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GEOTECHNICAL INVESTIGATION REPORT

Broadway Road Bridge Over Roosevelt
Water Conservation District (RWCD) Floodway
Mesa, Arizona

SHB Job No. E83-103

Consulting Geotechnical Engineers
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APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING

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August 18, 1983

RGA Consulting Engineers, Inc.
1102 West Indian School Road
Phoenix, Arizona 85013

SHB Job No. E83-103

Attention: Harold E. Ditzler, P.E.

Re: Broadway Road Bridge Over
Roosevelt Water Conservation
District (RWCD) Floodway
Mesa, Arizona

Gentlemen,

Our Geotechnical Investigation Report on the referenced project is herewith submitted. The report includes the results of test drilling, laboratory analysis and recommended criteria for foundation design.

Should any questions arise concerning this report, we would be pleased to discuss them with you.

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By _____
Norman H. Wetz, P.E.

Reviewed by _____
B. Dwaine Sergent, P.E.

Copies: Addressee (8)

Registered Professional Engineer (Civil) CERTIFICATE NO. 12176 NORMAN HAROLD WETZ Date Signed 8-18-83 ARIZONA, U.S.A.

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TABLE OF CONTENTS

Page

REPORT

Introduction 1
Project Description. 1
Investigation. 1
Site Conditions & Geotechnical Profile 2
Discussion & Recommendations 3

APPENDIX A

Test Drilling Equipment & Procedures A-1
Unified Soil Classification System A-2
Terminology Used to Describe the Relative Density, Consistency or Firmness of Soils. . . . A-3
Site Plan. A-4
Logs of Test Borings A-5

APPENDIX B

Classification Test Data B-1

APPENDIX C

Design Charts 1 & 2. . . . . C-1

SHB Job No. E83-103

Broadway Road Bridge Over
Roosevelt Water Conservation
District (RWCD) Floodway
Mesa, Arizona
SHB Job No. E83-103

1. INTRODUCTION

This report is submitted pursuant to a geotechnical investigation made by this firm of the site of the proposed Broadway Road Bridge Over Roosevelt Water Conservation District (RWCD) Floodway located in Mesa, Arizona. The object of this investigation was to evaluate the physical properties of the subsoils underlying the site to provide recommendations for foundation design and abutment support.

2. PROJECT DESCRIPTION

Preliminary details of the proposed construction were provided by Jay E. Mihalek, P.E., and Mihai Harabor, P.E., of RGA Consulting Engineers, Inc.

It is understood that a three-span, two-lane highway bridge will cross the proposed Roosevelt Water Conservation District Floodway. The bridge will be approximately 68 feet wide and 95 feet in length.

Should details involved in final design vary significantly from those as outlined, this firm should be notified for review and possible revision of recommendations.

3. INVESTIGATION

3.1 Subsurface Exploration

One exploratory boring was drilled to a depth of 28 feet

below existing grade. The boring was performed using 6 5/8-inch O.D. hollow stem auger. Standard penetration testing was performed at 5-foot intervals in the boring. The results of the field investigation are presented in Appendix A, which includes a brief description of drilling and sampling equipment and procedures, a site plan showing the boring locations and a log of the test boring. The field investigation was supervised by Norman H. Wetz, P.E., of this firm.

3.2 Laboratory Analysis

Moisture content determinations were made on all tube samples recovered. The results of these tests are shown on the boring logs.

Grain-size analysis and Atterberg Limits tests were performed on selected samples to aid in soil classification. The results of these tests are presented in Appendix B.

4. SITE CONDITIONS & GEOTECHNICAL PROFILE

4.1 Site Conditions

An existing irrigation canal is located immediately to the west of this bridge site. Also, an existing drainage canal with a small box culvert is located on the western portion of the bridge site. Broadway Road is existing and is a paved two-lane highway.

