Bank stabilization & Drop Structures

GEOTECHNICAL INVESTIGATION REPORT

Bridge Over Skunk Creek

at 83rd Avenue

Peoria, Arizona

SHB Job No. E88-9
Report No. 3

Consulting Geotechnical Engineers

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SHB Job No. E88-9
Report No. 3

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Attention: Mr. Donald R. Davis, P.E.
President

Re: Bridge Over Skunk Creek
at 83rd Avenue
Peoria, Arizona

Gentlemen:

Our Geotechnical Investigation Report providing recommendations for channel bank stabilization and drop structures in association with the 83rd Avenue bridge across Skunk Creek is herewith submitted. The report includes the results of the exploratory drilling and laboratory analysis completed for the channel bank stabilization and the drop structures, and recommended criteria for design.

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

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By Gary N. Sheppard
Gary N. Sheppard
Staff Engineer

And Norman H. Wetz
Norman H. Wetz, P.E.

Reviewed by George H. Beckwith
George H. Beckwith, P.E.

Registered Professional Engineer (Civil) Certificate No. 12176 Norman Harold Wetz Date Signed 3/23/89 Arizona, U.S.A.

Registered Professional Engineer (Civil) Certificate No. 5633 George Henry Beckwith Date Signed 3-23-89 Arizona, U.S.A.

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1. INTRODUCTION

This report is submitted pursuant to a geotechnical investigation of the channel bank stabilization and the channel drop structures associated with the 83rd Avenue bridge over Skunk Creek in Maricopa County, Arizona. The object of the investigation was to evaluate the physical properties of the subsoils underlying the site and to provide recommendations for channel bank stabilization and channel drop structure design.

2. PROJECT DESCRIPTION

Details of the project were provided to us by Vince Wismer, P.E. and Donald R. Davis, P.E., of Hoffman-Miller Engineers, Inc. It is understood that in association with the proposed new bridge over Skunk Creek at 83rd Avenue, two channel drop structures along with channel bank protection are planned.

The drop structures are located at station 69+80 upstream of the bridge and at station 25+00 downstream of the bridge. The proposed heights of the drop structures are 7 and 6 feet respectively. The proposed channel bank stabilization consists of approximately 1,340 feet along the south bank and 1,120 feet along the north channel bank.

It is understood that approximately 2,500 feet of channel bank stabilization is proposed for the project

site. All bank stabilization will tie to the existing Corp of Engineers bank protection and the Outer Loop bridge slope protection.

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

3. INVESTIGATION

3.1 Subsurface Investigation

Fourteen exploratory borings were drilled to depths ranging from 15 to 35 feet utilizing our truck-mounted CME-55 and CME-75 drill rigs advancing a 6 5/8-inch O.D. hollow stem auger. Standard penetration testing or open-end drive sampling was performed at selected intervals in the borings. In addition, bulk samples of auger cuttings were obtained from selected borings.

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 logs of the test borings. The field investigation was supervised by Steven C. Wilson, staff geologist of this firm.

3.2 Laboratory Analysis

Grain-size analysis, Atterberg limits, moisture content

and density tests were performed on selected subgrade samples. Moisture contents are shown on the boring logs in Appendix A, and the results of all other tests are presented in Appendix B.

4. SITE CONDITIONS & GEOTECHNICAL PROFILE

4.1 Site Conditions

The site is typical of an Arizona ephemeral stream bed. The site is relatively void of vegetative cover, though some areas contain sparse natural desert vegetation. Previous construction noted at the time of the field investigation includes the existing 83rd Avenue bridge and the Outer Loop bridge downstream of the project site. Also noted is the existing Corp of Engineers bank stabilization upstream of the project site, which consists of grouted riprap. The stabilization of the bank is limited to the south side with no stabilization being in place on the north side. Soil-cement stabilization of the river banks has been constructed for the Outer Loop bridge downstream of this project.

4.2 Geotechnical Profile

The soils encountered beneath the site consist predominantly of stratified deposits of silty and clayey sand with some gravel, cobbles and occasional boulders. These deposits extended to the full depth of our investigation. These soils are of low to medium plasticity with occasional zones of high plasticity. The deposits

were found to be firm to hard, and are weakly to strongly lime cemented. The degree of cementation typically increases with depth. A few thin layers of relatively clean sand and sand-gravel mixtures were encountered in the borings. These soils are nonplastic and are medium dense to very dense.

