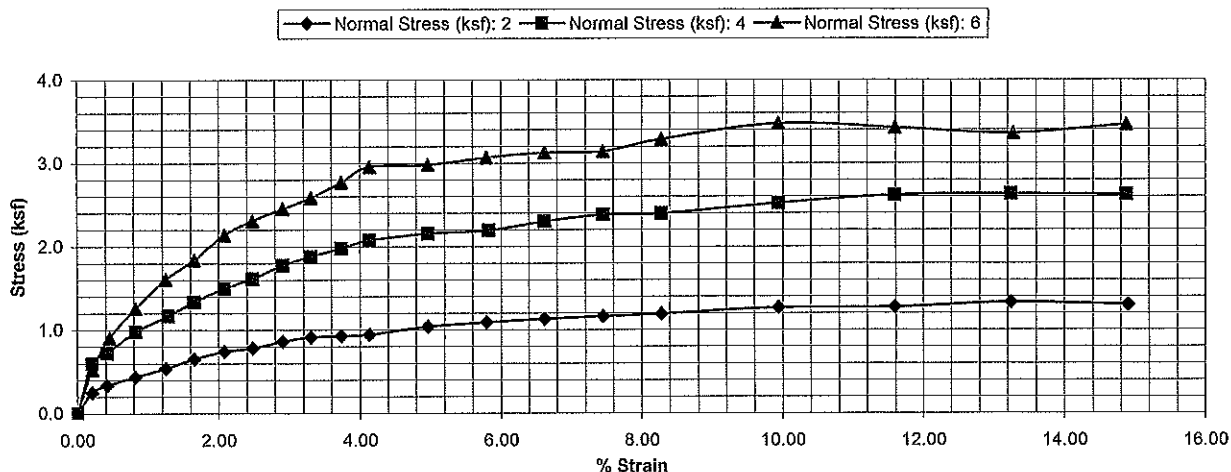
Checked By:

George Minassian

Figure 5



HWA GEOSCIENCES INC. Materials Testing Laboratory						
Direct Shear Test of Soils Under Consolidated Drained Conditions (ASTM D 3080)						
Project Name:	Nookchamps			Project Number:	2007-094-21	
Sample Point:	TP 3B			Sample Depth:	0	
Soil Description:	SILT (Remolded)			Sample No.:	0	
Soil Color:	Brown			Strain rate:	0.21 % per min.	
Soil Group Symbol:	ML			Soil Specific Gravity:	2.72 (assumed)	
Normal Stress (ksf)	2.00	4.00	6.00	Average	Indicated Strength Parameters	
Peak Stress (ksf)	1.331	2.632	3.473			
Residual Stress (ksf)	0.000	0.000	0.000			
Initial Moisture Content (%):	36.0	36.0	36.0	36.0	Cohesion (ksf)	phi Angle (degrees)
Wet Unit Weight (pcf):	102.0	102.5	102.3	102.3	Peak	0.34 28.2
Dry Unit Weight (pcf):	75.0	75.3	75.2	75.2	Residual	N/A N/A
Calculated Void Ratio	1.264	1.253	1.256	1.258		
Calculated Porosity	0.558	0.556	0.557	0.557		
Calculated Saturation (%)	77.5	78.2	78.0	77.9		



Checked By:

