19th AVE. BRIDGE.

ACDC BRIDGE AT 19th AVENUE

Phoenix, Arizona

Registered Professional Engineer
CERTIFICATE NO. 12875
STEVEN A. HAIRE
Date Signed 6-25-87
ARIZONA, U.S.A.

Prepared for

Entranco Mann Johnson Engineers
8805 North 23rd Avenue, Suite 9
Phoenix, Arizona

THOMAS-HARTIG & ASSOCIATES, INC.
SOIL AND FOUNDATION ENGINEERING • MATERIALS TESTING

THOMAS-HARTIG & ASSOCIATES, INC.
TOM W. THOMAS, P.E. · HARRY E. HARTIG, P.E.
Soil and Foundation Engineering · Materials Testing
7031 West Oakland Street Chandler, Arizona 85226 602/961-1169

25 June 1987

Entranco Mann Johnson Engineers, Inc.
8805 North 23rd Avenue, Suite 9
Phoenix, Arizona 85021

Attention: William Kanton

Project: ACDC Bridge at 19th Avenue
Phoenix, Arizona

Project No: 87-0478

This report presents the results of the geotechnical engineering services authorized on the site for the ACDC Bridge at 19th Avenue. The purpose of these services is to determine the soil conditions at the locations indicated which thereby provide a basis for the design discussions and recommendations presented herein. This firm should be notified for evaluation if conditions other than described herein are encountered during construction.

The services performed provide an evaluation at selected locations of the soils throughout the zone of significant foundation influence. Our field services have not included exploration for underlying geologic conditions or evaluation of potential geologic hazards such as seismic activity, faulting, and ground subsidence/cracking potential due to groundwater withdrawal.

The recommendations included are presented based upon the project information received and described in "Scope" Part I. This firm should be contacted for review if the design conditions are changed substantially.

Complimentary to this report, we will be pleased to review project plans and specifications relative to compliance to the intent of this report.

Respectfully submitted,

THOMAS-HARTIG & ASSOCIATES, INC.

By: Steven A. Haire, P.E.

Registered Professional Engineer
CERTIFICATE No. 12...
STEVEN A. HAIRE
Date Signed 6-25-87
ARIZONA, U.S.A.

Reviewed by: Kenneth L. Ricker, P.E.

Registered Professional Engineer
CERTIFICATE No. 10971
KENNETH L. RICKER
Date Signed 6-25-87
ARIZONA, U.S.A.

/cb

Copies to: Addressee (5)

THOMAS-HARTIG & ASSOC. 1977 10th ANNIVERSARY 1987 CHANDLER, ARIZ.

TABLE OF CONTENTS

Registered Professional Engineer (Civil)
CERTIFICATE NO.
STEVEN A. HAIRE
Date Signed 6-25-87
ARIZONA

PROJECT NO: 87-0478

PART I

REPORT

SCOPE

A new at-grade single-span bridge will be constructed on 19th Avenue adjacent to and north of the Arizona Canal over the proposed Arizona Canal Diversion Channel (ACDC) as shown on the attached site plan. Preliminary design and construction sequence for the proposed bridge structure are as follows:

1. The bridge will be constructed at-grade prior to excavation of the ACDC channel. Foundation loads at the abutments will be supported on drilled, cast-in-place concrete piers.

2. At a later date, the ACDC will be excavated below the bridge superstructure with vertical side walls, utilizing the in-place closely spaced bridge abutment drilled piers to retain the excavation. A reinforced concrete wall will then be attached to the piers to provide the finished vertical channel walls. The ACDC will be concrete lined, both sides and bottom, in the vicinity of the proposed bridge.

3. The proposed bridge structure will have a span of about 61 feet, and a width of about 84 feet. Preliminary designs call for a total of 11 drilled piers at each abutment, spaced about 7.75 feet apart. Structural loads for the drilled piers have been estimated by Entranco Mann Johnson Engineers to be less than about 150 kips each.

4. In addition to the bridge structure, the project will include relocation of several sewer lines.

This firm should be contacted for review and possible supplemental recommendations when the design concepts and construction sequences have been finalized.

SITE DESCRIPTION

The proposed bridge site is located within the right of way of 19th Avenue just north of the Arizona Canal in Phoenix, Arizona. The bridge will carry traffic at-grade on 19th Avenue across the proposed ACDC. The ACDC channel at this location will be excavated approximately 28 feet deep and 60 feet wide. There are numerous underground utilities beneath the street at the proposed bridge location.

INVESTIGATION

Three test borings were drilled at the locations shown on the attached site plan using a CME-55 rotary-auger drill rig and 7-inch diameter, hollow-stem augers. The soils encountered during the test drilling were visually classified, and representative soil samples were obtained at selected depths. Relatively undisturbed samples were obtained by driving a 2.42-inch I.D. ring-lined soil sampler at selected depths. Disturbed samples were obtained by driving a standard 2.0-inch O.D. split-spoon sampler at selected depths. Standard Penetration Tests were conducted in conjunction with the split-spoon sampling in general agreement with ASTM procedures, except for filling the hollow stem augers with water prior to sampling per the instructions of the Flood Control District of Maricopa County. The results of the test drilling are presented in Appendix A, "Field Results".

Representative samples obtained during the test drilling were subjected to the following laboratory analyses:

Test	Sample(s)	Purpose
Compression	Undisturbed (3)	Foundation settlement analyses
Direct Shear	Undisturbed (3)	Shear strength determination for bearing capacity and lateral earth pressure parameters
Sieve Analysis and Plasticity Index	Split-Spoon Sample (2) Bulk Sample (1)	Classification and engineering characteristics
Expansion	Compacted (1)	Expansion potential
Soluble salts, sulfates, and pH	Split-Spoon Sample (2) Bulk Sample (1)	Corrosion potential to concrete below-grade
Dry Density and/or Moisture Content*	Undisturbed (11)	In-situ density and/or moisture determination

*The moisture content of the soils may have been influenced by the presence of water in the hollow stem augers during sampling.

The results of the dry density and moisture content testing are reported on the boring logs, and the remainder of the test results are presented in Appendix B, "Laboratory Results".

SOIL CONDITIONS

As shown on the attached boring logs, the soil profile at the boring locations was relatively uniform. Soils encountered from the ground surface to depths varying from about 27 to 32 feet consisted of medium plasticity sandy clays. These soils are generally firm in the upper 7 to 12 feet, becoming very stiff to hard with depth. Underlying soils encountered throughout the remaining depths drilled consisted primarily of stratified deposits of granular soils including sands, silty sands, and clayey sands. Interlayered with these stratified granular deposits were lesser amounts of hard sandy clays exhibiting medium plasticity. Soil moisture contents were generally described as being damp to moist. No groundwater was encountered in any of the test borings during drilling operations; however, localized zones of perched groundwater may occur in the vicinity of the canal due to leakage.

DISCUSSION AND RECOMMENDATIONS

General: Geotechnical engineering recommendations for design of the bridge foundation piers to support axial loads and to function as lateral support for the ACDC channel excavation are presented in the following sections. These recommendations are based upon the results of the field and laboratory testing which are presented in Appendices A and B of this report, and the information provided to us by Entranco Mann Johnson Engineers. Other recommendations are possible and will be considered upon request.

Drilled Pier Axial Load Capacities: Drilled straight shaft cast-in-place concrete foundation elements bearing on the dense sand deposits at about 21 feet below the ACDC channel bottom will provide adequate support of the abutment loads. The following tabulation presents foundation recommendations for deep circular cast-in-place concrete piers. Recommendations for other foundation conditions are possible and will be considered upon request.

Footing Depth	Bearing Material	Allowable Foundation Bearing Pressure	Maximum Foundation Load
*20-22 feet	Undisturbed Dense Sands	32 ksf	375 kips 112

*Footings must bear at least 1 foot into the dense sands at the approximate indicated depth below the finished grade of the ACDC.

Since the drilled piers are designed as end-bearing footings, all drilling spoil and disturbed soils must be removed from the bottom of the drilled shafts before placement of any concrete. All drilled pier excavations should be observed by a representative of the geotechnical engineer to evaluate bearing conditions. If any undesirable materials are present at the pier bottom, the pier should be extended below the undesirable materials. All drilled piers should have a minimum shaft diameter of 30 inches to allow for visual observation of the bearing surface. Applicable safety codes will require safety casing for protection of personnel entering shafts for cleaning or observation.

Recommended foundation bearing pressures should be considered allowable maximums for dead plus design live loads and may be increased by one-third when considering total loads including transient wind or seismic forces. The weight of the foundation concrete below finished grade at the bottom of the ACDC channel may be neglected in dead load computations.

Estimated settlements for the drilled piers supporting the anticipated loads are approximately 1/4 to 1/2 inch if the natural foundation bearing soils remain at existing moisture conditions. Minor additional post-construction differential settlements could occur if the natural soils surrounding and beneath the drilled piers were to experience a significant increase in moisture content.

<u>Drilled Pier Lateral Analysis:</u> Drilled piers have been analyzed for permanent support of the ACDC channel walls. The analysis was performed using a computer program entitled, "COM624G, Analysis of Stress and Deflection for Laterally Loaded Piles Including Internal Generation of P-Y Curves", originally written by Reece and Sullivan at the University of Texas, Austin. The pier geometry used in the analysis is as follows:

1. Bottom of pier: 21 feet below the finish grade of ACDC channel bottom.

2. Top of pier: 20 feet above ACDC channel bottom.

3. Pier spacing: 7.75 feet. This spacing was specified by Entranco Mann

Johnson Engineers and corresponds to the preliminary spacing of the bridge girders.

A summary of the results of the lateral analysis is presented below:

*Load Case	Pier Spacing (ft)	Pier Diameter (ft)	Movement at Top of Pier (in)	Shear at Top of Pier (kips)	Maximum Moment along Pier (k-ft)
1	7.75	2.5	2.5	9	572
1	7.75	3.0	1.5	9	563
2	7.75	2.5	0	92	646
2	7.75	3.0	0	93.5	662
3	7.75	2.5	0	122	681
3	7.75	3.0	0	125	718

*Case 1: Top of pier free to rotate and move laterally. Shear at top of pier is only from active soil pressure on superstructure.

Case 2: Top of pier free to rotate. Bridge girders act as struts to prevent lateral movement.

Case 3: No rotation or lateral deflection permitted at top of pier. Bridge girders act as struts.

Detailed printouts of deflections, moments, and stresses along the pier length for each load case and pier diameter are presented in Appendix C.

Lateral Earth Pressures: The following tabulation presents recommendations for lateral earth pressures and friction coefficients for use in design.

[1]Lateral Backfill Pressures:	
Unrestrained walls	30 psf/ft.
Restrained walls	60 psf/ft.
Lateral Passive Pressures:	
Continuous walls/footings	250 psf/ft.
Spread columns/footings	350 psf/ft.
Circular drilled shafts	500 psf/ft.
Coefficient of Base Friction:	
Independent of passive resistance	0.40
In conjunction with passive resistance	0.30

[1]Equivalent fluid pressures for granular backfills assuming vertical walls and horizontal backfill surfaces (maximum 12-foot height). Pressures do not include temporary forces imposed during compaction of the

backfill, swelling pressures developed by over-compacted clayey backfill, hydrostatic pressures from inundation of backfill, or surcharge loads. Walls or abutments should be suitably braced during backfilling to prevent damage and excessive deflection.

Structural Fill: Any required structural fill materials should be imported inorganic granular soils free of vegetation, debris, organic contaminants, and fragments larger than 6 inches in size. All structural fill materials should meet the following recommendations:

Maximum particle size------------------------------6 inches
Maximum percent passing No. 200 sieve--------------30 percent
Maximum percent expansion--------------------------1.5 percent*

*Performed on sample remolded to 95 percent of the maximum ASTM D698 dry density at a moisture content of 2 percent below optimum under a 100 psf surcharge pressure.

All structural backfill placed behind the bridge structure should be compacted to a minimum of 95 percent of the maximum ASTM D698 dry density at a moisture content of optimum -1 to optimum +3 percent to help reduce the settlement of the compacted fill.

The natural on-site surface soils encountered in the upper 30 feet $\pm$ do not meet the requirements for structural fill recommended above. These sandy clay soils exhibited a moderate expansion potential when compacted and then saturated under a light surcharge pressure. Therefore, these soils should not be used as structural fill.