4.3 Soil Moisture & Groundwater Conditions

Groundwater was encountered in one of the borings at a depth of approximately 7 feet. This boring was located in close proximity to the ponded water within the wildlife protected area upstream of the proposed bridge site and it appears that the ponded water is directly influencing groundwater elevations in that area.

No free groundwater was encountered in any of the other borings at the time of the investigation and soil moisture contents were low to moderate throughout the depths investigated. A temporarily high localized groundwater table can be expected to exist during and after flows in the channel due to surface water permeating the soils.

It is our opinion that in situ moisture conditions are somewhat drier than those reported. Due to maintaining the borehole full of water during standard penetration testing, increased moisture contents were likely measured. This is apparently the result of water being forced between the sample and the inner wall of the sampler.

5. DISCUSSION & RECOMMENDATIONS

5.1 Slope Stabilization & Erosion Control

Several stabilization alternatives were considered for the project including dumped riprap, grouted riprap and soil cement. Each alternative would require a minimum toe-down depth equal to the anticipated maximum general scour and a minimum freeboard of 4 feet above the design flow.

5.1.1 Dumped Riprap

Based on model tests and the tractive force method, Maynord (1978) has developed a relationship between the D_{50} riprap size and the channel Froude Number. For a factor of safety of 1.5 on a 1:2 (vertical to horizontal) side slope the relationship is as follows:

$$D_{50} = \text{depth} \times 0.3F^3$$

For the channel reach being investigated, design velocities range from 11 feet per second for the general channel to 16 feet per second in the vicinity of the proposed drop structures. Based on a channel bottom width of 290 feet and a side-slope of 2H:1V the Froude numbers for the two cases mentioned above are 0.585 and 0.850 respectively. These are based on an average depth of 11 feet. The values for the D_{50} riprap size for the two cases are summarized as follows:

Velocity	Depth	Froude No.	D_{50} size
11 ft/sec	11 ft	0.585	0.67 ft
16 ft/sec	11 ft	0.850	2.03 ft

Overall gradation of the riprap should have a minimum size of 1/3 the D_{50} and a maximum size of 2 times the D_{50}.

The use of riprap for this project may not be economically feasible because material meeting the above criteria is not available in significant quantities at the site and materials would have to be quarried and transported to the job site.

5.1.2 Soil-Cement

Soil-cement is probably the most feasible alternative for bank stabilization and erosion protection for the project. The surface soils at the project site can be utilized in the mixture, however the high percentage of fines and the plasticity index of those fines may require some blending with off-site materials. Lime may be added first to reduce the plasticity index and improve workability prior to the addition of cement. It is recommended that a mixture of soil, fly ash, lime and cement be investigated for soil-cement protection.

The soil used for soil-cement should not have more than 30 percent material finer than the no. 200 sieve, and have a maximum particle size of 2 inches. For

estimating purposes, the cement content of soilcement should be 12 percent. The exact cement content should be determined in accordance with ASTM D558, D559 and D560 using the on-site soil that will be used for the soil-cement treatment.

The soil-cement protection should be constructed in 6- to 8-inch lifts with a minimum horizontal width of 8 feet to facilitate access of construction machinery. Shrinkage cracks and some maintenance should be expected with soil-cement protection. Soil-cement protection can be implemented on slopes as steep as 1H:1V.

5.1.3 Grouted Riprap

Another feasible alternative for channel bank stabilization is the use of grouted riprap. The advantage of using grouted riprap is that smaller rock particles could be used than would be required with dumped riprap. It is important that the grout penetrates the full thickness of the riprap, thus making good workmanship essential in acquiring adequate protection. As mentioned previously, it may not be economically feasible to use larger particles due to haul distance and availibility of this type of material in the general area.

5.2 Drop Sructures

To maintain grade within the the proposed channel, two

drop structures are proposed for the project. The first drop structure is located approximately 4,500 feet upsteam of the proposed 83rd Avenue bridge and the second is approximately 100 feet downstream of the bridge. The stuctures will provide a drop in the channel grade of 7 feet and 6 feet respectively. It is proposed that the drop structures will be constructed of reinforced concrete or grouted riprap including downstream and upstream aprons to prevent the formation of any scour holes during high flows.