George Minassian

Figure 6

# Bearing Capacity (Terzaghi) TP1A

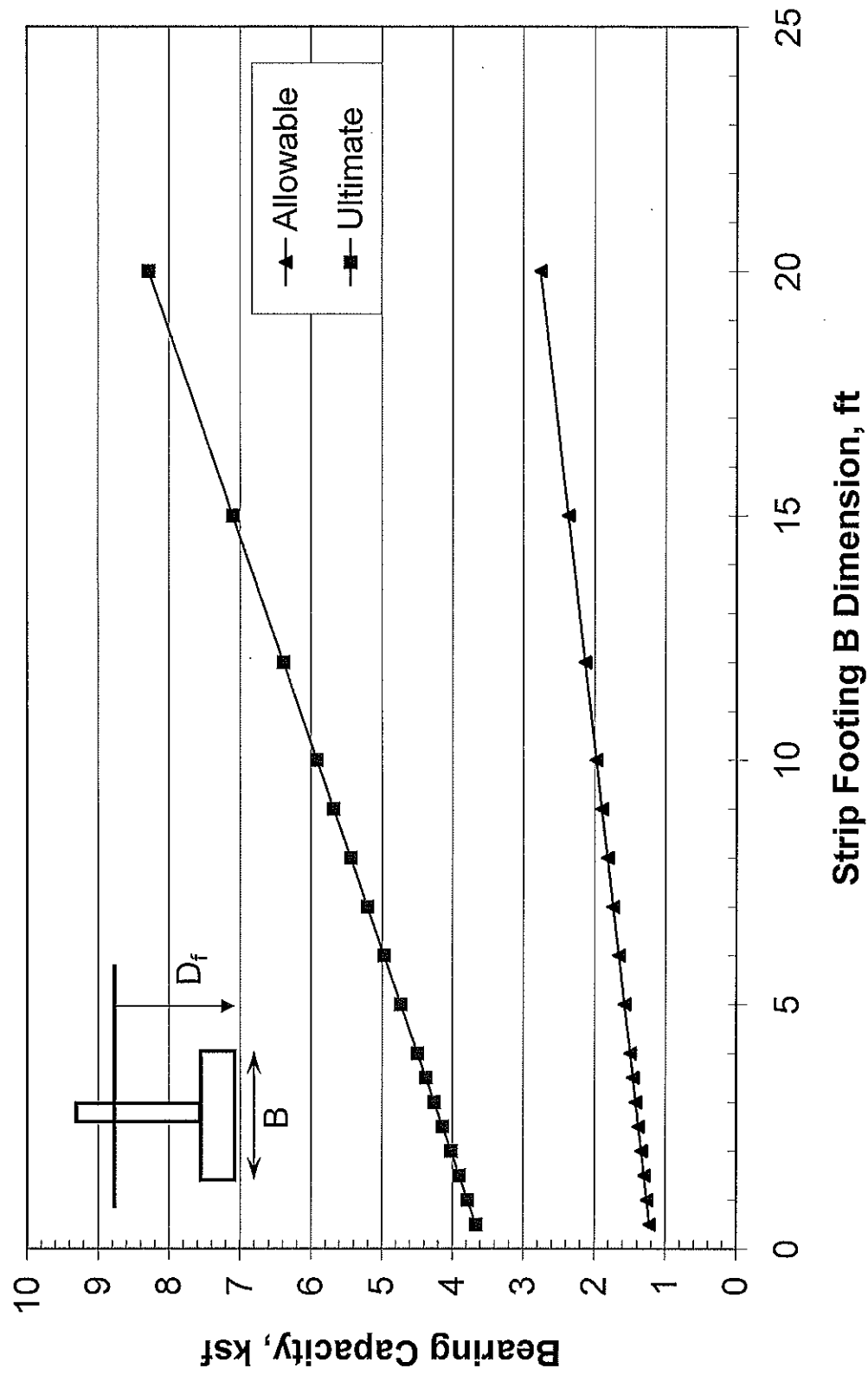