Site Drainage and Water Control: Final grading should be done so that all surface water is diverted away from the bridge foundations and abutment wall to prevent an accumulation and infiltration of water into the surrounding soils. Special attention should be given to sealing the ACDC lining around all bridge foundations.

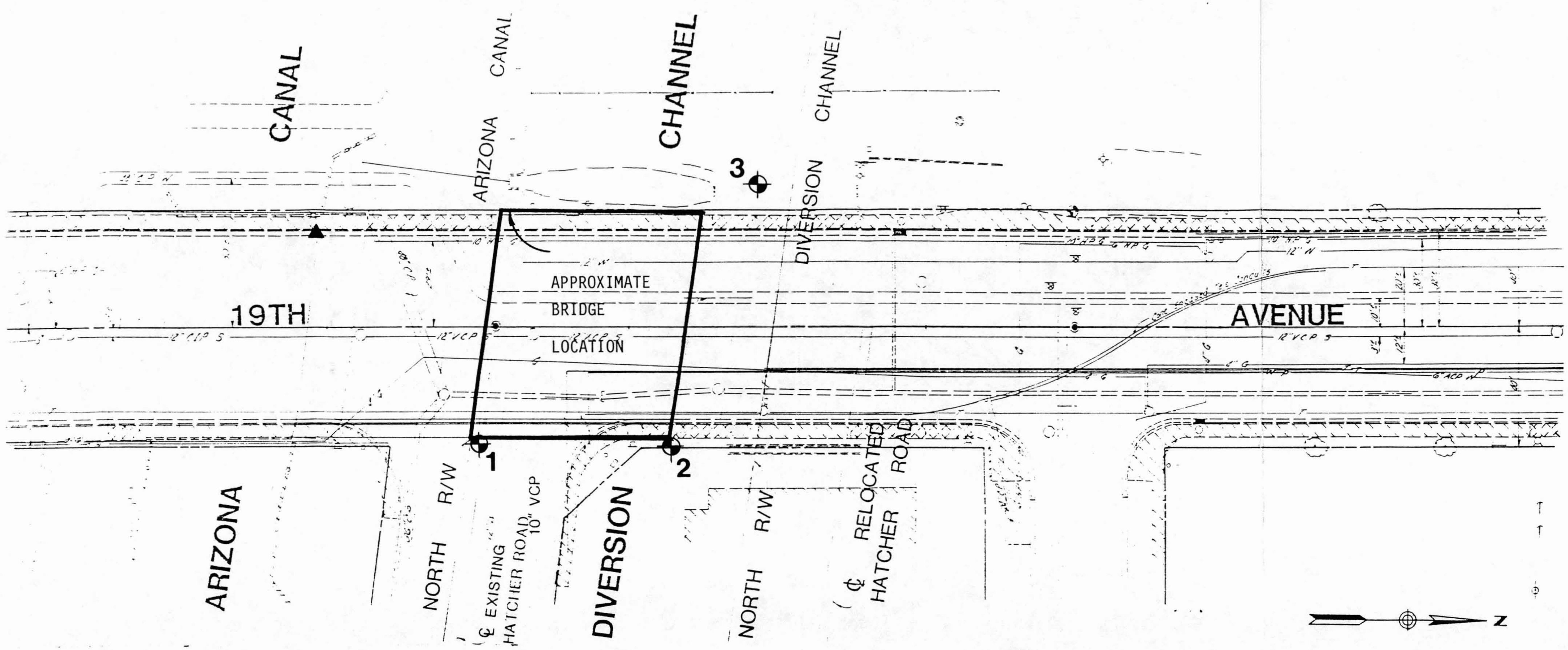
Excavation and Pier Drilling Conditions: The test drilling and field sampling at the site was performed for design purposes. It is not possible to accurately correlate auger drilling results with the ease or difficulty of digging for various types and sizes of excavation or drilling equipment. We present the following general comments regarding excavatability for the designers' information with the understanding that they are approximations based only on test boring data. More accurate information regarding excavatability should be evaluated by contractors or other interested parties from test excavations using the intended equipment.

Excavations into the site soils throughout the depth of the ACDC channel should be possible with conventional excavating equipment. Excavations should be sloped or braced as required to provide personnel safety and satisfy local safety code regulations. Drilled pier excavations should experience only minor caving in the upper sandy clay deposits to depths of about 30 feet. Moderate to severe caving may be encountered in some locations at depths below about 30 feet below existing grade where the pier excavations intercept scattered relatively clean sand lenses. Because our test borings were drilled with drilling fluid in the boring (as directed by Maricopa County Flood Control District), we were not able to observe an indication of the caving potential in these soils in a dry hole. A test drilled pier installation may be desirable at the site to evaluate the stability of a full size pier excavation to the design depth. Casing or other stabilization techniques may be necessary for portions of drilled shafts penetrating these clean sand lenses.

Corrosion: Based on the relatively low soluble sulfates content of the tested soil samples, it is recommended that concrete on and below grade be made of Type II cement.

APPENDIX A

FIELD RESULTS



LEGEND

⊕ Indicates test boring location

▲ Benchmark: Brass cap in street at NW corner of existing Arizona Canal bridge

LEGEND

SOIL CLASSIFICATION ASTM: D2487

COARSE-GRAINED SOIL

MORE THAN 50% LARGER THAN 200 SIEVE SIZE

Symbol	Letter	DESCRIPTION	MAJOR DIVISIONS
	GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LESS THAN 5% - 200 FINES	GRAVELS More than half of coarse fraction is larger than No. 4 Sieve size.
	GP	POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LESS THAN 5% - 200 FINES	
	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES, MORE THAN 12% - 200 FINES	
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES, MORE THAN 12% - 200 FINES	
	SW	WELL-GRADED SANDS OR GRAVELLY SANDS, LESS THAN 5% - 200 FINES	SANDS More than half of coarse fraction is smaller than No. 4 sieve size.
	SP	POORLY-GRADED SANDS OR GRAVELLY SANDS, LESS THAN 5% - 200 FINES	
	SM	SILTY SANDS, SAND-SILT MIXTURES MORE THAN 12% - 200 FINES	
	SC	CLAYEY SANDS, SAND-CLAY MIXTURES MORE THAN 12% - 200 FINES	

FINE-GRAINED SOIL

MORE THAN 50% SMALLER THAN 200 SIEVE SIZE

Symbol	Letter	DESCRIPTION	MAJOR DIVISIONS
	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	SILTS AND CLAYS Liquid limit less than 50
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAYS OF LOW PLASTICITY	
	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS, ELASTIC SILTS	SILTS AND CLAYS Liquid limit greater than 50
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	

log denotes visual approximation unless accompanied by mechanical analysis and Atterberg limits.

GRAIN SIZES

U.S. STANDARD SERIES SIEVE: 200, 50, 16, 4 — CLEAR SQUARE SIEVE OPENINGS: ¾", 3", 6"

SILTS & CLAYS DISTINGUISHED ON BASIS OF PLASTICITY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

MOISTURE CONDITION (INCREASING MOISTURE ⟶)

DRY	SLIGHTLY DAMP	DAMP	MOIST	VERY MOIST	WET (SATURATED)
		(PL)			(LL)

DEFINITIONS

Penetration Resistance — Blows per foot using 'A' rod and 140 lb. hammer with 30 inch free fall unless otherwise noted.

N Standard Penetration Resistance (ASTM:D1586), 2.0 inch O.D. split barrel sampler.

C Continuous Penetration Resistance, 2.0 inch O.D. Bull Nose.

R Penetration Resistance, 2.42 inch I.D. Ring Sampler

Sample Type

R - Ring T - Shelby Tube S - Standard Split Barrel B - Block
G - Grab C - Cutting V - Vertical Face Cut

CONSISTENCY			RELATIVE DENSITY	
CLAYS & SILTS	BLOWS/FOOT*	STRENGTH‡	SANDS & GRAVELS	BLOWS/FOOT*
VERY SOFT	0-2	0-¼	VERY LOOSE	0-4
SOFT	2-4	¼-½	LOOSE	4-10
FIRM	4-8	½-1	MEDIUM DENSE	10-30
STIFF	8-16	1-2	DENSE	30-50
VERY STIFF	16-32	2-4	VERY DENSE	OVER 50
HARD	OVER 32	OVER 4		

* Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1-⅜ inch I.D.) split spoon (ASTM D-1588).

‡ Unconfined compressive strength in tons/sq. ft. Read from a pocket penetrometer.

SOIL BORING LOG

NO. 1 ELEV: 99.2 ft. SIZE OF HOLE 7 in. FIELD ENGR: JT DATE: 6 May 1987

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT C	N	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	MED	POOR	GRAIN SHAPE ANGULAR	SURANGULAR	ROUNDED	SUBROUNDED	RELATIVE DENSITY LOW	MED	HIGH	PLASTICITY NONE	LOW	MEDIUM	HIGH	CONSISTENCY SOFT	FIRM	STIFF	VERY STIFF	HARD	CEMENTATION NONE	WEAK	MEDIUM	STRONG
1					Damp	Sandy Clay; brown;	CL											X	X			X				X			
2					to	stratified with occasional																								
3					Moist	lenses of clayey sand (SC).																								
4																														
5		8	R	104	9																									
6																														
7																														
8																							X	X					
9																														
10		~~16~~	~~S~~																											
1																														
2																														
3																														
4																														
5		20	R	118	10																									
6																														
7																														
8																														
9																														
20																														
1																														
2																														
3																									X				
4																														
5		51	R	109	18																									
6																														
7																														
8																														
9																														
30		~~27~~	~~S~~																											
1																														
2																														
3						Sand, Silty Sand, and Clayey	SP-	X	X			X		X			X	X	X								X			
4						Sand; brown; stratified;	SM,																							
5		100	R	*	5	occasional gravelly lenses;	SM,																							
6						scattered lenses of hard	SC																							
7						sandy clay (CL).																								
8						Clayey Sandy Gravel; brown;	GC	X				X		X			X		X	X							X			
9						possible cobbles.																								
40		~~RF~~	~~S~~																											

CONTINUED

Project No. 87-0478

THOMAS-HARTIG & ASSOCIATES, INC.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. This boring data was compiled primarily for design purposes, and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

SOIL BORING LOG

NO. 1 ELEV: 99.2 ft. SIZE OF HOLE 7 in. FIELD ENGR: JT DATE: 6 May 1987

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT		SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION			GRAIN SHAPE				RELATIVE DENSITY			PLASTICITY				CONSISTENCY					CEMENTATION			
	C	N						WELL	MED	POOR	ANGULAR	SUBANGULAR	ROUNDED	SUBROUNDED	LOW	MED	HIGH	NONE	LOW	MEDIUM	HIGH	SOFT	FIRM	STIFF	VERY STIFF	HARD	NONE	WEAK	MEDIUM	STRONG
1						Clayey Sandy Gravel; brown;	GC	X				X		X			X		X	X							X			
2						possible cobbles																								
3																														
4																														
5																														
6																														
7																														
8																														
9																														
50																														
1																														
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3																														
4																														
5																														
6																														
7																														
8																														
9																														
80																														

Auger Refusal at 42 feet

Ground water encountered: none

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SOIL BORING LOG

NO. 2 ELEV: 98.6 ft. SIZE OF HOLE 7 in. FIELD ENGR: JT DATE: 6 May 1987

Depth Ft.	Penetration Resistance Blows/Ft		Sample Type	Dry Density PCF	Moisture Content	Description	Soil Classification	Gradation			Grain Shape				Relative Density			Plasticity				Consistency					Cementation			
	C	N						Well	Med	Poor	Angular	Surangular	Rounded	Subrounded	Low	Med	High	None	Low	Medium	High	Soft	Firm	Stiff	Very Stiff	Hard	None	Weak	Medium	Strong
1					Damp	Sandy Clay; brown;	CL												X	X			X				X			
2					to	stratified with occasional																								
3					Moist	lenses of clayey sand (SC).																								
4																														
5																														
6																														
7																														
8																														
9																														
10		7	S																											
1																														
2																														
3																								X	X					
4																														
5																														
6																														
7																														
8																														
9																														
20		30	R	106	17																									
1																														
2																														
3																														
4																														
5		22	S																											
6																														
7																														
8																										X				
9																														
30		40	R	109	17																									
1																														
2																														
3						Sand, Silty Sand, and Clayey	SP-	X	X			X		X			X	X	X								X			
4						Sand; brown; stratified;	SM,																							
5		RF	S			occasional gravelly lenses;	SM,																							
6						scattered lenses of hard	SC																							
7						sandy clay (CL).																								
8																														
9																														
40		60	S																											

CONTINUED

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SOIL BORING LOG

NO. 2 ELEV: 98.6 ft. SIZE OF HOLE 7 in. FIELD ENGR: JT DATE: 6 May 1987

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SURANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
1					Damp	Sandy Clay; brown;	CL												X	X						X	X			
2					to	stratified with occasional																								
3					Moist	lenses of clayey sand (SC).																								
4																														
5		48	R	103	22																									
6																														
7																														
8					Damp	Sand, Silty Sand, and Clayey	SP-	X	X			X		X			X	X	X								X			
9						Sand; brown; stratified;	SM,																							
50						occasional gravelly lenses;	SM,																							
1		49	S			scattered lenses of hard	SC																							
2						sandy clay (CL).																								
3																														
4																														
5																														
6		84	S																											
7																														
8					Damp	Sandy Clay; brown;	CL												X	X						X	X			
9					to	stratified with occasional																								
60					Moist	lenses of clayey sand (SC).																								
1		52	S																											
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
70																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
80																														

Stopped test drilling at: 60.5 ft.