4.2 Geotechnical Profile

The subsurface soils consist of a surface layer of man-made fill that extends approximately 2½ feet below existing grade at the boring location. This material is a clayey sand of low plasticity and was found to be relatively firm. Sandy clay underlies the man-made fill and extends to about 18 feet below existing grade. The sandy clay is weakly to moderately cemented and firm to hard. The clayey sand extends from 18 feet to the full depth of the boring. This material is moderately lime cemented and is hard. In general, subsurface materials are similar to those encountered in an investigation for widening of a nearby structure (SHB Job No. E83-104).

4.3 Soil Moisture & Groundwater Conditions

No free groundwater was encountered in the borings and soil moisture contents were relatively low throughout.

5. DISCUSSION & RECOMMENDATIONS

5.1 Analysis of Results

Some of the near surface soils are somewhat moisture sensitive and would be weakened with substantial moisture increases. Thus, for the loads involved in this type of structure, excessive settlements could be experienced for shallow spread-type footings bearing upon the near surface soils at the site. Therefore, it is

recommended that the main structure elements be supported on straight, machine-cleaned, cast-in-place concrete piers bearing a minimum of 15 feet below grade. Drilled foundations would be less affected by moisture increase and the possibility of moisture increase at bearing depths would be more remote. Design criteria for drilled piers are given in Section 5.2.

5.2 Straight, Machine-Cleaned, Cast-in-Place Concrete Piers

5.2.1 Downward Loads

Straight, machine-cleaned, drilled, cast-in-place concrete piers are recommended for the support of the foundation loads involved. Safe downward capacities of piers extending a minimum of 15.0 feet below the finished grade elevation are given in Design Chart 1 in Appendix C.

Capacities apply to full dead plus live loads. A one-third increase is recommended when considering wind or seismic forces.

5.2.2 Estimated Settlements

It is estimated that settlements of pier foundations designed and constructed in accordance with criteria presented herein will not exceed ½ inch.

5.2.3 Resistance to Lateral Loads

Design Chart 2, shown in Appendix C, presents the estimated ultimate lateral soil bearing pressures versus depth. It is recommended that a factor of safety of 2.0 be used in determining working values of soil bearing pressures, based on this chart.

Criteria given above apply to isolated piers spaced no closer than 3 diameters on center perpendicular to the line of thrust and 6 diameters on center parallel to the line of thrust.

5.2.4 Cleaning of Drilled Pier Excavations

Straight drilled pier excavations should be advanced with a single flight auger, or bucket auger bits, to the design depth. It should be verified by inspection and measurement that excavations are open to that depth. The auger should be placed back in the holes and two additional passes made to clean loose material present in the bottom of the holes.

5.2.5 Placement of Concrete

Concrete should be placed through a hopper or other device approved by the geotechnical engineer so that it is channeled in such a manner to free fall and clear the walls of the excavation and reinforcing steel until it strikes the bottom. Adequate compaction will be achieved by free fall of the concrete up

to the top 5.0 feet. The top 5.0 feet of concrete should be vibrated in order to achieve proper compaction. The concrete should be designed, from a strength standpoint, so that the slump during placement is in the range of 4 to 6 inches.

5.2.6 Inspection & Construction

Continuous inspection of the construction of drilled piers should be carried out by the geotechnical engineer.

The inspector should verify proper diameter, depth and cleaning, and should also verify the nature of the materials encountered in the pier excavations. Concrete placement should be continuously observed by the inspector to insure that it meets requirements. An inspection report should be submitted on each pier stating, in writing, that all details have been inspected and meet requirements.

It appears that drilled pier excavations can be advanced to the depths recommended with little or no caving. Caving is expected to be very minimal, so concrete quantities may be very near the neat volume indicated by the plans.