FIGURE 7

# Bearing Capacity (Terzaghi) TP1B/2B

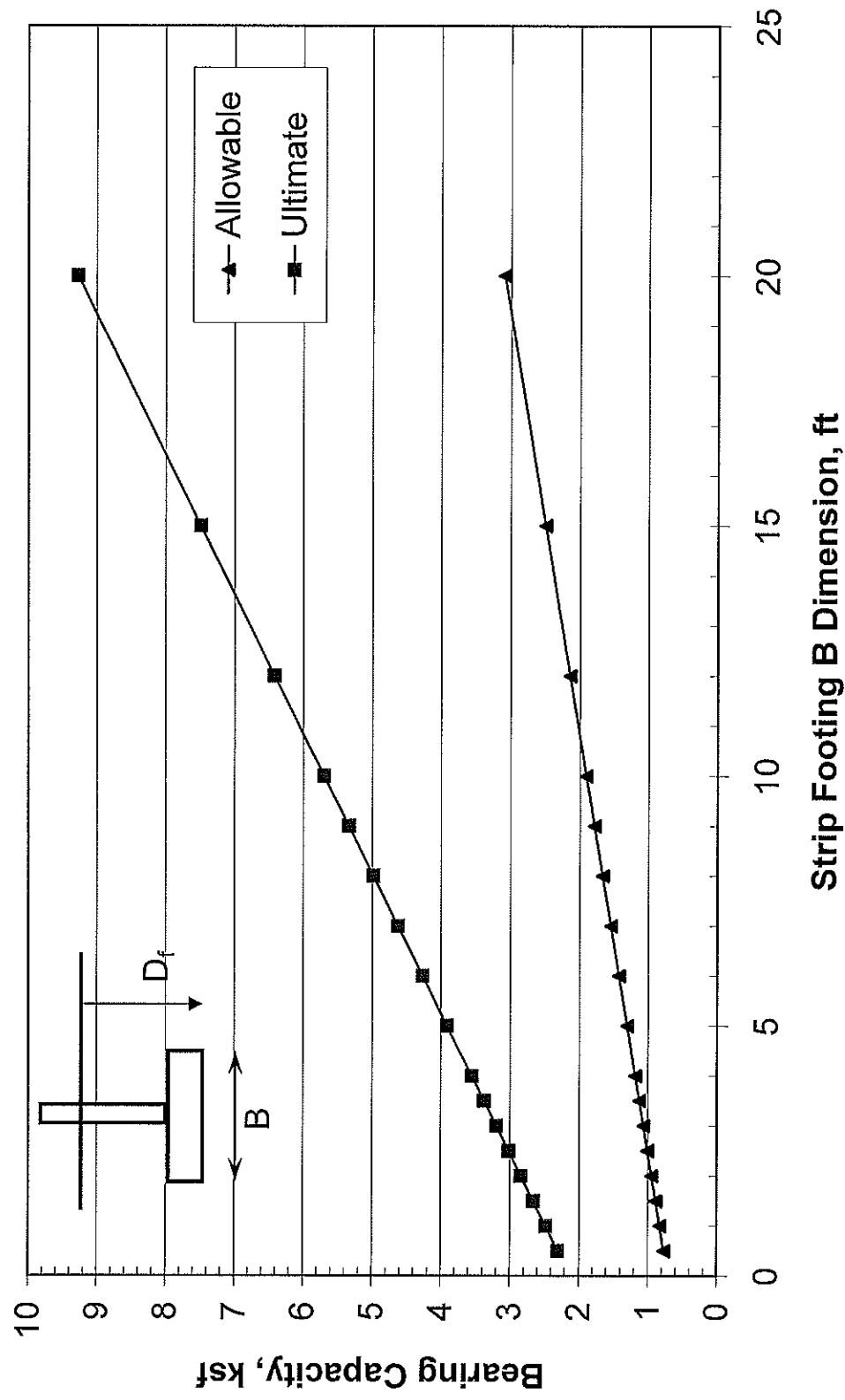


FIGURE 8