Ground water encountered: none

Project No. 87-0478

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO. 3 ELEV: 99.3 ft. SIZE OF HOLE 7 in. FIELD ENGR: JT DATE: 11 May 1987

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SURANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
1					Damp	Sandy Clay; brown;	CL												X	X			X				X			
2					to	stratified with occasional																								
3					Moist	lenses of clayey sand (SC).																								
4																														
5		7	S																											
6																														
7																														
8																									X	X				
9																														
10		39	R	105	20																									
1																														
2																														
3																														
4																														
5		19	S																											
6																														
7																														
8																														
9																														
20		30	R	103	16																									
1																														
2																														
3																										X				
4																														
5		41	S																											
6																														
7																														
8						Sand, Silty Sand, and Clayey	SP-	X	X			X		X			X	X	X								X			
9						Sand; brown; stratified;	SM,																							
30		54	R	122	9	occasional gravelly lenses;	SM,																							
1						scattered lenses of hard	SC																							
2						sandy clay (CL).																								
3																														
4																														
5		51	S																											
6																														
7																														
8																														
9																														
40		32	S																											

CONTINUED

Project No. 87-0478

THOMAS-HARTIG & ASSOCIATES, INC.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. This boring data was compiled primarily for design purposes, and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

SOIL BORING LOG

NO. 3 ELEV: 99.3 ft. SIZE OF HOLE 7 in. FIELD ENGR: JT DATE: 11 May 1987

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION
1					Damp	Sandy Clay; brown;	CL
2					to	stratified with occasional	
3					Moist	lenses of clayey sand (SC).	
4						Sand, Silty Sand, and Clayey	SP-
5		50	R	119	8	Sand; brown; stratified;	SM,
6						occasional gravelly lenses;	SM,
7						scattered lenses of hard	SC
8						sandy clay (CL).	
9							
50		73	S				
1							
2							
3							
4							
5		75	R	111	12		
6							
7							
8					Damp	Sandy Clay; brown;	CL
9					to	stratified with occasional	
60		87	S		Moist	lenses of clayey sand (SC).	
1							
2							
3							
4							
5							
6							
7							
8							
9							
70							
1							
2							
3							
4							
5							
6							
7							
8							
9							
80							

DEPTH FT	GRADATION			GRAIN SHAPE				RELATIVE DENSITY			PLASTICITY				CONSISTENCY					CEMENTATION			
	WELL	MED	POOR	ANGULAR	SURANGULAR	ROUNDED	SUBROUNDED	LOW	MED	HIGH	NONE	LOW	MEDIUM	HIGH	SOFT	FIRM	STIFF	VERY STIFF	HARD	NONE	WEAK	MEDIUM	STRONG
1												X	X						X		X		
2																							
3																							
4	X	X			X		X			X	X	X								X			
5																							
6																							
7																							
8																							
9																							
50																							
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8												X							X	X			
9																							
60																							
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
70																							
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
80																							

Stopped test drilling at: 60.5 ft.

Ground water encountered: none

Project No. 87-0478

THOMAS-HARTIG & ASSOCIATES, INC.

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APPENDIX B

LABORATORY RESULTS

REPORT ON LABORATORY TESTS

SAMPLE: Date 5/14/87

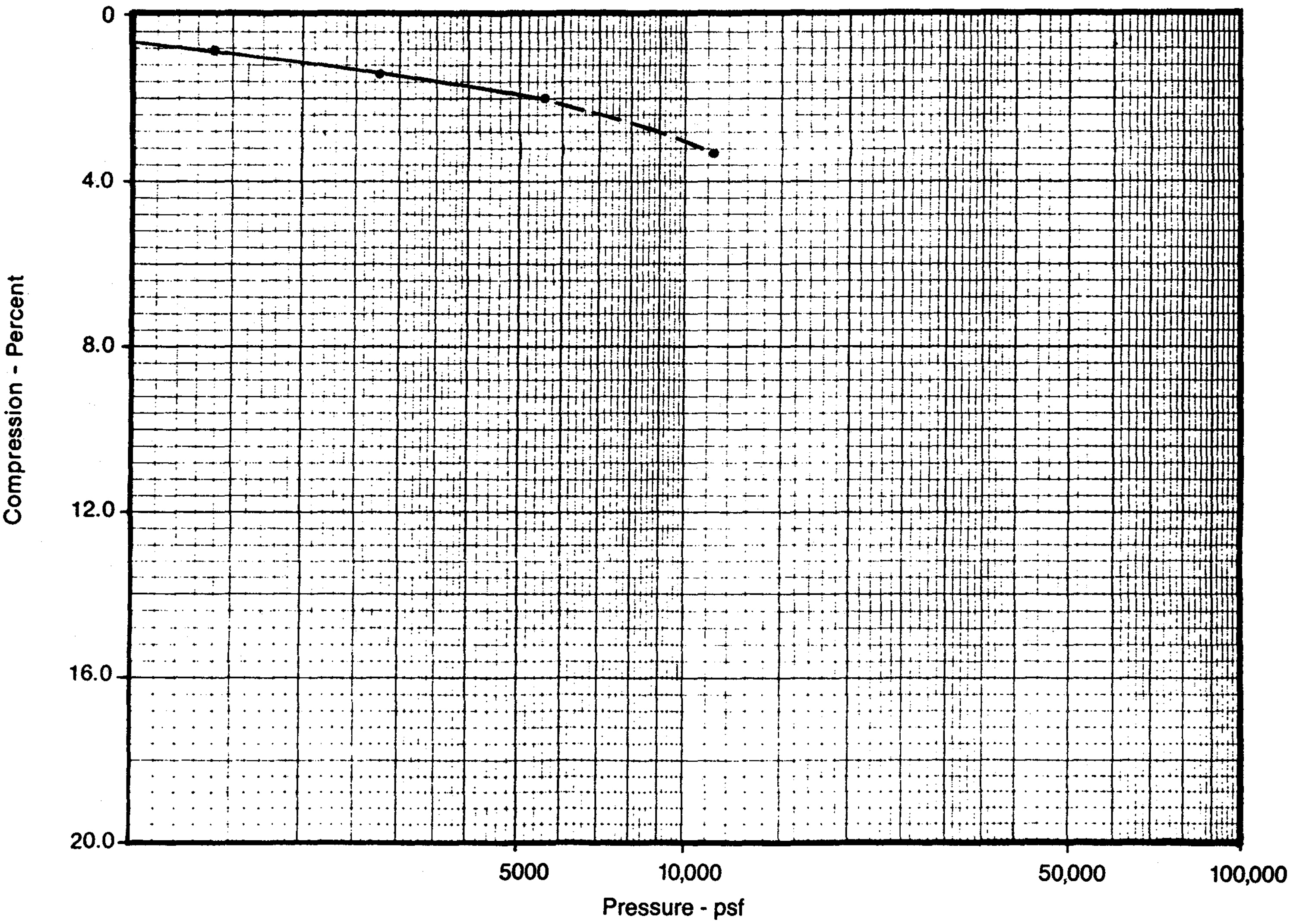
Source Test Boring #1; 24 - 25'

Type Driven ring sample; 109 pcf dry density; 18% field moisture

Material Sandy Clay (CL)

Sampled By TH/Thompson

TESTED: Compression; test sample submerged at 5545 psf.



Project No. 87-0478

THOMAS-HARTIG & ASSOCIATES, INC

REPORT ON LABORATORY TESTS

SAMPLE: Date 5/14/87

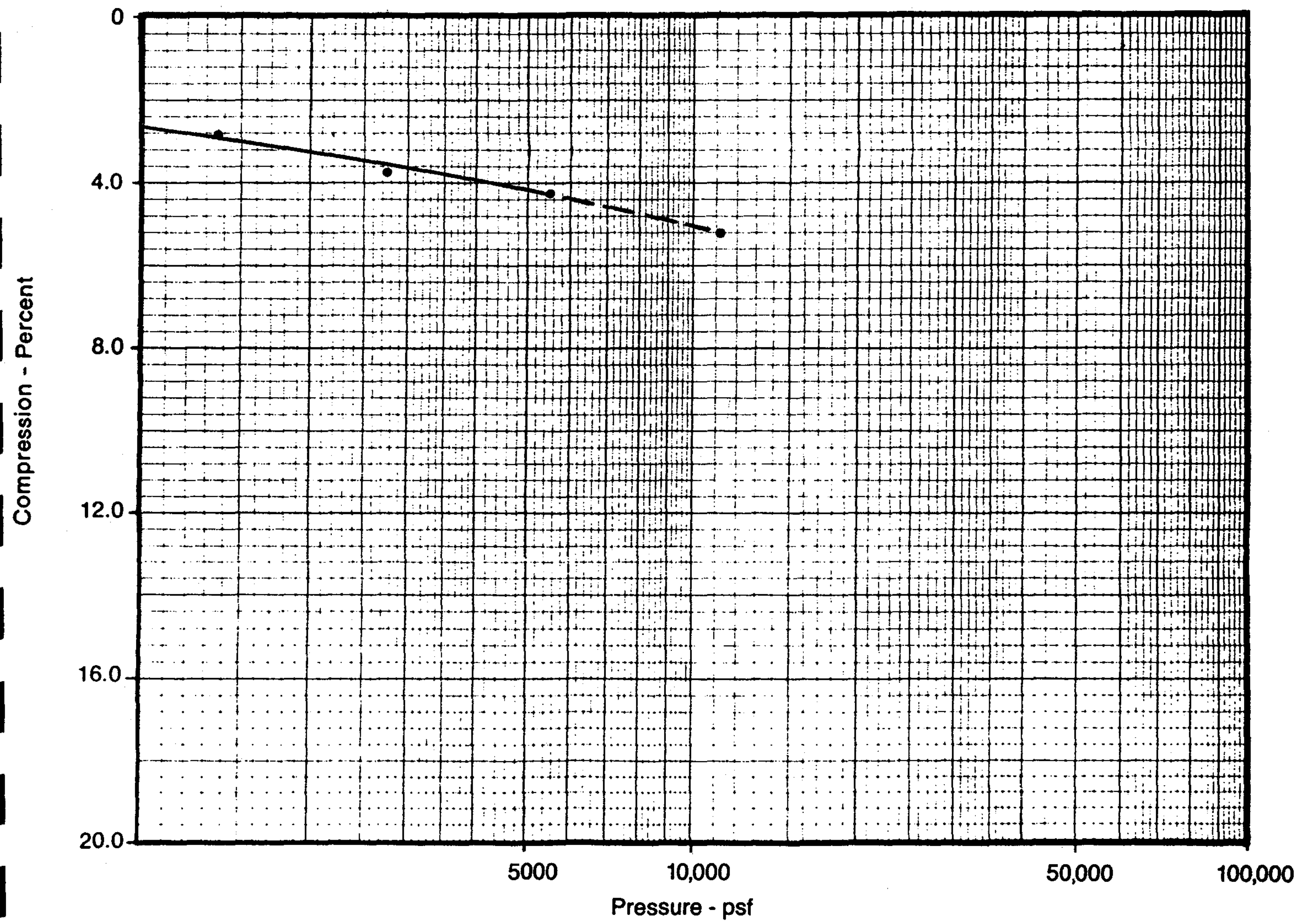
Source Test boring #2; 20 - 30'

Type Driven ring sample; 109 pcf dry density; 17% field moisture

Material Sandy clay (CL)

Sampled By TH/Thompson

TESTED: Compression; test sample submerged at 5545 psf.