5.2.1 Drilled, Cast-in-Place Concrete Piers

5.2.1.1 Downward Loads

Straight-shafted, drilled, cast-in-place concrete piers are recommended for the support of the drop structures. Safe downward capacities of straight-shafted piers are presented in Figure 1 for the upstream structure and in Figure 2 for the downstream structure. Capacities shown are based on end-bearing only. These capacities apply to full dead load plus live loads. A one-third increase is recommended when considering wind or seismic forces.

The methodology and design input parameters utilized in the analysis of drilled pier capacity are presented in Appendix C. Complete design calculations are also provided in Appendix C. It is recommended that the minimum depth of embedment for all drilled piers be 10 feet below the anticipated scour depth.

5.2.1.2 Estimated Settlements

Settlements of pier foundations were estimated using methods outlined in the NAVFAC Design Manual 7.1, (1982).* Estimated settlements based on this method are provided in Appendix C. The estimated settlements are very small in lieu of the small anticipated loads of less than 3 kips per lineal foot for the drop structures.

X Need to compute final settlements

5.2.1.3 Resistance to Lateral Loads

The design for lateral loads should be in accordance with procedures detailed by Broms (1965, 1964a, 1964b). The soil should be modeled as both cohesive and cohesionless, with the lower allowable lateral load from these procedures to be used for design.

Based on our experience with the site soils and results of the direct shear tests performed for the bridge report, conservative strength parameters recommended for use in computing the ultimate lateral resistance are O = 25 deg. and c = 1,000 pounds per square foot. The passive earth pressure coefficient for the cohesionless case is 3.0. The in situ unit weight of the soil can be taken as 110 pounds per cubic foot.

?

Implementation of Broms' procedures also requires a

*References are found at the end of this report.

coefficient of horizontal subgrade reaction, k_h. For the cohesive case, a value of k_hD = 460 pounds per square inch, independent of depth, is recommended. Thus, for a 36-inch diameter pier, k_h = 13 pounds per cubic inch. For the cohesionless case, k_h varies with depth in accordance with the relationship where z is the depth below finished grade and D is the pier

$$_h = n_h(z/D)$$

diameter. In using this relationship, a value of n_h of 60 pounds per cubic inch is recommended. These values are in conformance with values suggested by Broms (1964a, 1964b). Values of the coefficient of subgrade reaction should be reduced by a factor of 2 for analysis of seismic loading conditions.

Criteria provided 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.

5.2.1.4 <u>Cleaning of Drilled Pier Excavations</u>

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. Loose material present in the bottom

of the holes should be cleaned using the auger or other equipment so that no more than 3 inches of loose material is present after cleaning.

5.2.1.5 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 5 to 7 inches.

5.2.1.6 Inspection & Construction

Continuous inspection of the construction of drilled piers should be carried out by the geotechnical engineer. The inspector should verify diameter, depth and cleaning, and should also verify the nature of the materials encountered in the pier excavations. Concrete lacement should be continuously observed by the inspector to ensure that it meets requirements. An insection report should be submitted for each pier stating, in writing, that all details have been inspected and meet requirements.

It appears that straight-shafted, drilled pier excavations may require casing or slurry methods for advancement for the upper portion of the drilled piers. Since some caving is anticipated, concrete quantities may exceed the neat volumes indicated by the plans. Guide specifications for drilled, cast-in-place concrete piers utilizing slurry-assisted construction are provided in Appendix D of Report No. 1.

5.2.2 Spread-Type Footings

5.2.2.1 Downward Loads

As an alternative to drilled piers, spread-type footings will provide safe support of the drop structures. Safe downward capacities of spread-type footings are presented in Appendix C along with complete design calculations. It is recommended that the minimum depth of embedment for spread-type footings be 5.0 feet below the anticipated scour depth.

5.2.2.2 Estimated Settlements

Due to the very low anticipated vertical loads from the drop structures, settlement estimates were not calculated and should be considered negligible for design considerations.

5.2.2.3 Resistance to Lateral Loads

A passive earth pressure of 350 pounds per square foot per foot of depth against footings and walls is recommended for the resistance of lateral loads. A coefficient of friction of 0.45 is recommended for computation of the lateral resistance between the base of foundations and the soil.