5.3 Abutment Wall Design Criteria

Free draining granular backfill should be utilized behind the abutments and in roadway approach fills. This

material should consist of sand and gravel, and have no more than 12 percent passing the no. 200 sieve. This material should be nonplastic when tested in accordance with ASTM D422 and D423. Compaction of the fill should be at least 98 percent of maximum density as determined by ASTM D1557. The earth pressures against the abutments would depend upon on the degree of restraint. Rigid, absolutely restrained abutments would be subjected to earth pressures represented by a hydrostatic load diagram of about 50 pounds per square foot per foot of depth. Rotation or lateral translation of the walls equal to about 0.001 times the height would reduce earth pressures to the active state of about 30 pounds per square foot per foot of depth. Slight lateral translation equal to about 0.0005 times the height would result in an intermediate pressure diagram on the order of 40 pounds per square foot per foot of depth.

TEST DRILLING EQUIPMENT & PROCEDURES

Drilling Equipment Truck-mounted CME-55 drill rigs powered with 4 or 6 cylinder Ford industrial engines are used in advancing test borings. The 4 cylinder and 6 cylinder engines are capable of delivering about 4,350 and 6,500 foot/pounds torque to the drill spindle, respectively. The spindle is advanced with twin hydraulic rams capable of exerting 12,000 pounds downward force. Drilling through soil or softer rock is performed with 6 1/2 O.D., 3 1/4 I.D. hollow stem auger or 4 1/2 inch continuous flight auger. Carbide insert teeth are normally used on the auger bits so they can often penetrate rock or very strongly cemented soils which require blasting or very heavy equipment for excavation. Where refusal is experienced in auger drilling, the holes are sometimes advanced with tricone gear bits and NX rods using water or air as a drilling fluid. Where auger and tricone gear bits cannot be used to advance the hole due to cobbles or caving conditions, the ODEX (overburden drilling with the eccentric method) is used. A percussion down-the-hole hammer underreams the hole and 5 inch steel casing is introduced into the hole during drilling. The drill bit is eccentric and can be removed from the center of the casing to allow sampling of the material below the bit penetration depth.

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 procedure. In many cases, 2" O.D., 1 3/8" I.D. samplers are used to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3" O.D. samplers lined with 2.42" I.D. brass rings. The driving energy is generally recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the samplers in 6 inch increments. However, in stratified soils, driving resistance is sometimes recorded in 2 or 3 inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. These values are expressed in blows per foot on the logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587). Where samples of rock are required, they are obtained by NX diamond core drilling (ASTM D2113). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings.

Continuous Penetration Tests Continuous penetration tests are performed by driving a 2" O.D. blunt nosed penetrometer adjacent to or in the bottom of borings. The penetrometer is attached to 1 5/8" O.D. drill rods to provide clearance to minimize side friction so that penetration values are as nearly as possible a measure of end resistance. Penetration values are recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the penetrometer in one foot increments or less.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487) with appropriate group symbols being shown on the logs.

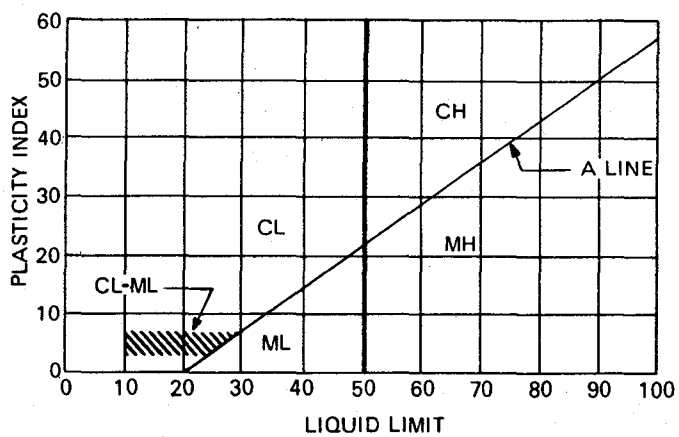
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the Unified Soil Classification system on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corp of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
					GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 seive)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (LIMITS PLOT BELOW "A" LINE & HATCHED ZONE ON PLASTICITY CHART)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)			MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS (LIMITS PLOT ABOVE "A" LINE & HATCHED ZONE ON PLASTICITY CHART)	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)			CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE: Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with limits plotting in the hatched zone on the plasticity chart to have double symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to ¾ in.
Fine gravel	¾ in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY, CONSISTENCY OR FIRMNESS OF SOILS

The terminology used on the boring logs to describe the relative density, consistency or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by the ASTM D1586 procedure using 2" O.D., 1 3/8" I.D. samplers.