# **Bearing Capacity (Terzaghi)** **TP3B**

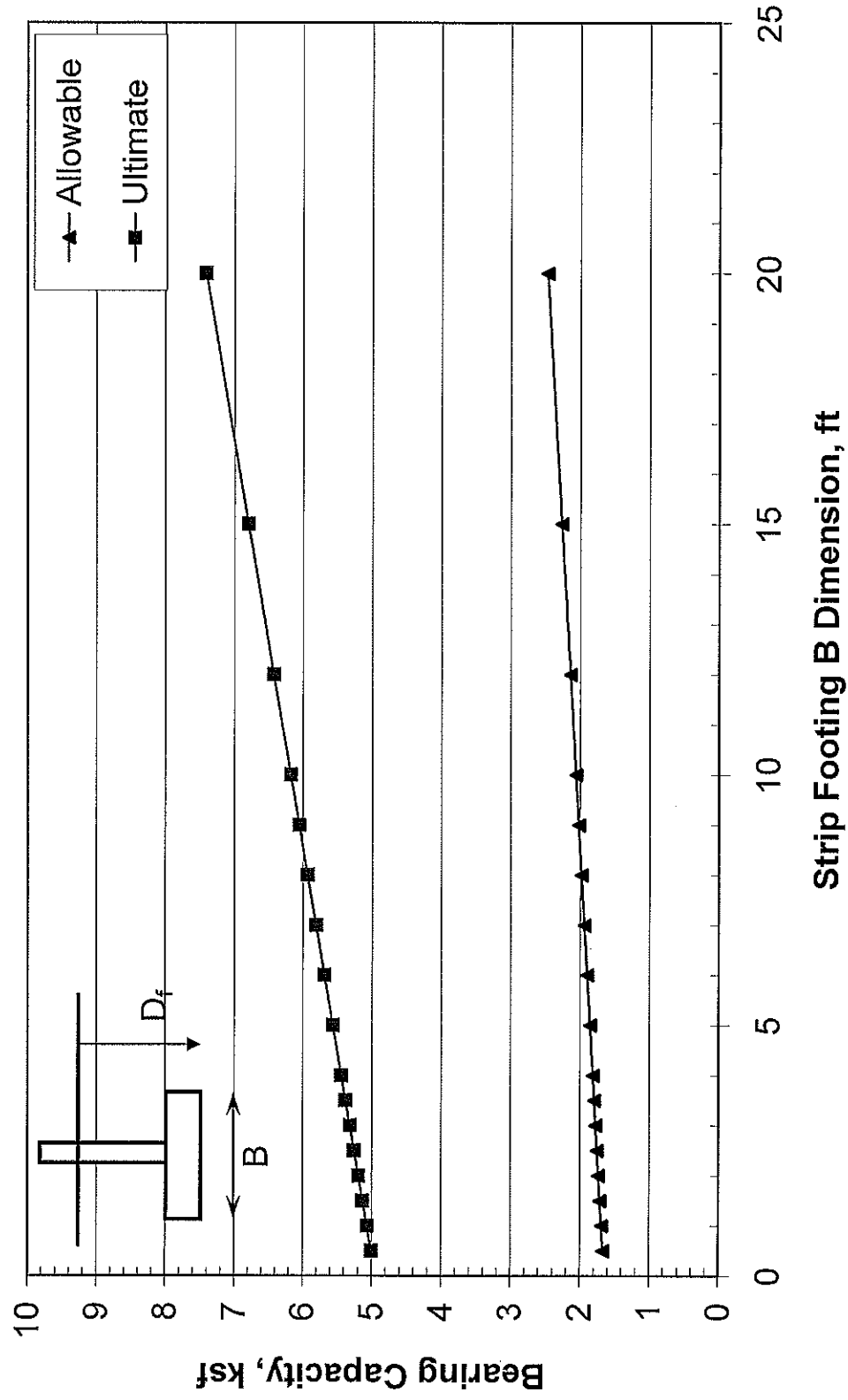


FIGURE 9

# **Bearing Capacity (Terzaghi) for Square Footing** **TP1A**

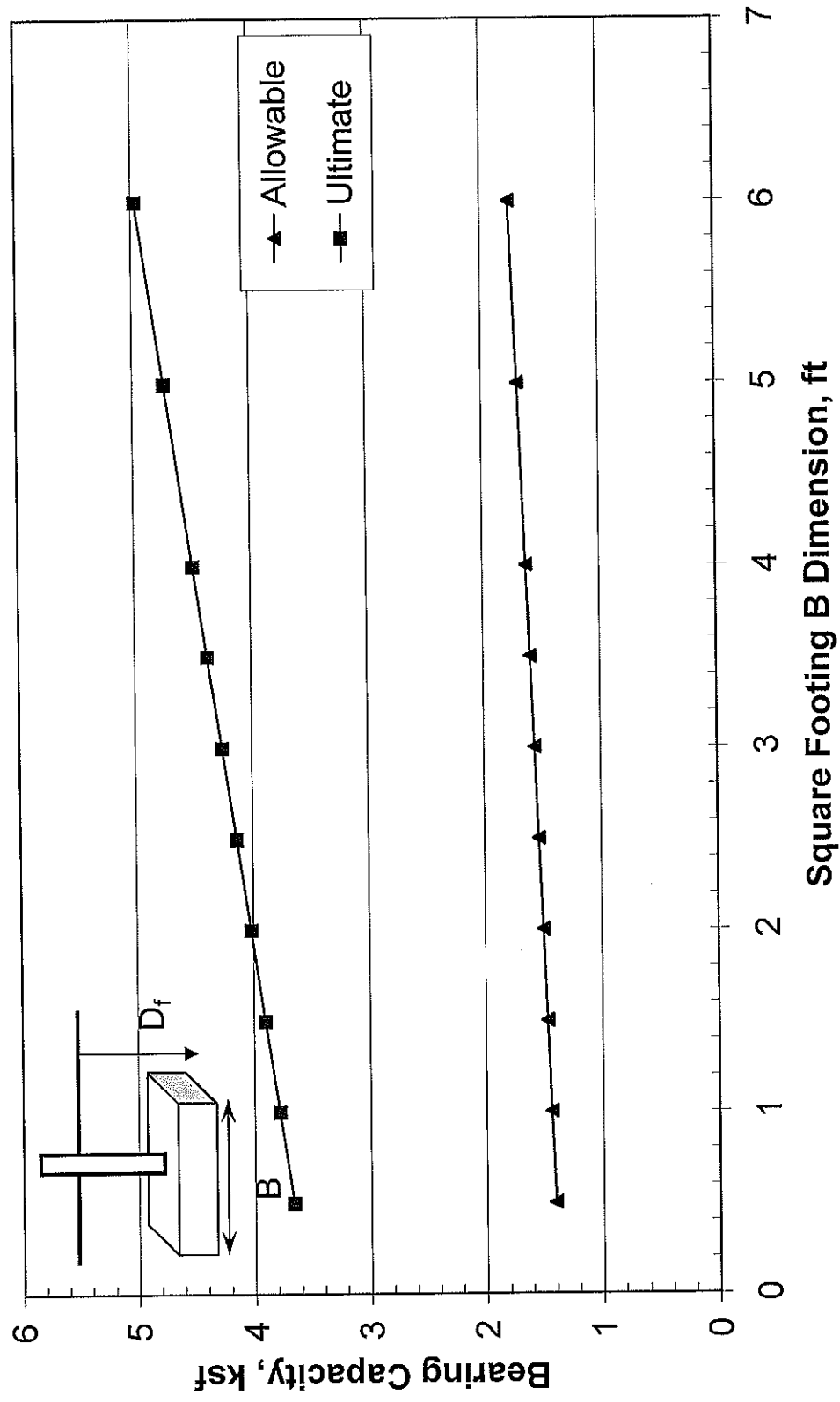


FIGURE 10