REFERENCES

Broms, B.B., 1964a, Lateral Resistance of Piles in Cohesive Soils, ASCE, JSMFD, Volume 90, No. SM2, March, pp. 27-63.

Broms, B.B., 1964b, Lateral Resistance of Piles in Cohesionless Soils, ASCE, JSMFD, Volume 90, No. SM3, May, pp. 123-156.

Broms, B.B., 1965, Design of Laterally Loaded Piles, ASCE, JSMFD, Volume 90, No. SM3, May, pp. 79-99.

NAVFAC, 1982, Soil Mechanics, Design Manual 7.1.

NAVFAC, 1982, Foundations and Earth Structures, Design Manual 7.2.

Maynord, S.T., 1978, Practical Riprap Design, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

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.

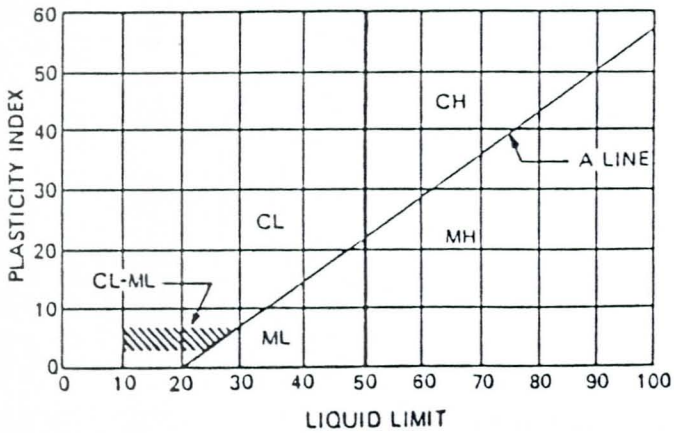
UNIFIED SOIL CLASSIFICATION SYSTEM

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.

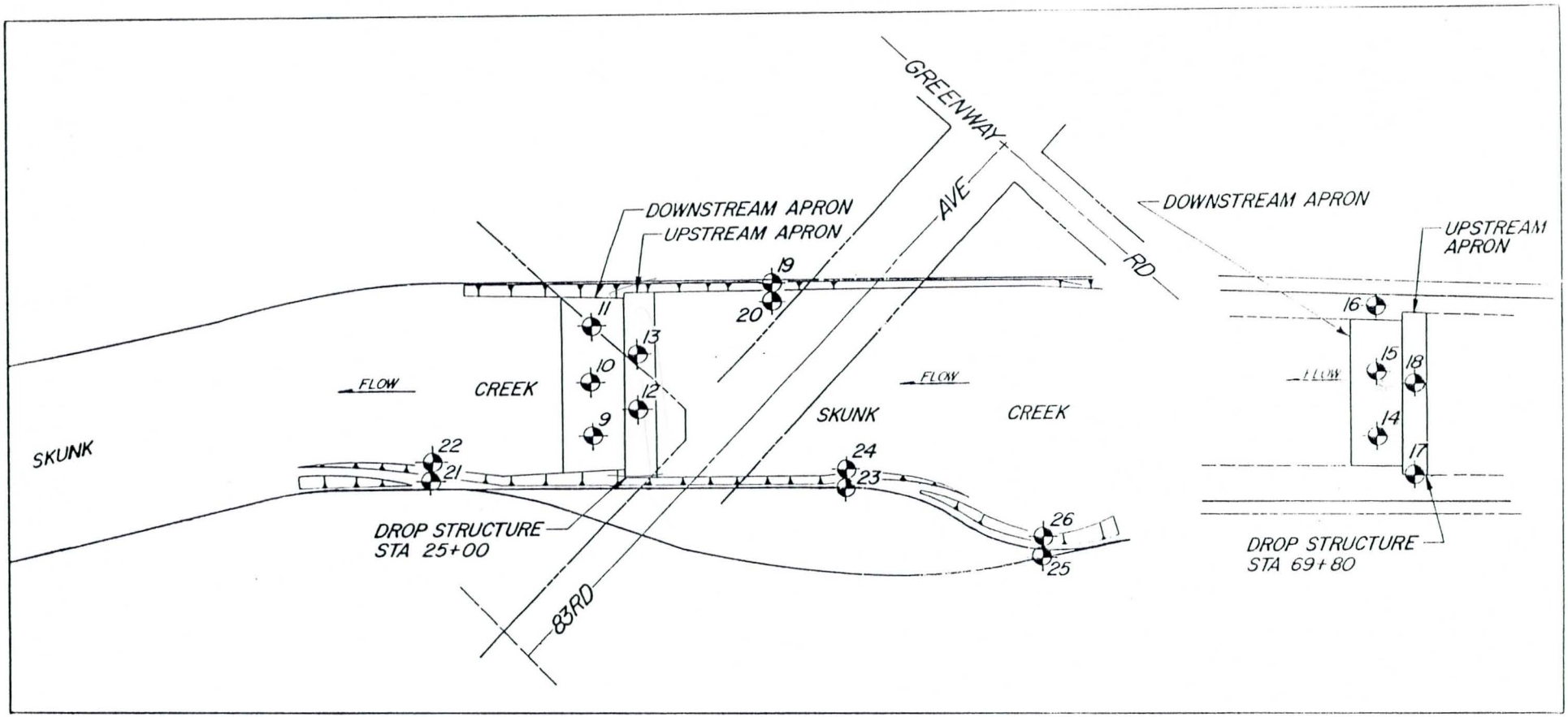
N	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