REPORT ON LABORATORY TESTS

SAMPLE: Date 5/14/87

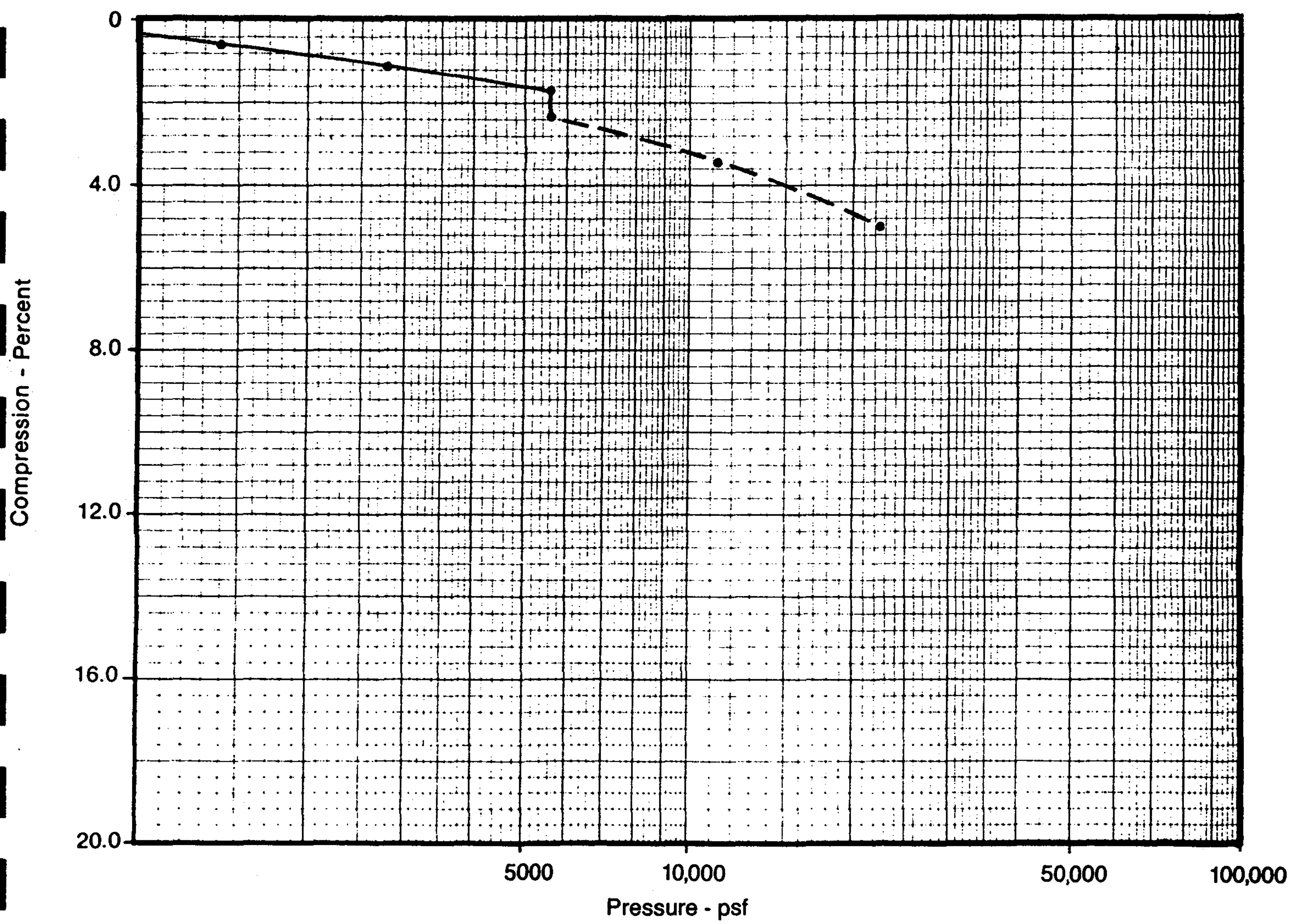
Source Test boring #4; 44 - 45'

Type Driver ring sample; 119 pcf dry density; 8% dield moisture

Material Sandy clay (CL)

Sampled By TH/Thompson

TESTED: Compression' test sample submerged at 5545 psf



Project No.

THOMAS HARTIG & ASSOCIATES, INC

REPORT ON LABORATORY TESTS

SAMPLE: Date 6/1/87

Source Noted below

Type Grab samples

Material Surface soil

Sampled By TH/Thompson

TESTED: Percent expansion upon soaking of remolded sample compacted to approximately 95% of the maximum ASTM D698 density at less than optimum moisture content.

RESULTS:

Sample	Dry Density	Initial Moisture	Surcharge Pressure	Percent Expansion Upon Soaking
3; 0' - 10'	105 pcf	13%	100 psf	3.88

$P_3 = \underset{29°}{\gamma z K_a} - 2C\sqrt{K_a}$

$P_3 = f(C_i$

THOMAS-HARTIG & ASSOCIATES, INC.

REPORT ON LABORATORY TESTS

SAMPLE: Date 6/1/87

Source Test boring #2; 19 - 20'

Type Driven ring sample; 106 pcf dry density, 17% field moisture

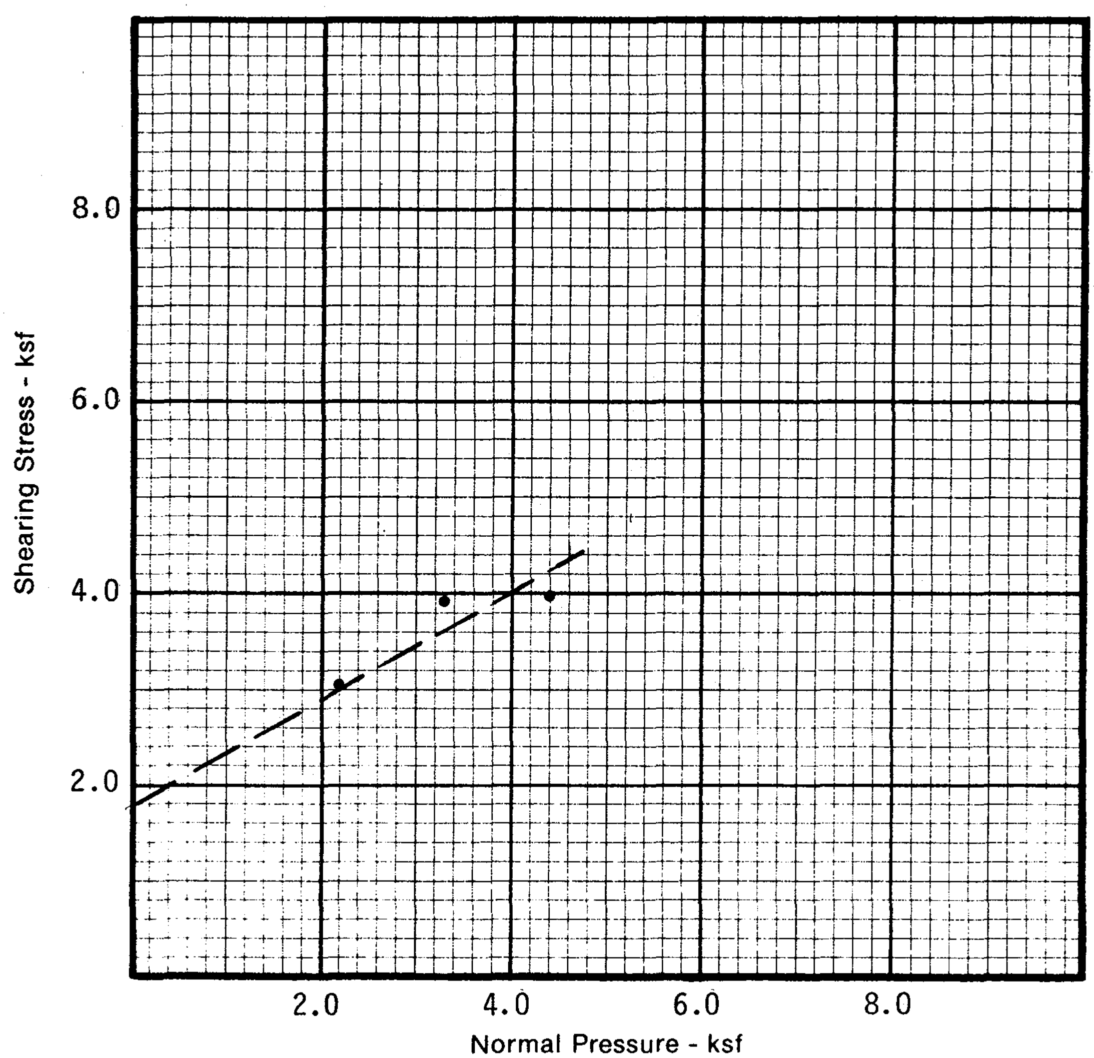
Material Sandy clay (CL)

Sampled By TH/Yurkovich

TESTED: Direct shear, sample submerged and consolidated prior to shear.

RESULTS:

Friction Angle (Ø) = 29^{0} √ Cohesion (c) = 1.8 ksf



Project No. 87-0478

THOMAS-HARTIG & ASSOCIATES, INC.

REPORT ON LABORATORY TESTS

SAMPLE: Date 6/1/87

Source Test boring #2; 45 - 46'

Type Driven ring sample; 103 pcf dry density; 22% field moisture

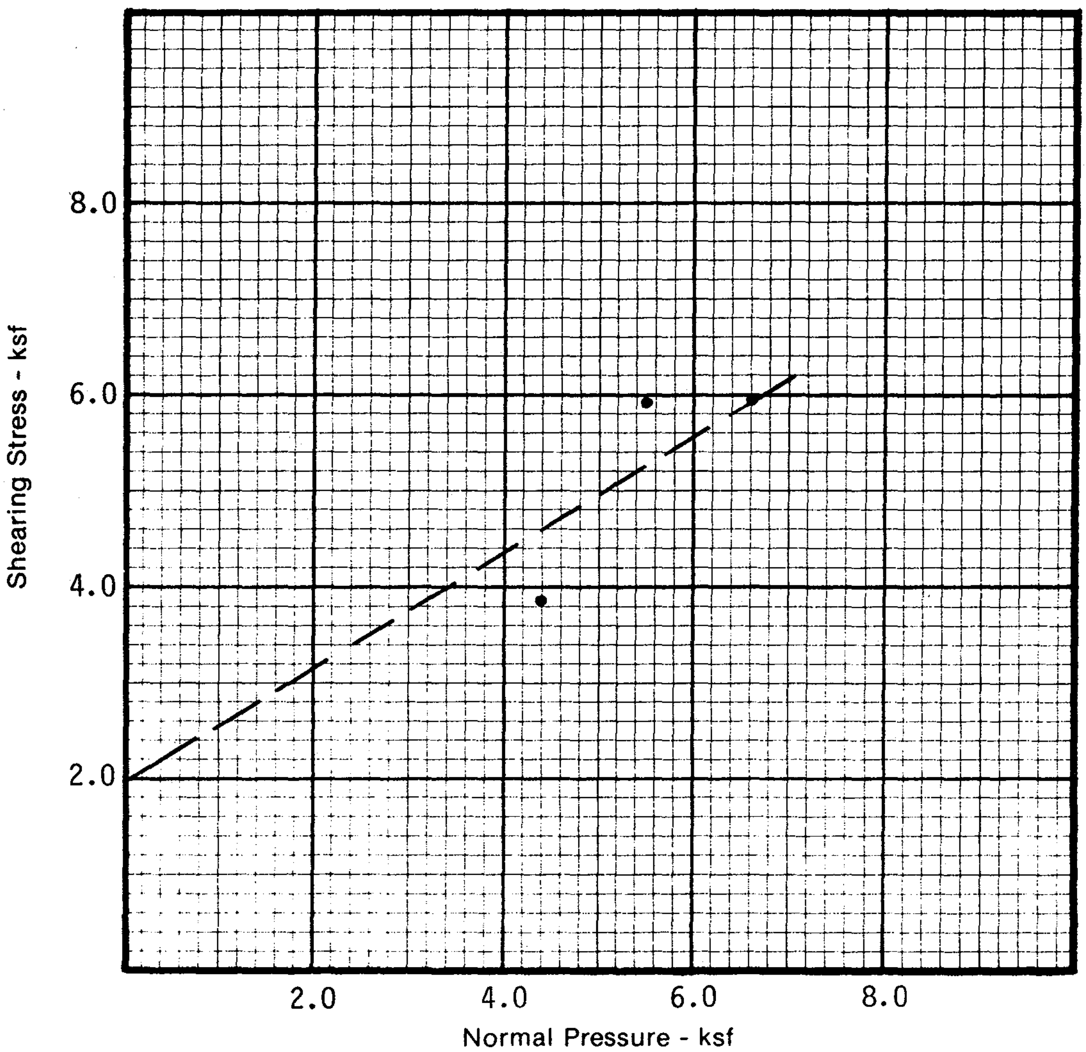
Material Sandy clay (CL)

Sampled By TH/Yurkovich

TESTED: Direct shear, sample submerged and consolidated prior to shear.