1. Relative Density. Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

N	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

2. Relative Consistency. Terms for description of clays which are saturated or near saturation.

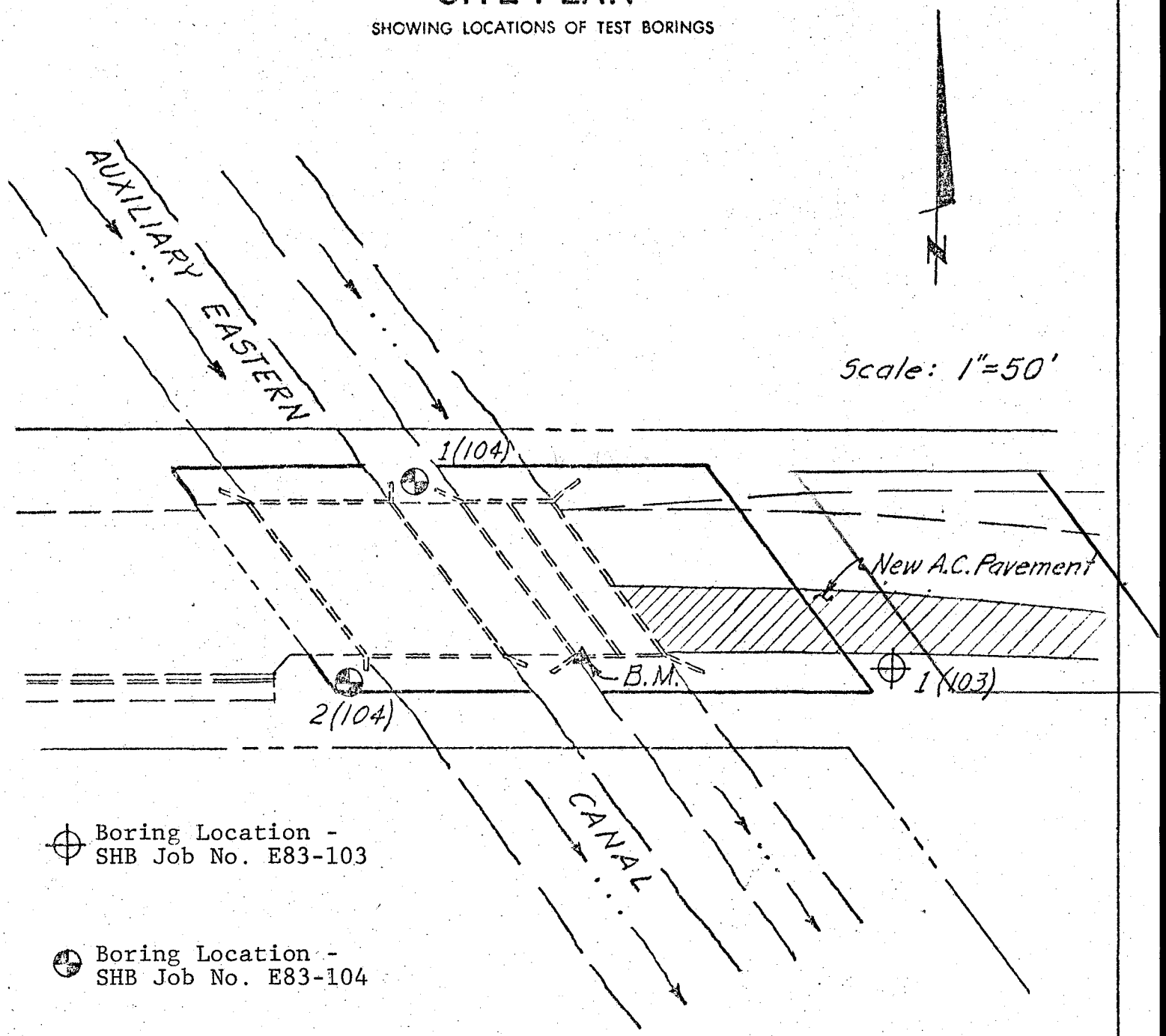
N	Relative Consistency	Remarks
0-2	Very soft	Easily penetrated several inches with fist.
3-4	Soft	Easily penetrated several inches with thumb.
5-8	Medium stiff	Can be penetrated several inches with thumb with moderate effort.
9-15	Stiff	Readily indented with thumb, but penetrated only with great effort.
16-30	Very stiff	Readily indented with thumbnail.
30+	Hard	Indented only with difficulty by thumbnail.