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



0 100 200
SCALE IN FEET

LEGEND
11 Borehole Location

SITE PLAN
SHOWING BORING LOCATIONS

Bridge Over Skunk Creek
at 83rd Avenue
Peoria, Arizona
SHB Job No. E88-9
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SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

PROJECT 83rd Avenue Bridge Over Skunk Creek

LOG OF TEST BORING NO. 9

JOB NO. E88-9 DATE 1-30-89

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	24				moist firm to hard	CLAYEY SAND & GRAVEL, some cobbles, predominantly medium to coarse grained sand, fine to coarse grained gravel, subrounded, medium plasticity, brown & gray
								GC		
5				S	50/5"					
										note: lenses of clayey sand, fine to medium grained, medium plasticity, light brown
10				S	50/2" no rec					
				A						
								CL	moist to very moist hard	SANDY CLAY, medium plasticity, brown
15				S	71					
20				S	50/4"				moist to slightly moist hard	CLAYEY SAND & GRAVEL, predominantly fine to medium grained, medium plasticity, light brown
								SC & GC		
25				S	50/ 4 1/2"					Stopped auger at 24'6" Sampler refused at 25' 4 1/2"
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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.

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS
PHOENIX · ALBUQUERQUE · SANTA FE
SALT LAKE CITY · EL PASO · TUCSON · RENO/SPARKS

PROJECT 83rd Avenue Bridge Over Skunk Creek

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BORING TYPE 6 5/8" Hollow Stem Auger
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DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	65				moist hard	CLAYEY SAND & GRAVEL, some cobbles, predominantly medium to coarse grained sand, well graded gravel, subrounded, medium plasticity, brown
								GC		
5				S	50/3"					
10				S	50/6"				moist hard	CLAYEY SAND, predominantly fine grained, weakly lime cemented, medium plasticity, light brown
								SC		
15				U	63					
20				S	50/ 3 1/2"			GC	slightly moist hard	CLAYEY SAND & GRAVEL, some cobbles, predominantly fine to medium grained sand, predominantly coarse grained gravel, subrounded, medium plasticity, light brown
25				S	63					
								SP-SC	slightly moist very firm to hard	SAND, trace of clay, predominantly medium grained, low plasticity to nonplastic, light brown
30				S	56					
35				S	34					
40										Stopped auger at 34'6" Stopped sampler at 36'
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 11

JOB NO. E88-9 DATE 1-30-89

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	95			GC	moist hard	CLAYEY SAND & GRAVEL, some cobbles, predominantly medium to coarse grained sand, well graded gravel, subrounded, medium plasticity, brown & gray
5				S	61					
10				S	51			SC	very moist very firm to hard	CLAYEY SAND, trace of fine grained gravel, predominantly fine to medium grained, medium plasticity, light brown
15				S	41					
								CL	very moist	SANDY CLAY, medium plasticity, brown
20				S	65			SC		
								SC-SW	moist hard	CLAYEY SAND, trace of fine grained gravel, predominantly fine to medium grained, medium plasticity, light brown
25				S	50/2"					
30									moist hard	CLAYEY SAND, some predominantly fine grained gravel, well graded sand, subangular, low plasticity, light brown
35										Stopped auger at 24'6" Sampler refused at 25'2"
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 12