RESULTS:

Friction Angle (Ø) = 31° √ Cohesion (c) = 2.0 ksf



Project No. 87-0478

THOMAS-HARTIG & ASSOCIATES, INC.

REPORT ON LABORATORY TESTS

SAMPLE: Date 6/1/87

Source Test boring #3; 29 - 30'

Type Driven ring sample; 122 pcf dry density; 9% field moisture

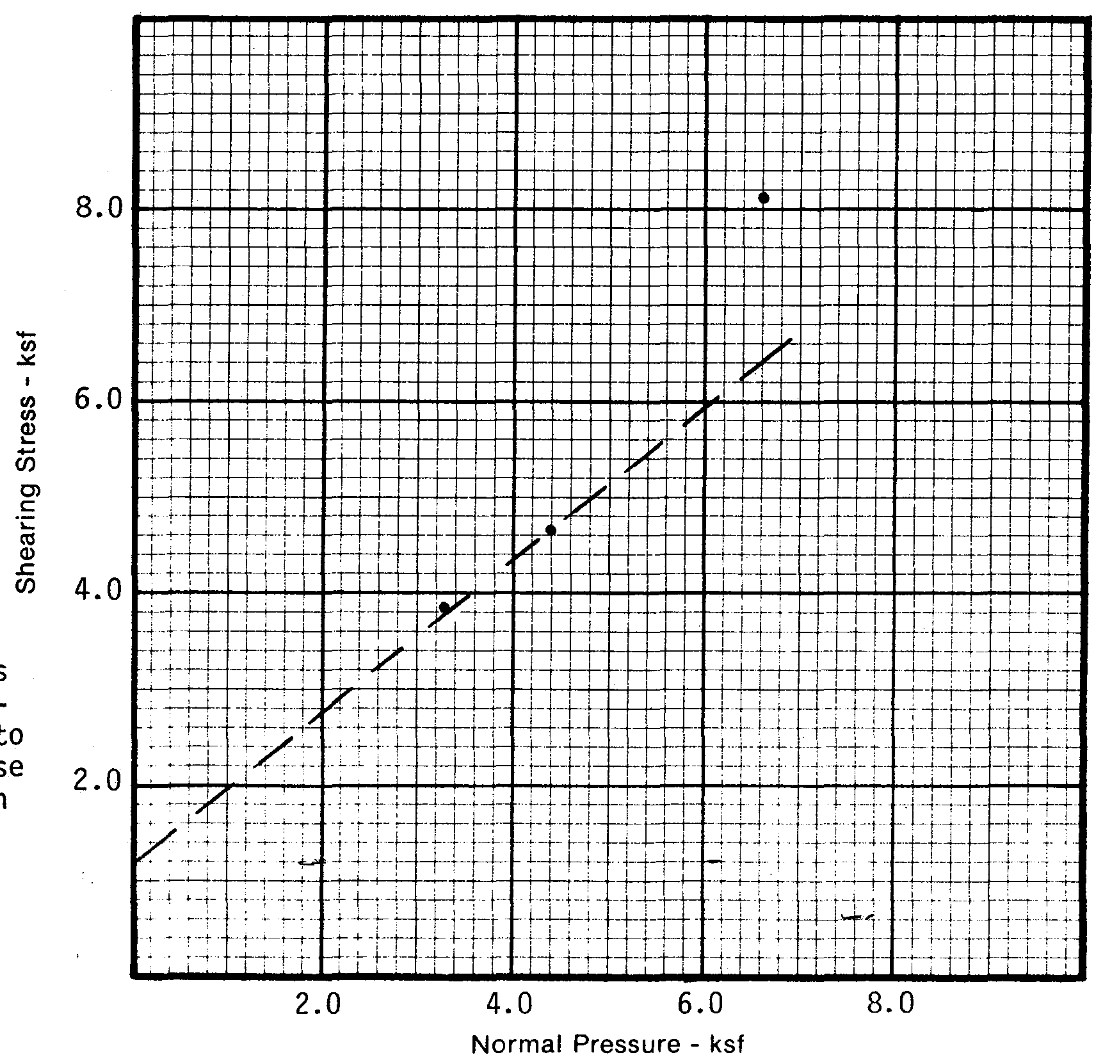
Material Silty Clayey Sand (SM-SC)

Sampled By TH/Yurkovich

TESTED: Direct shear, sample submerged and consolidated prior to shear.

RESULTS:

Friction Angle (Ø) =*39° ✓ Cohesion (c) = 1.2 ksf*



Shear envelope is probably not representative due to presence of coarse sand particles on failure plane.

REPORT ON LABORATORY TESTS

SAMPLE: Date 6/1/87

Source As noted below

Type Bag samples of auger cuttings and split-spoon samples

Material Soil

Sampled By TH/Thompson

TESTED: Sieve Analysis and Atterberg Limits

RESULTS:

Sample	LL	PI	Sieve Size - 200	100	50	30	16	Accum. % Passing 8	4	3/4"	1"	2"	3"	* Class
2; 49' - 50'	25	2	15	19	26	39	54	72	88	100				SM
2; 59' - 60'	39	11	73	81	87	91	94	97	99	100				CL
3; 0' - 10'	35	15	76	82	86	89	91	94	97	100				CL

* Unified Soil Classification

Project No. 87-0478

THOMAS-HARTIG & ASSOCIATES, INC.

REPORT ON LABORATORY TESTS

SAMPLE: Date 6/1/87

Source As noted below

Type Splitspoon and bulk samples

Material Soil

Sampled By TH/Yurkovich

TESTED: Soluble Salts, Sulfates, pH

RESULTS:

Sample	Percent Soluble Salts	Percent Sulfates	pH
2; 34 - 35.5'	0.12	0.005	9.9
2; 54 - 55.5'	0.13	0.006	9.9
3; 0 - 10'	0.11	0.011	8.4

APPENDIX C

RESULTS OF LATERAL PILE ANALYSIS

Three cases of pile loading were analyzed. Results are presented on the following pages:

Case	Pier Diameter	Pile Spacing	Pile Head Restraint
1	2.5 ft.	7.75 ft.	None
1	3.0 ft.	7.75 ft.	None
2	2.5 ft.	7.75 ft.	Zero lateral deflection
2	3.0 ft.	7.75 ft.	Zero lateral deflection
3	2.5 ft.	7.75 ft.	Zero deflection or rotation
3	3.0 ft.	7.75 ft.	Zero deflection or rotation

GEOSOFT

COM624G

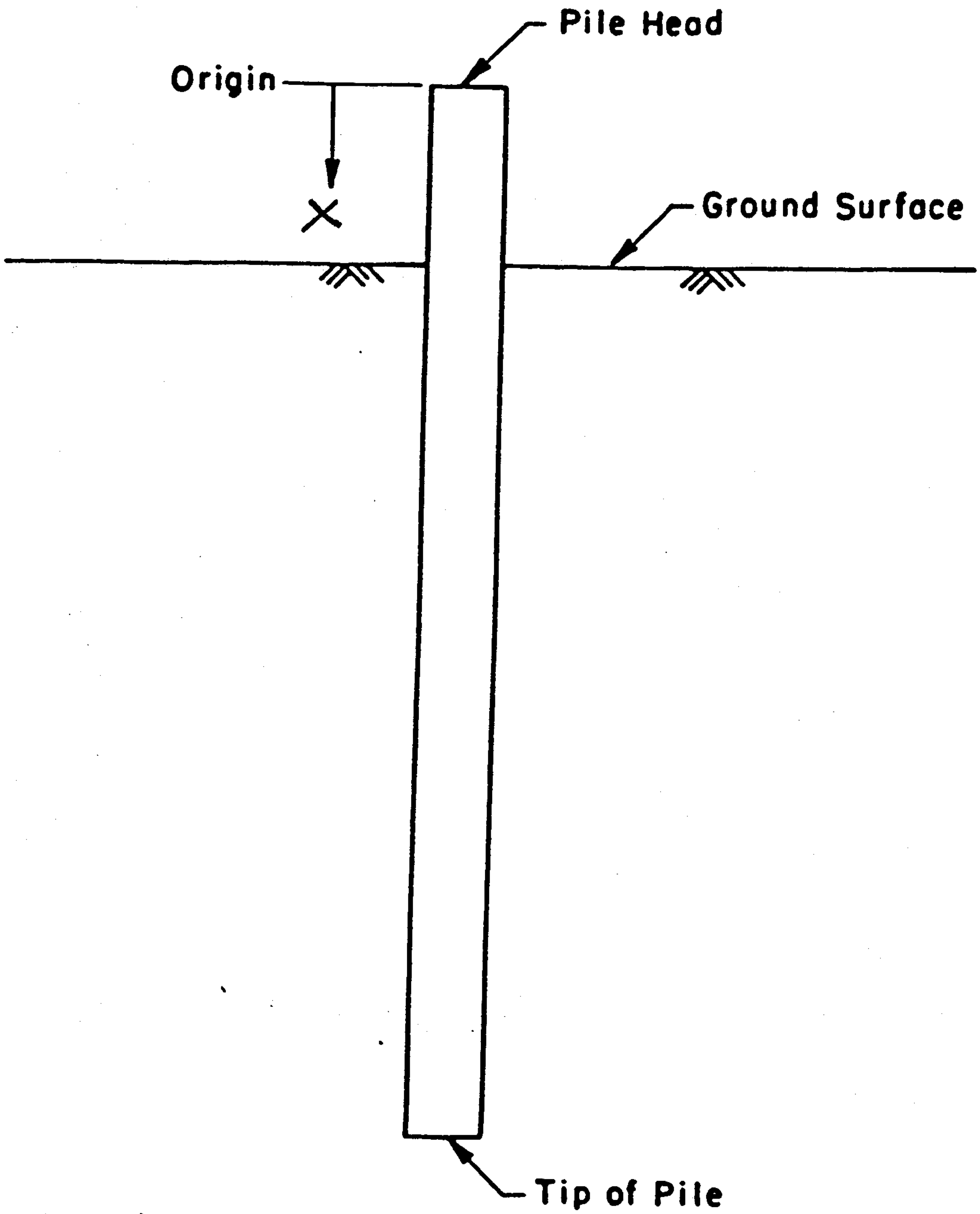
ANALYSIS OF STRESS AND DEFLECTION FOR LATERALLY LOADED PILES INCLUDING INTERNAL GENERATION OF P-Y CURVES