3. Relative Firmness. Terms for description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays, cemented granular materials, silts and silty and clayey granular soils.

N	Relative Firmness
0-4	Very soft
5-8	Soft
9-15	Moderately firm
16-30	Firm
31-50	Very firm
50+	Hard

SITE PLAN

SHOWING LOCATIONS OF TEST BORINGS



Boring Location - SHB Job No. E83-103

Boring Location - SHB Job No. E83-104

B.M. - Brass Cap in Headwall of Box Culvert - Assumed Elevation = 100.0'

Broadway Road Bridge Over
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PROJECT Broadway Road Bridge Over RWCD Floodway

JOB NO. E83-103 DATE 8-5-83

LOG OF TEST BORING NO. 1

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 98.68' 1343.57

DATUM Assumed - See Site Plan

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	19		5	SC	dry firm	Man-made FILL CLAYEY SAND, some gravel, low plasticity, brown
5			X	S	27		12		slightly moist to dry firm to hard	SANDY CLAY, weakly to moderately lime cemented, medium plasticity, brown to light brown
10			X	S	79		8	CL		
15			X	S	69		9			
20			X	S	51		7		slightly moist hard	CLAYEY SAND, well graded, angular, moderately lime cemented, low plasticity, light brown
								SC		
25			X	S	50/5½"		10			
			X	S	50/4½"		12			
30										Auger refused at 28' Sampler refused at 28'10½"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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TABULATION OF TEST RESULTS