JOB NO. E88-9 DATE 1-31-89

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/6"				moist hard	CLAYEY SAND & GRAVEL, some cobbles, predominantly fine grained sand, predominantly coarse grained gravel, subrounded, medium plasticity, brown & gray
5				S	50/1" no rec			GC		
10				S	42			CL	very moist very firm	SANDY CLAY, fine grained sand, medium plasticity, light brown
15				S	70 no rec			GC	moist hard	CLAYEY GRAVEL, some sand, predominantly fine to medium grained gravel, subangular, medium plasticity, brown
20				S	55					
25										Stopped auger at 19'6" Stopped sampler at 21'
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 13

JOB NO. E88-9 DATE 1-30-89

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/3"				moist hard	CLAYEY SAND & GRAVEL, some cobbles, predominantly fine to medium grained sand, subrounded, medium plasticity, light brown
								GC		
5				S	50/3"					
10				U	100/ 2 1/2"				moist hard	CLAYEY SAND, trace of gravel, predominantly fine grained, medium plasticity, light brown
								SC		
15				S	51					
20				S	50/4"			GC	very moist hard	CLAYEY SAND & GRAVEL, predominantly fine to medium grained sand, medium plasticity, brown
25										
30										Stopped auger at 19'6" Sampler refused at 20'4"
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 14

JOB NO. E88-9 DATE 2-9-89

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	34				moist	CLAYEY SAND & GRAVEL, trace of silt, occasional cobbles, predominantly medium grained sand, subrounded to subangular, medium plasticity, brown
				S	27				firm to hard	
5				S	50/5"			GC		
				A			14			
10				S	56					
15				S	61				moist	CLAYEY SAND, some silt, occasional gravel, predominantly fine to medium grained, subangular to angular, low to medium plasticity, brown
								SC	hard	
20				S	50/5"					Stopped auger at 20' Sampler refused at 20'5"
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 15

JOB NO. E88-9 DATE 1-31-89

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/3"				moist hard	CLAYEY SAND, GRAVEL & COBBLES, predominantly fine to medium grained sand, well graded gravel, subangular, medium plasticity, brown & gray
								GC		
5				S	50/3"					
								CL	very moist	SANDY CLAY, medium plasticity, brown
10				S	88			GC		
								SC & CL	moist hard	CLAYEY SAND, GRAVEL & COBBLES, predominantly fine grained sand, well graded gravel, subangular to subrounded, medium plasticity, brown & gray
15				S	67					
20				S	42			SC	moist hard	CLAYEY SAND to SANDY CLAY, some gravel, predominantly fine to medium grained, medium plasticity, brown
25				S	50/4"			SP & GP		
									moist very firm	CLAYEY SAND, predominantly fine to medium grained, low plasticity, brown
30				S	50/5"					
35									slightly moist hard	SAND & GRAVEL, predominantly fine to medium grained sand, well graded gravel, nonplastic, light brown
40										Stopped auger at 29' Sampler refused at 29'5"
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 16

JOB NO. E88-9 DATE 1-31-89

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	89				moist to very moist hard	CLAYEY SAND, GRAVEL & COBBLES, fine to medium grained sand, well graded gravel, subrounded, medium plasticity, brown & gray
								GC		
5				S	50/4" no rec					
								sc/cl	moist	SANDY CLAY to CLAYEY SAND, predominantly fine grained, medium plasticity, brown
10				S	50/2"					
								GC		
15				S	31				moist hard	CLAYEY GRAVEL, some sand, small amount of cobbles, medium plasticity, brown note: considerable cobbles below 12'
								SC		
20				S	38					
								SP	moist very firm	CLAYEY SAND, fine grained sand, low plasticity, brown
25				S	50/4"					
30									slightly moist hard	GRAVELLY SAND, predominantly fine to medium grained sand, well graded gravel, subangular, nonplastic, light brown
35										Stopped auger at 24'6" Sampler refused at 25'4"
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 17

JOB NO. E88-9 DATE 2-9-89

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	30		9		moist	CLAYEY SAND & GRAVEL, predominantly medium grained sand, trace of silt, occasional cobbles, subangular to subrounded, medium plasticity, brown
				S	30				firm to very firm	
5				S	41					
				A				GC		note: mantle of cobbles at surface, angular, diameter ranging from 6" to 12" maximum
10				S	42					
15										Auger refused at 14'
20										
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 18