Originally written by Reese and Sullivan at U.T.Austin

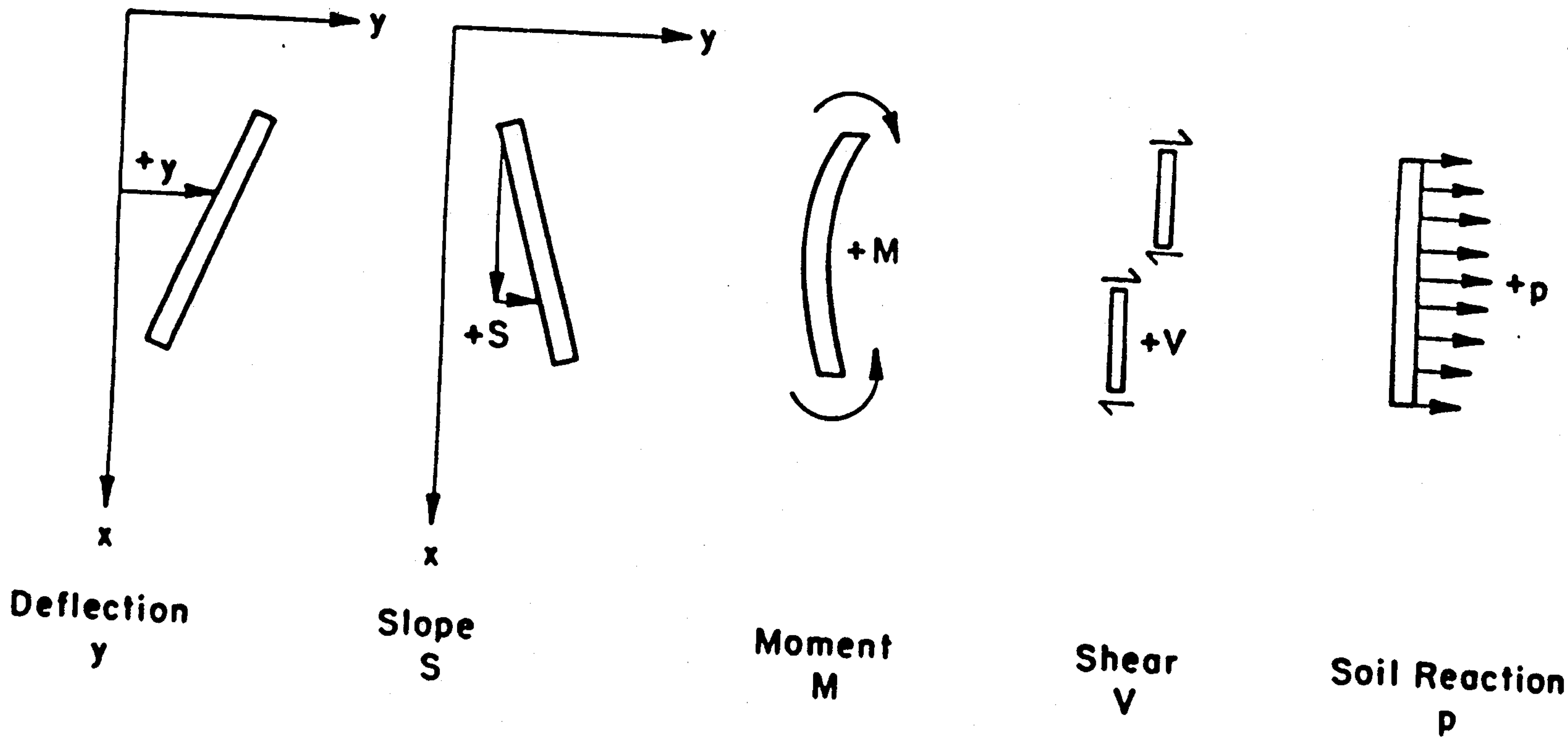
adapted for

IBM PC and Compatibles by

GEOSOFT
1442 LINCOLN AVENUE, SUITE 146
ORANGE, CALIFORNIA 92665
714/998-4030



Coordinate System



Sign Convention

19th Ave. Bridge

NUMBER OF PILE INCREMENTS = 82
TOLERANCE ON DETERMINATION OF DEFLECTIONS = .100D-04 IN
MAXIMUM NUMBER OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
MAXIMUM ALLOWABLE DEFLECTION = .30D+03 IN

INPUT CODES
OUTPT = 1
KCYCL = 1
KBC = 1
KPYOP = 0
INC = 4

ACDC,41 FT PILE,D=30",KA CASE

CASE 1
D=30"

UNITS--ENGL

O U T P U T   I N F O R M A T I O N
****

PILE LOADING CONDITION

APPLIED MOMENT AT PILE HEAD = .000D+00 LBS-IN
LATERAL LOAD AT PILE HEAD = .895D+04 LBS
AXIAL LOAD AT PILE HEAD = .144D+06 LBS

X	DEFLECTION	MOMENT	TOTAL STRESS	DISTR. LOAD	SOIL MODULUS	FLEXURAL RIGIDITY
IN	IN	LBS-IN	LBS/IN**2	LBS/IN	LBS/IN**2	LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.254D+01	.000D+00	.204D+03	.000D+00	.000D+00	.172D+12
24.00	.233D+01	.245D+06	.281D+03	.000D+00	.000D+00	.172D+12
48.00	.211D+01	.491D+06	.358D+03	.000D+00	.000D+00	.172D+12
72.00	.190D+01	.736D+06	.435D+03	.278D+02	.000D+00	.172D+12
96.00	.170D+01	.998D+06	.517D+03	.834D+02	.000D+00	.172D+12
120.00	.149D+01	.131D+07	.615D+03	.139D+03	.000D+00	.172D+12
144.00	.129D+01	.170D+07	.737D+03	.195D+03	.000D+00	.172D+12
168.00	.110D+01	.220D+07	.894D+03	.250D+03	.000D+00	.172D+12
192.00	.911D+00	.284D+07	.110D+04	.306D+03	.000D+00	.172D+12
216.00	.734D+00	.366D+07	.135D+04	.361D+03	.000D+00	.172D+12
240.00	.569D+00	.468D+07	.168D+04	.417D+03	.000D+00	.172D+12
264.00	.420D+00	.580D+07	.203D+04	.000D+00	.128D+04	.172D+12
288.00	.290D+00	.662D+07	.228D+04	.000D+00	.348D+04	.172D+12
312.00	.182D+00	.686D+07	.236D+04	.000D+00	.662D+04	.172D+12
336.00	.969D-01	.642D+07	.222D+04	.000D+00	.108D+05	.172D+12
360.00	.332D-01	.539D+07	.190D+04	.000D+00	.160D+05	.172D+12
384.00	-.124D-01	.405D+07	.148D+04	.000D+00	.283D+05	.172D+12
408.00	-.445D-01	.280D+07	.108D+04	.000D+00	.405D+04	.172D+12
432.00	-.671D-01	.167D+07	.729D+03	.000D+00	.548D+04	.172D+12
456.00	-.840D-01	.753D+06	.441D+03	.000D+00	.655D+04	.172D+12
480.00	-.984D-01	.151D+06	.251D+03	.000D+00	.740D+04	.172D+12

OUTPUT VERIFICATION

```
THE MAXIMUM MOMENT IMBALANCE FOR ANY ELEMENT      =   .239D-05 IN-LBS
THE MAX. LATERAL FORCE IMBALANCE FOR ANY ELEMENT =   .563D-06 LBS

COMPUTED LATERAL FORCE AT PILE HEAD         =   .89500D+04 LBS
COMPUTED MOMENT AT PILE HEAD                =   .00000D+00 IN-LBS
COMPUTED SLOPE AT PILE HEAD                 =  -.88675D-02

THE OVERALL MOMENT IMBALANCE                =   .232D-04 IN-LBS
THE OVERALL LATERAL FORCE IMBALANCE         =  -.178D-06 LBS
```

OUTPUT SUMMARY

```
PILE HEAD DEFLECTION    =   .254D+01 IN
MAXIMUM BENDING MOMENT =   .686D+07 IN-LBS
MAXIMUM TOTAL STRESS    =   .236D+04 LBS/IN**2
MAXIMUM SHEAR FORCE     =   .483D+05 LBS
NO. OF ITERATIONS           =        29
MAXIMUM DEFLECTION ERROR    =   .664D-05 IN
```

1 ACDC,41 FT PILE,D=30",KA CASE (Case 1)

SUMMARY TABLE
****

LATERAL LOAD (LBS)	BOUNDARY CONDITION BC2	AXIAL LOAD (LBS)	YT (IN)	ST (IN/IN)	MAX. MOMENT (IN-LBS)	MAX STRE (LBS/IN
.895D+04	.000D+00	.144D+06	.254D+01	-.887D-02	.686D+07	.236 D+04

FINITE DIFFERENCE PARAMETERS

NUMBER OF PILE INCREMENTS	=	82
TOLERANCE ON DETERMINATION OF DEFLECTIONS	=	.100D-04 IN
MAXIMUM NUMBER OF ITERATIONS ALLOWED FOR PILE ANALYSIS	=	100
MAXIMUM ALLOWABLE DEFLECTION	=	.360D+03 IN

INPUT CODES

OUTPT = 1
KCYCL = 1
KBC = 1
KPYOP = 0
INC = 4

ACDC,41 FT PILE,D=36",KA CASE,P=0

CASE 1

D = 36"

UNITS--ENGL

O U T P U T   I N F O R M A T I O N

****

PILE LOADING CONDITION

APPLIED MOMENT AT PILE HEAD	=	.000D+00 LBS-IN
LATERAL LOAD AT PILE HEAD	=	.895D+04 LBS
AXIAL LOAD AT PILE HEAD	=	.150D+06 LBS

X IN	DEFLECTION IN	MOMENT LBS-IN	TOTAL STRESS LBS/IN**2	DISTR. LOAD LBS/IN	SOIL MODULUS LBS/IN**2	FLEXURAL RIGIDITY LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.133D+01	.000D+00	.147D+03	.000D+00	.000D+00	.356D+12
24.00	.122D+01	.231D+06	.189D+03	.000D+00	.000D+00	.356D+12
48.00	.112D+01	.462D+06	.231D+03	.000D+00	.000D+00	.356D+12
72.00	.101D+01	.694D+06	.274D+03	.278D+02	.000D+00	.356D+12
96.00	.901D+00	.941D+06	.319D+03	.834D+02	.000D+00	.356D+12
120.00	.796D+00	.124D+07	.372D+03	.139D+03	.000D+00	.356D+12
144.00	.693D+00	.161D+07	.441D+03	.195D+03	.000D+00	.356D+12
168.00	.593D+00	.210D+07	.529D+03	.250D+03	.000D+00	.356D+12
192.00	.496D+00	.273D+07	.644D+03	.306D+03	.000D+00	.356D+12
216.00	.404D+00	.354D+07	.791D+03	.361D+03	.000D+00	.356D+12
240.00	.317D+00	.455D+07	.975D+03	.417D+03	.000D+00	.356D+12
264.00	.237D+00	.566D+07	.118D+04	.000D+00	.213D+04	.356D+12
288.00	.167D+00	.649D+07	.133D+04	.000D+00	.581D+04	.356D+12
312.00	.107D+00	.676D+07	.138D+04	.000D+00	.112D+05	.356D+12
336.00	.585D-01	.635D+07	.130D+04	.000D+00	.194D+05	.356D+12
360.00	.198D-01	.531D+07	.111D+04	.000D+00	.270D+05	.356D+12
384.00	-.104D-01	.397D+07	.869D+03	.000D+00	.324D+05	.356D+12
408.00	-.342D-01	.273D+07	.643D+03	.000D+00	.546D+04	.356D+12
432.00	-.535D-01	.161D+07	.440D+03	.000D+00	.703D+04	.356D+12
456.00	-.703D-01	.709D+06	.276D+03	.000D+00	.802D+04	.356D+12
480.00	-.858D-01	.133D+06	.172D+03	.000D+00	.872D+04	.356D+12

THE MAXIMUM MOMENT IMBALANCE FOR ANY ELEMENT = -.201D-05 IN-LBS
THE MAX. LATERAL FORCE IMBALANCE FOR ANY ELEMENT = -.397D-06 LBS

COMPUTED LATERAL FORCE AT PILE HEAD = .89500D+04 LBS
COMPUTED MOMENT AT PILE HEAD = .00000D+00 IN-LBS
COMPUTED SLOPE AT PILE HEAD = -.45322D-02

THE OVERALL MOMENT IMBALANCE = .156D-03 IN-LBS
THE OVERALL LATERAL FORCE IMBALANCE = -.303D-05 LBS

OUTPUT SUMMARY

PILE HEAD DEFLECTION = .133D+01 IN
MAXIMUM BENDING MOMENT = .676D+07 IN-LBS
MAXIMUM TOTAL STRESS = .138D+04 LBS/IN**2
MAXIMUM SHEAR FORCE = .479D+05 LBS
NO. OF ITERATIONS = 26
MAXIMUM DEFLECTION ERROR = .928D-05 IN