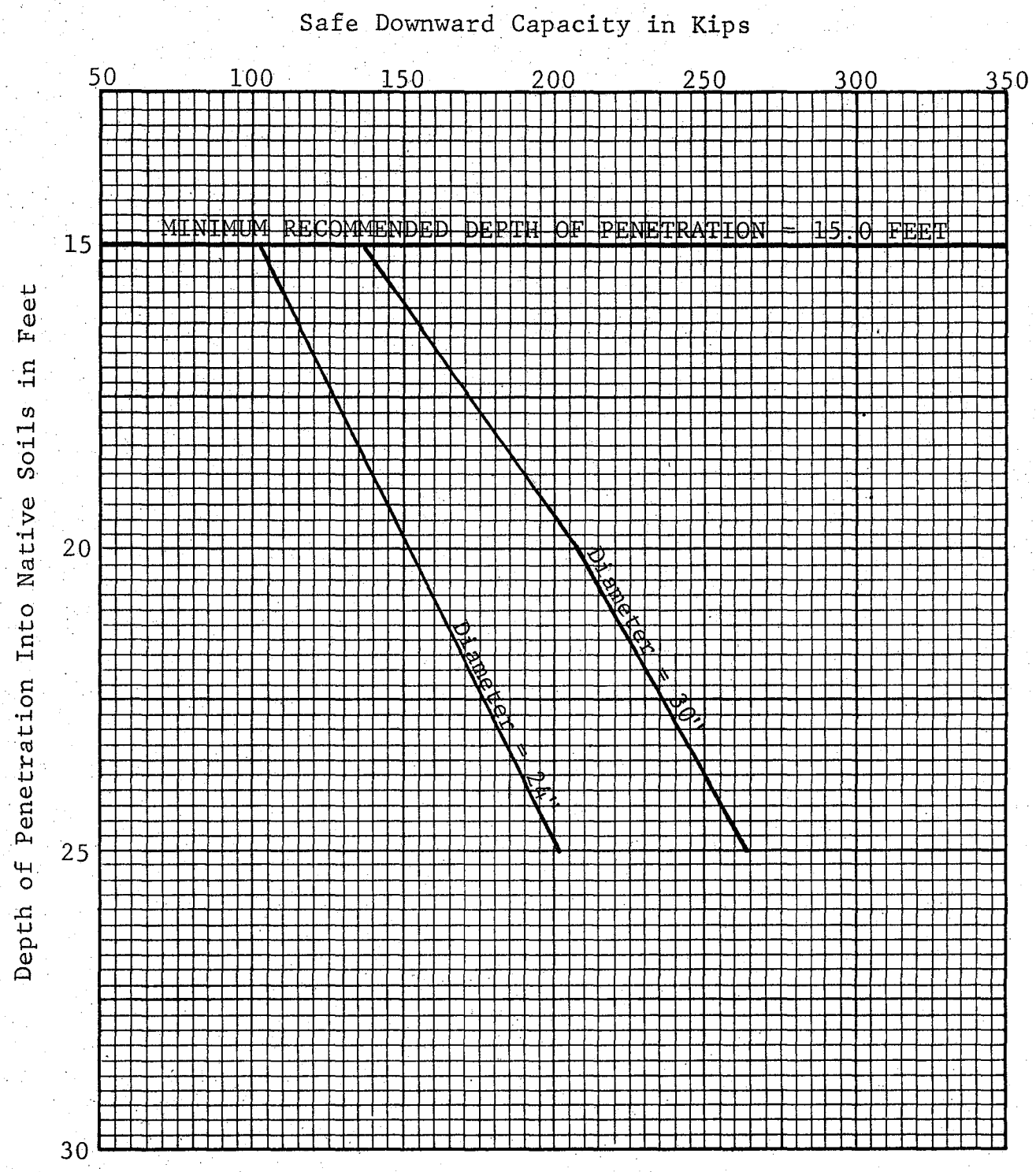
Job No. E83-103

HOLE NO	DEPTH	UNIFIED CLASS	L.L.	P.I.	SIEVE ANALYSIS-ACCUM % PASSING #200 .75"	#100 1"	#50 1.5"	#40 2"	#30 2.5"	#16 3"	#10 3.5"	#8 4"	#4 6"	.25" 8"	.375" 10"	.5" 12"	LAB NO
1	AT-5'	CL	49	29	65.8	77	84	85	87	93	96	97	100				3-103-2
1	AT-20'	SC	60	34	43.4	49	54	57	60	69	78	80	93	97	100		3-103-5