# **Bearing Capacity (Terzaghi) for Square Footing** **TP1B/2B**

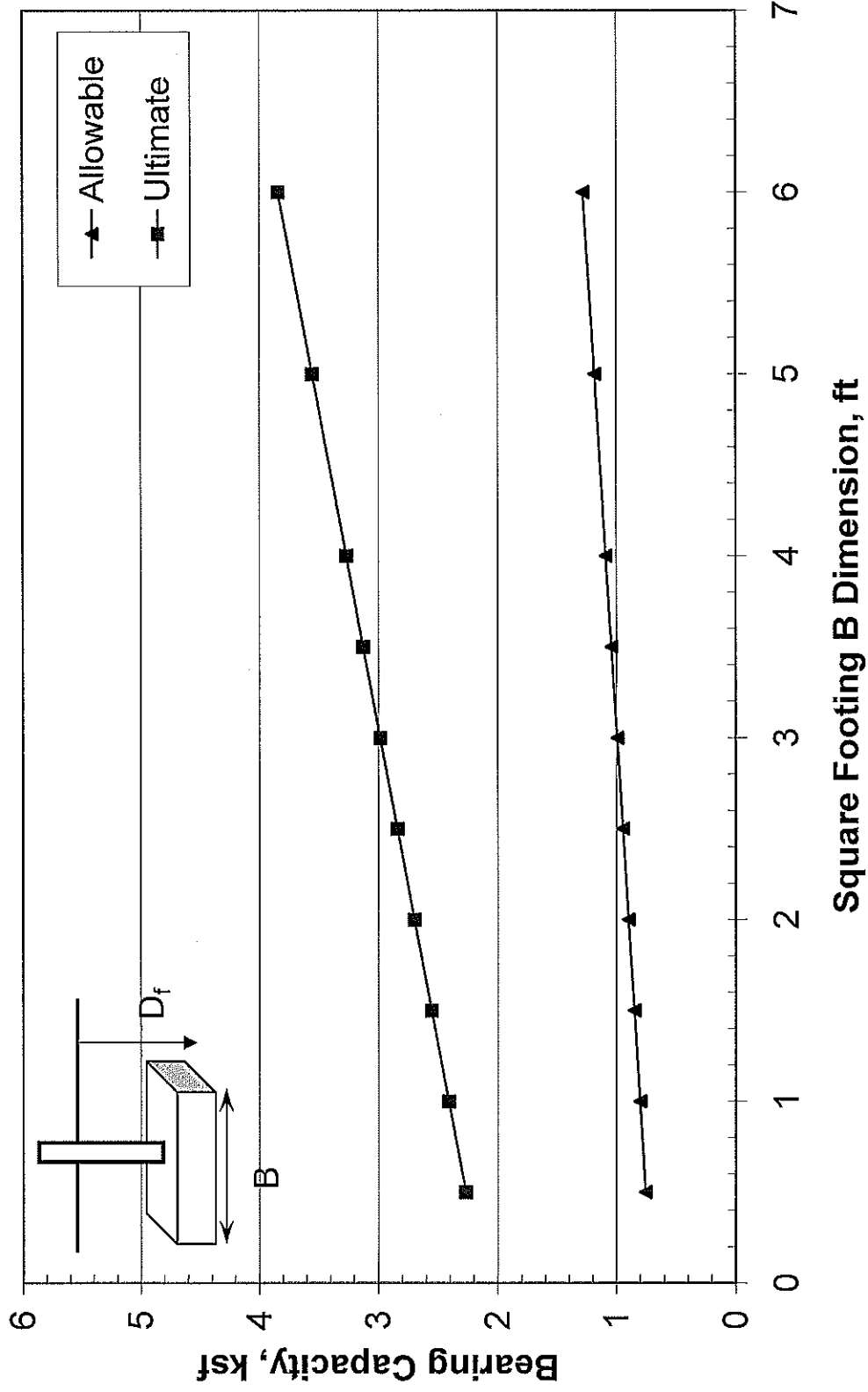


FIGURE 11