1 ACDC,41 FT PILE,D=36",KA CASE,P=0 (CASE 1)

SUMMARY TABLE
****

LATERAL LOAD (LBS)	BOUNDARY CONDITION BC2	AXIAL LOAD (LBS)	YT (IN)	ST (IN/IN)	MAX. MOMENT (IN-LBS)	MAX. STRESS (LBS/IN**2
.895D+04	.000D+00	.150D+06	.133D+01	-.453D-02	.676D+07	.138D+(D+04

FINITE DIFFERENCE PARAMETERS

NUMBER OF PILE INCREMENTS	=	82
TOLERANCE ON DETERMINATION OF DEFLECTIONS	=	.100D-04 IN
MAXIMUM NUMBER OF ITERATIONS ALLOWED FOR PILE ANALYSIS	=	100
MAXIMUM ALLOWABLE DEFLECTION	=	.30D+03 IN

INPUT CODES

OUTPT = 1
KCYCL = 1
KBC = 1
KPYOP = 0
INC = 4

1 ACDC,41 FT PILE,D=30",KO CASE ((Case 2))

UNITS--ENGL

O U T P U T   I N F O R M A T I O N

****

PILE LOADING CONDITION

APPLIED MOMENT AT PILE HEAD	=	.000D+00 LBS-IN
LATERAL LOAD AT PILE HEAD	=	-.920D+05 LBS
AXIAL LOAD AT PILE HEAD	=	.144D+06 LBS

X	DEFLECTION	MOMENT	TOTAL STRESS	DISTR. LOAD	SOIL MODULUS	FLEXURAL RIGIDITY
IN	IN	LBS-IN	LBS/IN**2	LBS/IN	LBS/IN**2	LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.442D-01	-.248D-07	.204D+03	.372D+03	.000D+00	.172D+12
24.00	.162D+00	-.211D+07	.867D+03	.455D+03	.000D+00	.172D+12
48.00	.272D+00	-.396D+07	.145D+04	.537D+03	.000D+00	.172D+12
72.00	.370D+00	-.549D+07	.193D+04	.620D+03	.000D+00	.172D+12
96.00	.449D+00	-.667D+07	.230D+04	.703D+03	.000D+00	.172D+12
120.00	.505D+00	-.744D+07	.254D+04	.786D+03	.000D+00	.172D+12
144.00	.537D+00	-.775D+07	.264D+04	.868D+03	.000D+00	.172D+12
168.00	.543D+00	-.756D+07	.258D+04	.951D+03	.000D+00	.172D+12
192.00	.524D+00	-.682D+07	.235D+04	.103D+04	.000D+00	.172D+12
216.00	.483D+00	-.547D+07	.192D+04	.112D+04	.000D+00	.172D+12
240.00	.422D+00	-.349D+07	.130D+04	.120D+04	.000D+00	.172D+12
264.00	.351D+00	-.112D+07	.554D+03	.000D+00	.145D+04	.172D+12
288.00	.276D+00	.963D+06	.507D+03	.000D+00	.361D+04	.172D+12
312.00	.203D+00	.248D+07	.983D+03	.000D+00	.616D+04	.172D+12
336.00	.139D+00	.329D+07	.124D+04	.000D+00	.874D+04	.172D+12
360.00	.857D-01	.341D+07	.128D+04	.000D+00	.105D+05	.172D+12
384.00	.437D-01	.298D+07	.114D+04	.000D+00	.171D+05	.172D+12
408.00	.115D-01	.218D+07	.889D+03	.000D+00	.112D+05	.172D+12
432.00	-.134D-01	.132D+07	.619D+03	.000D+00	.184D+05	.172D+12
456.00	-.338D-01	.590D+06	.389D+03	.000D+00	.130D+05	.172D+12
480.00	-.522D-01	.112D+06	.239D+03	.000D+00	.119D+05	.172D+12

OUTPUT VERIFICATION

```
THE MAXIMUM MOMENT IMBALANCE FOR ANY ELEMENT      =  -.874D-06 IN-LBS
THE MAX. LATERAL FORCE IMBALANCE FOR ANY ELEMENT  =   .106D-06 LBS

COMPUTED LATERAL FORCE AT PILE HEAD       =  -.92000D+05 LBS
COMPUTED MOMENT AT PILE HEAD              =  -.24830D-07 IN-LBS
COMPUTED SLOPE AT PILE HEAD               =   .49452D-02

THE OVERALL MOMENT IMBALANCE              =  -.713D-04 IN-LBS
THE OVERALL LATERAL FORCE IMBALANCE       =   .446D-06 LBS
```

OUTPUT SUMMARY

```
PILE HEAD DEFLECTION    =   .442D-01 IN
MAXIMUM BENDING MOMENT  =  -.775D+07 IN-LBS
MAXIMUM TOTAL STRESS    =   .264D+04 LBS/IN**2
MAXIMUM SHEAR FORCE     =   .100D+06 LBS
NO. OF ITERATIONS       =          27
MAXIMUM DEFLECTION ERROR =  .787D-05 IN
```

Case 2
D = 30"

NUMBER OF PILE INCREMENTS = 82
TOLERANCE ON DETERMINATION OF DEFLECTIONS = .1000D-04 IN
MAXIMUM NUMBER OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
MAXIMUM ALLOWABLE DEFLECTION = .360D+03 IN

INPUT CODES
OUTPT = 1
KCYCL = 1
KBC = 1
KPYOP = 0
INC = 4

1 ACDC,41 FT PILE,D=36",KO CASE

UNITS--ENGL

O U T P U T   I N F O R M A T I O N

****

Case 2
D=36"

PILE LOADING CONDITION

APPLIED MOMENT AT PILE HEAD = .000D+00 LBS-IN
LATERAL LOAD AT PILE HEAD = -.935D+05 LBS
AXIAL LOAD AT PILE HEAD = .150D+06 LBS

X	DEFLECTION	MOMENT	TOTAL STRESS	DISTR. LOAD	SOIL MODULUS	FLEXURAL RIGIDITY
IN	IN	LBS-IN	LBS/IN**2	LBS/IN	LBS/IN**2	LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.818D-02	.000D+00	.147D+03	.372D+03	.000D+00	.356D+12
24.00	.680D-01	-.214D+07	.536D+03	.455D+03	.000D+00	.356D+12
48.00	.124D+00	-.401D+07	.878D+03	.537D+03	.000D+00	.356D+12
72.00	.174D+00	-.558D+07	.116D+04	.620D+03	.000D+00	.356D+12
96.00	.215D+00	-.679D+07	.138D+04	.703D+03	.000D+00	.356D+12
120.00	.245D+00	-.759D+07	.153D+04	.786D+03	.000D+00	.356D+12
144.00	.263D+00	-.793D+07	.159D+04	.868D+03	.000D+00	.356D+12
168.00	.268D+00	-.778D+07	.156D+04	.951D+03	.000D+00	.356D+12
192.00	.261D+00	-.707D+07	.143D+04	.103D+04	.000D+00	.356D+12
216.00	.242D+00	-.577D+07	.120D+04	.112D+04	.000D+00	.356D+12
240.00	.214D+00	-.382D+07	.843D+03	.120D+04	.000D+00	.356D+12
264.00	.180D+00	-.149D+07	.418D+03	.000D+00	.259D+04	.356D+12
288.00	.143D+00	.575D+06	.252D+03	.000D+00	.648D+04	.356D+12
312.00	.107D+00	.211D+07	.532D+03	.000D+00	.112D+05	.356D+12
336.00	.750D-01	.297D+07	.687D+03	.000D+00	.166D+05	.356D+12
360.00	.472D-01	.312D+07	.715D+03	.000D+00	.214D+05	.356D+12
384.00	.245D-01	.270D+07	.639D+03	.000D+00	.237D+05	.356D+12
408.00	.608D-02	.196D+07	.504D+03	.000D+00	.199D+05	.356D+12
432.00	-.917D-02	.117D+07	.360D+03	.000D+00	.264D+05	.356D+12
456.00	-.225D-01	.505D+06	.239D+03	.000D+00	.188D+05	.356D+12
480.00	-.350D-01	.862D+05	.163D+03	.000D+00	.171D+05	.356D+12

THE MAXIMUM MOMENT IMBALANCE FOR ANY ELEMENT = -.665D-06 IN-LBS
THE MAX. LATERAL FORCE IMBALANCE FOR ANY ELEMENT = -.927D-07 LBS

COMPUTED LATERAL FORCE AT PILE HEAD = -.93500D+05 LBS
COMPUTED MOMENT AT PILE HEAD = .00000D+00 IN-LBS
COMPUTED SLOPE AT PILE HEAD = .25157D-02

THE OVERALL MOMENT IMBALANCE = -.124D-05 IN-LBS
THE OVERALL LATERAL FORCE IMBALANCE = -.362D-08 LBS

OUTPUT SUMMARY

PILE HEAD DEFLECTION = .818D-02 IN
MAXIMUM BENDING MOMENT = -.794D+07 IN-LBS
MAXIMUM TOTAL STRESS = .159D+04 LBS/IN**2
MAXIMUM SHEAR FORCE = .985D+05 LBS
NO. OF ITERATIONS = 26
MAXIMUM DEFLECTION ERROR = .703D-05 IN

1 ACDC,41 FT PILE,D=36",KO CASE (Case 2)

SUMMARY TABLE
****

LATERAL LOAD (LBS)	BOUNDARY CONDITION BC2	AXIAL LOAD (LBS)	YT (IN)	ST (IN/IN)	MAX. MOMENT (IN-LBS)	MAX. STRESS (LBS/IN**2
-.935D+05	.000D+00	.150D+06	.818D-02	.252D-02	-.794D+07	.159D+(

D+04

FINITE DIFFERENCE PARAMETERS

NUMBER OF PILE INCREMENTS	=	82
TOLERANCE ON DETERMINATION OF DEFLECTIONS	=	.100D-04 IN
MAXIMUM NUMBER OF ITERATIONS ALLOWED FOR PILE ANALYSIS	=	100
MAXIMUM ALLOWABLE DEFLECTION	=	.30D+03 IN

INPUT CODES

OUTPT = 1
KCYCL = 1
KBC = 2
KPYOP = 0
INC = 4

1 ACDC,41 FT PILE,D=30",KO CASE,FIXED HEAD (Case 3)

UNITS--ENGL

O U T P U T   I N F O R M A T I O N
****

PILE LOADING CONDITION

SLOPE AT PILE HEAD	=	.000D+00 IN/IN
LATERAL LOAD AT PILE HEAD	=	-.122D+06 LBS
AXIAL LOAD AT PILE HEAD	=	.144D+06 LBS

X	DEFLECTION	MOMENT	TOTAL STRESS	DISTR. LOAD	SOIL MODULUS	FLEXURAL RIGIDITY
IN	IN	LBS-IN	LBS/IN**2	LBS/IN	LBS/IN**2	LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.272D-01	.817D+07	.277D+04	.372D+03	.000D+00	.172D+12
24.00	.394D-01	.536D+07	.189D+04	.455D+03	.000D+00	.172D+12
48.00	.696D-01	.280D+07	.108D+04	.537D+03	.000D+00	.172D+12
72.00	.109D+00	.553D+06	.377D+03	.620D+03	.000D+00	.172D+12
96.00	.151D+00	-.134D+07	.624D+03	.703D+03	.000D+00	.172D+12
120.00	.188D+00	-.282D+07	.109D+04	.786D+03	.000D+00	.172D+12
144.00	.216D+00	-.386D+07	.142D+04	.868D+03	.000D+00	.172D+12
168.00	.231D+00	-.438D+07	.158D+04	.951D+03	.000D+00	.172D+12
192.00	.232D+00	-.436D+07	.158D+04	.103D+04	.000D+00	.172D+12
216.00	.218D+00	-.375D+07	.138D+04	.112D+04	.000D+00	.172D+12
240.00	.192D+00	-.248D+07	.985D+03	.120D+04	.000D+00	.172D+12
264.00	.157D+00	-.831D+06	.465D+03	.000D+00	.257D+04	.172D+12
288.00	.120D+00	.593D+06	.390D+03	.000D+00	.640D+04	.172D+12
312.00	.841D-01	.158D+07	.702D+03	.000D+00	.110D+05	.172D+12
336.00	.538D-01	.206D+07	.850D+03	.000D+00	.151D+05	.172D+12
360.00	.303D-01	.206D+07	.853D+03	.000D+00	.167D+05	.172D+12
384.00	.136D-01	.176D+07	.757D+03	.000D+00	.273D+05	.172D+12
408.00	.271D-02	.126D+07	.601D+03	.000D+00	.330D+05	.172D+12
432.00	-.392D-02	.733D+06	.434D+03	.000D+00	.461D+05	.172D+12
456.00	-.807D-02	.300D+06	.298D+03	.000D+00	.379D+05	.172D+12
480.00	-.112D-01	.418D+05	.217D+03	.000D+00	.378D+05	.172D+12