PROJECT Broadway Road Bridge Over RWCD Floodway **JOB NO.** E83-103

DESIGN CHART 1

SAFE DOWNWARD CAPACITIES OF STRAIGHT, DRILLED (MACHINE-CLEANED), CAST-IN-PLACE CONCRETE PIERS



N = 50
~~clay~~ q_u = 3.4 TSF
c = 1.7 TSF
C_A = .85 TSF

N = 50
Sand
$\phi = 38°$

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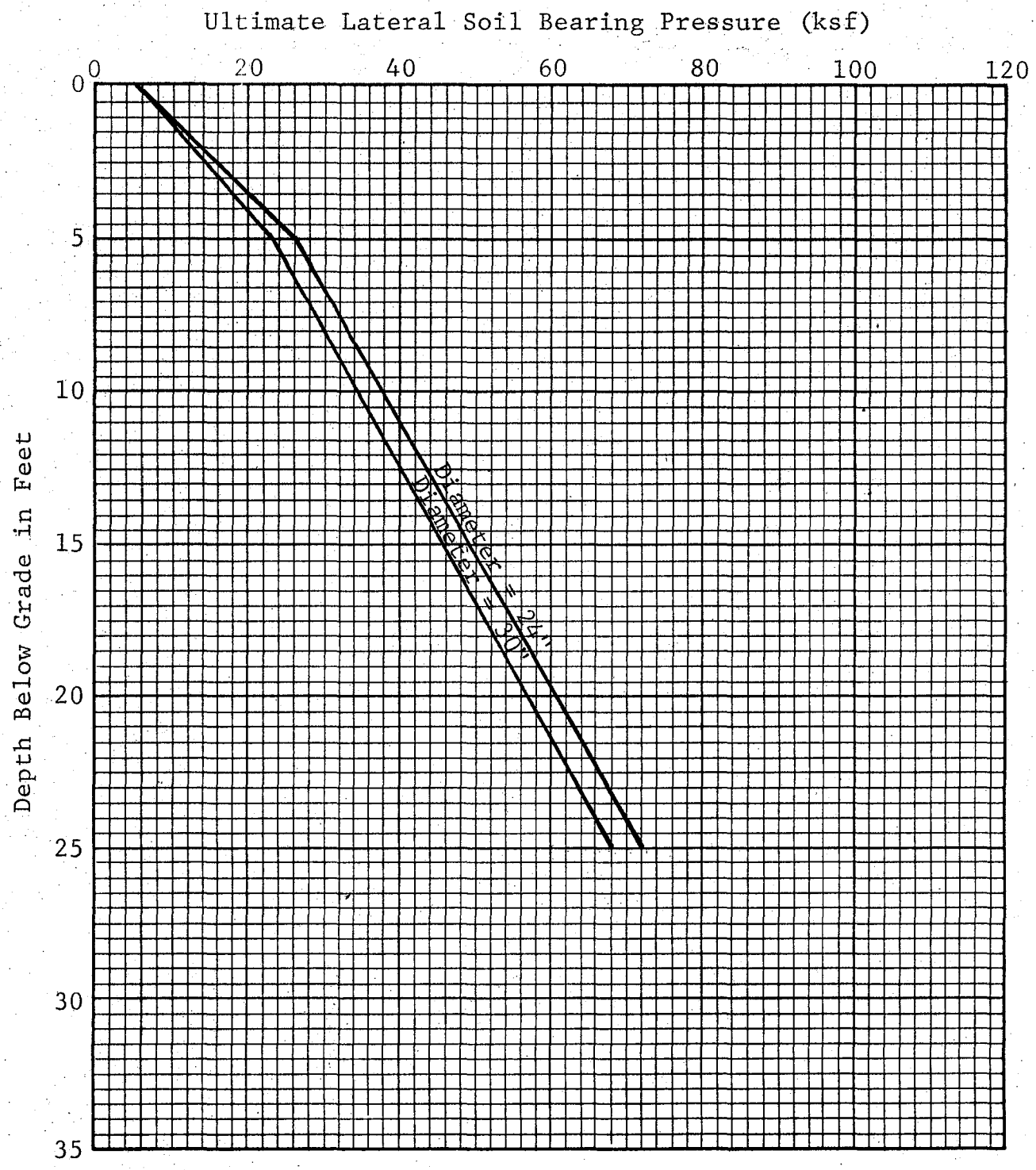
PROJECT Broadway Road Bridge Over RWCD Floodway **JOB NO.** E83-103

DESIGN CHART 2

ULTIMATE LATERAL BEARING PRESSURE OF STRAIGHT, DRILLED, CAST-IN-PLACE CONCRETE PIERS VERSUS DEPTH



$c = 1.7$ TSF

$\frac{9c}{3} = 5.4$ TSF

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