# Bearing Capacity (Terzaghi) for Square Footing TP3B

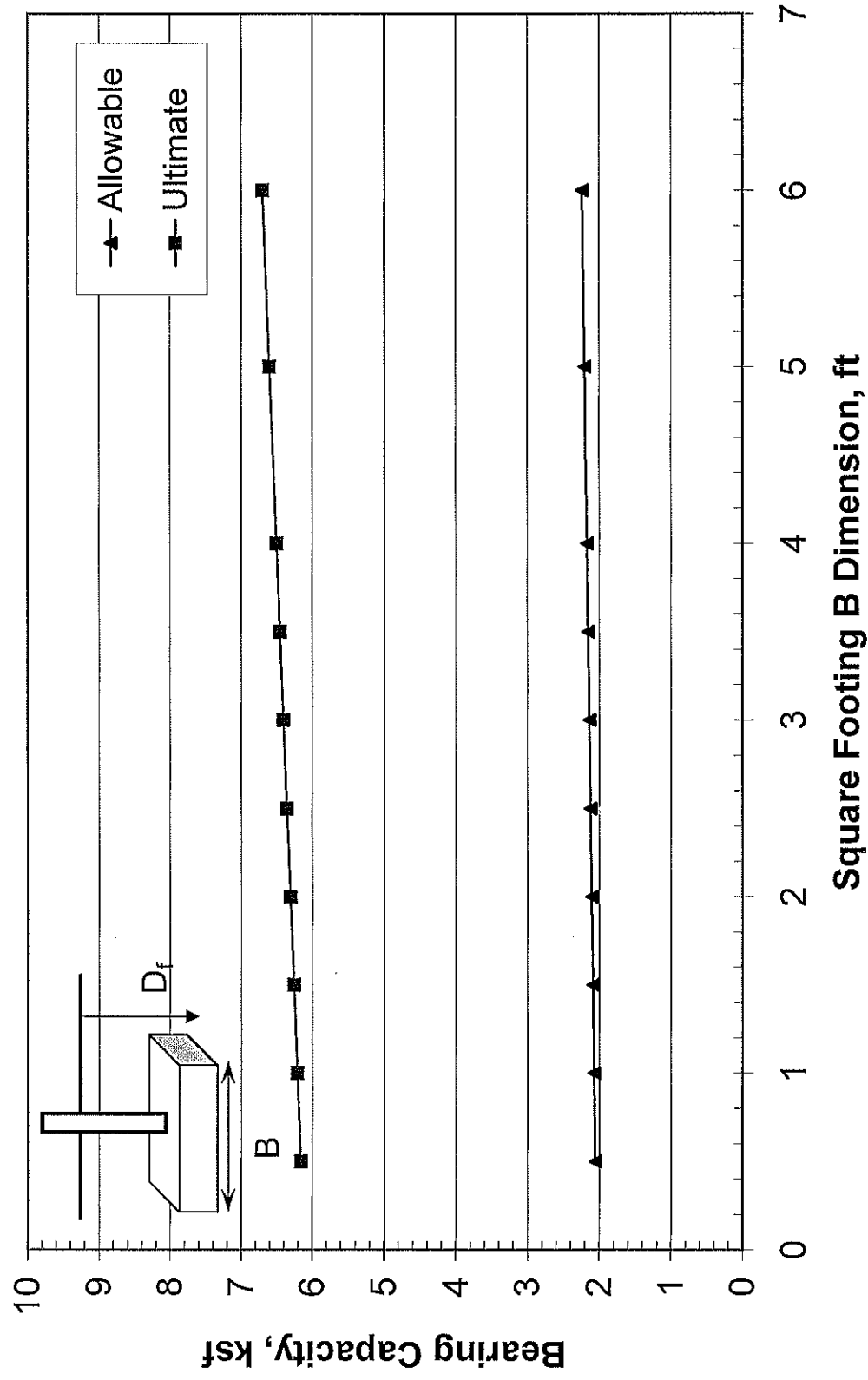


FIGURE 12