OUTPUT VERIFICATION

THE MAXIMUM MOMENT IMBALANCE FOR ANY ELEMENT = -.194D-06 IN-LBS
THE MAX. LATERAL FORCE IMBALANCE FOR ANY ELEMENT = -.383D-07 LBS

COMPUTED LATERAL FORCE AT PILE HEAD = -.12200D+06 LBS
COMPUTED SLOPE AT PILE HEAD = .28912D-18 IN/IN

THE OVERALL MOMENT IMBALANCE = .247D-04 IN-LBS
THE OVERALL LATERAL FORCE IMBALANCE = -.616D-07 LBS

OUTPUT SUMMARY

PILE HEAD DEFLECTION = .272D-01 IN
MAXIMUM BENDING MOMENT = .817D+07 IN-LBS
MAXIMUM TOTAL STRESS = .277D+04 LBS/IN**2
MAXIMUM SHEAR FORCE = .700D+05 LBS
NO. OF ITERATIONS = 18
MAXIMUM DEFLECTION ERROR = .908D-05 IN

1 ACDC,41 FT PILE,D=30",KO CASE,FIXED HEAD (Case 3)

S U M M A R Y T A B L E
****

LATERAL LOAD (LBS)	BOUNDARY CONDITION BC2	AXIAL LOAD (LBS)	YT (IN)	ST (IN/IN)	MAX. MOMENT (IN-LBS)	MAX. STRES (LBS/IN*
-.122D+06	.000D+00	.144D+06	.272D-01	.289D-18	.817D+07	.277D D+04

PILE LOADING CONDITION

SLOPE AT PILE HEAD = .000D+00 IN/IN
LATERAL LOAD AT PILE HEAD = -.125D+06 LBS
AXIAL LOAD AT PILE HEAD = .150D+06 LBS

CASE 3

D = 36"

X	DEFLECTION	MOMENT	TOTAL STRESS	DISTR. LOAD	SOIL MODULUS	FLEXURAL RIGIDITY
IN	IN	LBS-IN	LBS/IN**2	LBS/IN	LBS/IN**2	LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.254D-02	.861D+07	.171D+04	.372D+03	.000D+00	.356D+12
24.00	.876D-02	.573D+07	.119D+04	.455D+03	.000D+00	.356D+12
48.00	.243D-01	.310D+07	.712D+03	.537D+03	.000D+00	.356D+12
72.00	.448D-01	.784D+06	.290D+03	.620D+03	.000D+00	.356D+12
96.00	.667D-01	-.118D+07	.361D+03	.703D+03	.000D+00	.356D+12
120.00	.868D-01	-.273D+07	.644D+03	.786D+03	.000D+00	.356D+12
144.00	.102D+00	-.383D+07	.845D+03	.868D+03	.000D+00	.356D+12
168.00	.112D+00	-.443D+07	.954D+03	.951D+03	.000D+00	.356D+12
192.00	.114D+00	-.449D+07	.963D+03	.103D+04	.000D+00	.356D+12
216.00	.110D+00	-.394D+07	.864D+03	.112D+04	.000D+00	.356D+12
240.00	.986D-01	-.275D+07	.648D+03	.120D+04	.000D+00	.356D+12
264.00	.832D-01	-.117D+07	.361D+03	.000D+00	.449D+04	.356D+12
288.00	.659D-01	.195D+06	.183D+03	.000D+00	.108D+05	.356D+12
312.00	.488D-01	.117D+07	.360D+03	.000D+00	.162D+05	.356D+12
336.00	.335D-01	.169D+07	.455D+03	.000D+00	.216D+05	.356D+12
360.00	.209D-01	.180D+07	.475D+03	.000D+00	.270D+05	.356D+12
384.00	.112D-01	.159D+07	.436D+03	.000D+00	.324D+05	.356D+12
408.00	.409D-02	.118D+07	.362D+03	.000D+00	.269D+05	.356D+12
432.00	-.118D-02	.708D+06	.276D+03	.000D+00	.123D+06	.356D+12
456.00	-.529D-02	.288D+06	.200D+03	.000D+00	.558D+05	.356D+12
480.00	-.891D-02	.380D+05	.154D+03	.000D+00	.477D+05	.356D+12

OUTPUT VERIFICATION

COMPUTED LATERAL FORCE AT PILE HEAD = -.12500D+06 LBS
COMPUTED SLOPE AT PILE HEAD = -.36140D-19 IN/IN

THE OVERALL MOMENT IMBALANCE = .203D-04 IN-LBS
THE OVERALL LATERAL FORCE IMBALANCE = -.146D-06 LBS

OUTPUT SUMMARY

PILE HEAD DEFLECTION = .254D-02 IN
MAXIMUM BENDING MOMENT = .861D+07 IN-LBS
MAXIMUM TOTAL STRESS = .171D+04 LBS/IN**2
MAXIMUM SHEAR FORCE = .670D+05 LBS
NO. OF ITERATIONS = 6
MAXIMUM DEFLECTION ERROR = .543D-05 IN

ACDC,41 FT PILE,D=36",KO CASE,ROT. AT TOP=0 (Case 3)

SUMMARY TABLE
****

LATERAL LOAD (LBS)	BOUNDARY CONDITION BC2	AXIAL LOAD (LBS)	YT (IN)	ST (IN/IN)	MAX. MOMENT (IN-LBS)	MAX. STRESS (LBS/IN**2
-.123D+06	.000D+00	.150D+06	.296D-01	.289D-18	.823D+07	.164D+0
-.124D+06	.000D+00	.150D+06	.159D-01	-.289D-18	.842D+07	.168D+0
-.125D+06	.000D+00	.150D+06	.254D-02	-.361D-19	.861D+07	~~.171D+0~~ .171D+04

THOMAS-HARTIG & ASSOCIATES, INC.

TOM W. THOMAS, P.E. · HARRY E. HARTIG, P.E.
Soil and Foundation Engineering · Materials Testing
7031 West Oakland Street Chandler, Arizona 85226 602/961-1169

James R. Morrow
John P. Boyd, P.E.
Charles H. Atkinson, P.E.
Donald J. Spadola, P.E.
Glen K. Copeland, P.E.
James M. Willson, P.E.
Frank M. Guerra, P.E.
Roger A. Brewer, P.E.
Steven A. Haire, P.E.
Chet L. Pearson, P.E.
Kenneth L. Ricker, P.E.

FEB 03 88
ENTRANCO ◦ MANN ◦ JOHNSON, INC.

02 February 1988

Entranco Mann Johnson Engineers, Inc.
8805 North 23rd Avenue, Suite 9
Phoenix, Arizona 85021

Attention: William Kantor

Project: ACDC Bridge at 19th Avenue

Project No. 87-0478

As you requested, we have attached a copy of calculations for stability of soil between the drilled piers. A pier spacing of 81.5 inches (center to center), and a pier diameter of 36 inches was used in the calculations. Soil strength parameters used were $\phi = 29^{o}$, C = 500 psf.

Respectfully submitted,

THOMAS-HARTIG & ASSOCIATES, INC.

Steven A. Haire, P.E.

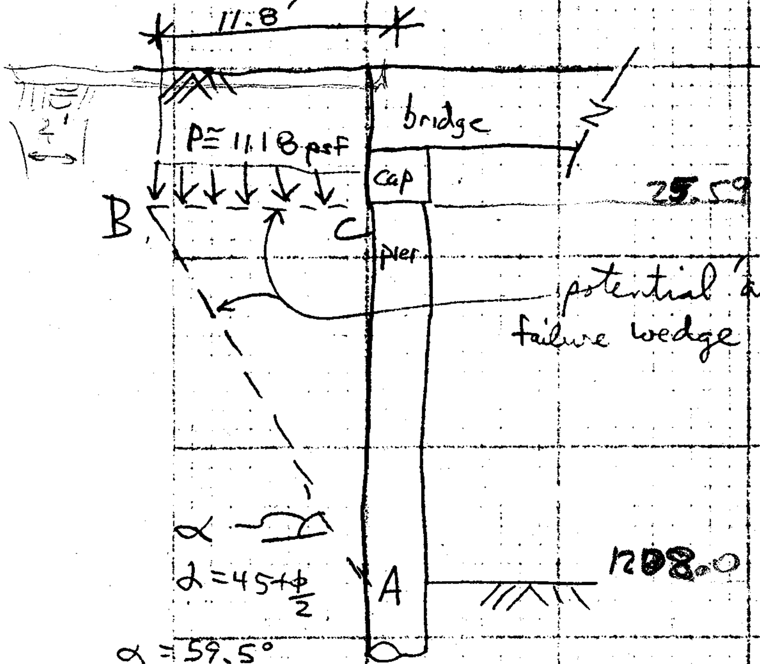
/smb

Enclosures

Thomas-Hartig & Assoc, Inc.
2720 S. Hardy Drive
Tempe, Arizona 85282

PROJECT NO. 87-0478 COMPUTED BY SH DATE 1-28-88
SUBJECT Arching CHECKED BY [illegible] DATE 2/2/88

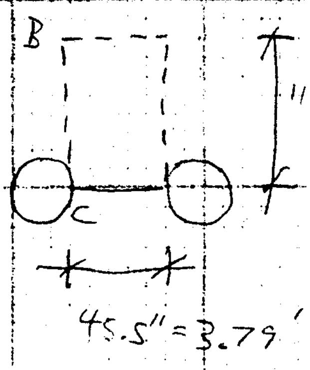
Cross Section



P = 7' * 124 pcf + 250 psf surcharge
P = 1118 psf

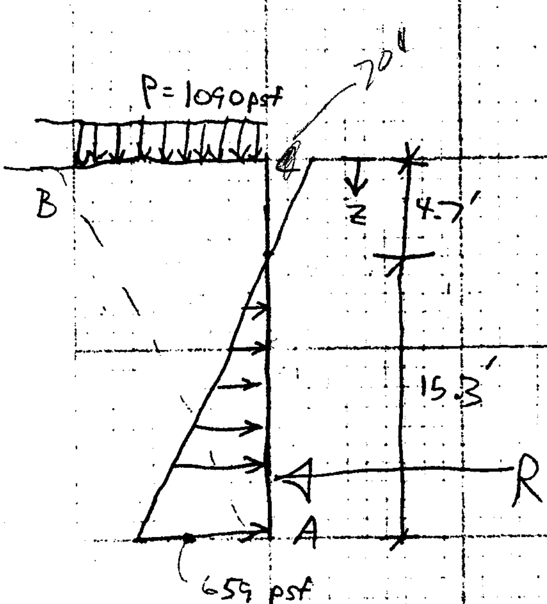
Soil properties: $\phi = 29°$
$c = 500$ psf
$\gamma \cong 124$ pcf

Plan View



Thomas-Hartig & Assoc, Inc.
2720 S. Hardy Drive
Tempe, Arizona 85282

PROJECT NO. 87-0478 COMPUTED BY SH DATE 1-29-88
SUBJECT Arching CHECKED BY [illegible] DATE 2/2/88



$K_a = \tan^2(45 - \frac{\phi}{2}) = 0.347$ ✓

$\sqrt{K_a} = 0.589$

$P_a = q K_a - 2c\sqrt{K_a}$

$P_a = (1118 + 124 z)(0.347) - 2(500)(.589)$

$P_a = \cancel{388} + 43 z - 589$

$P_a = 43z - 201$

$@ z = 0 : P_a = -201$ psf

$@ z = 20 : P_a = 659$ psf

$@ z = 4.7, P = 0$

~~$R = \frac{659}{2} * 15.3 = 5041$ lb/ft of soil~~

$R = 5041 * 3.79' = 19{,}105$ lb required to keep wedge from sliding

spacing between piers

Cohesion on sides of wedge $= cA = 500\text{ psf}[11.8 * 20 * \frac{1}{2} * 2]$
$= 118{,}000$ lb

$\therefore$ F.S. $\approx \frac{118{,}000}{19{,}105} = 6.2$

$\therefore$ Overall stability of soil wedge between piers is OK