JOB NO. E88-9 DATE 1-31-89

RIG TYPE CME-55
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/4"				moist hard	CLAYEY SAND, GRAVEL & COBBLES, predominantly fine to medium grained sand, gap graded gravel, subrounded, medium plasticity, brown & gray
5				S	50/2"			GC		
10				S	84					
15				U	50			SC & CL	moist very firm	SANDY CLAY to CLAYEY SAND, predominantly fine grained, medium plasticity, brown
20				S	50/4 1/2"			GC-GP	moist to slightly moist hard	CLAYEY SAND, GRAVEL & COBBLES, poorly graded, subrounded, low plasticity, brown & gray
25										Stopped auger at 19'6" Sampler refused at 19' 10 1/2"
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 19

JOB NO. E88-9 DATE 2-8-89

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1175.9
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/5"				slightly moist hard	SANDY GRAVEL, considerable clay, some silt & cobbles, subangular to subrounded, moderately lime cemented, low to medium plasticity, light brown to brown
				S	50/ 5 1/2"					
5				S	50/ 5 1/2"					
				A				GP-GC		
10				S	50/1" no rec					
15				S	50/ 1 1/2"					Auger refused at 15'6" on cobbles
20										
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 20

JOB NO. E88-9 DATE 2-9-89

RIG TYPE CME-75
BORING TYPE Continuous Flight Auger
SURFACE ELEV. 1158.1
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	23			SM	moist firm	SILTY SAND, some clay & gravel, occasional cobbles, predominantly fine to medium grained, subangular to angular, low plasticity, dark brown
5				S	68			SC	moist hard	CLAYEY SAND, trace of gravel, predominantly fine to medium grained, weakly lime cemented, medium to high plasticity, reddish brown
10				U	90					
15										Stopped auger at 10' Stopped sampler at 11'
20										
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 21

JOB NO. E88-9 DATE 2-8-89

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1178.1
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	60				moist	CLAYEY GRAVEL, considerable medium grained sand, some cobbles, subangular, weakly lime cemented, medium plasticity, brown
									hard	
				S	69			GC		
5				S	50/0" no rec					
				A						
10										Auger refused at 8'6" on cobbles
15										
20										
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 22

JOB NO. E88-9 DATE 2-9-89

RIG TYPE CME-75
BORING TYPE Continuous Flight Auger
SURFACE ELEV. 1164.4
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/5"			GC	slightly moist hard	CLAYEY SAND & GRAVEL, subrounded to subangular, low to medium plasticity, brown
5								GP-GC	hard	SANDY GRAVEL, considerable cobbles, some clay & boulders, predominantly coarse grained, low plasticity, brown
10				S	82		25	MH	very moist hard	SANDY SILT, occasional gravel, weakly lime cemented, medium to high plasticity, reddish brown
15				S	50/5"					
20										Stopped CFA at 15' Sampler refused at 15'11"
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 23

JOB NO. E88-9 DATE 2-8-89

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1181.7
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	17			SM-SC	moist moderately firm	SILTY SAND, considerable clay, some gravel, predominantly fine to medium grained, subangular to angular, weakly lime cemented, low to medium plasticity, dark brown
				S	5			GP-GC		
5				S	8					
10				S	42			GP-GC	moist soft	SANDY GRAVEL, some clay & silt, subangular to subrounded, weakly lime cemented, low plasticity, brown
15									slightly moist very firm	SANDY GRAVEL, some clay & cobbles, well graded, subrounded to rounded, nonplastic to low plasticity, light brown
20										Auger refused at 13'6"
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 24

JOB NO. E88-9 DATE 2-9-89

RIG TYPE CME-75
BORING TYPE 6 5/8" HSA / CFA
SURFACE ELEV. 1168.2
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50				moist hard	SANDY GRAVEL, considerable clay, some silt, occasional cobbles, subrounded to subangular, low plasticity, brown
								GP		
5				S	50/ 5 1/2"					
10				S	50/5"				moist hard	CLAYEY SAND, some silt, occasional cobbles, predominantly medium grained, medium to high plasticity, reddish brown
				A			12	SC		
15				S	50/2"					
20										Stopped auger at 15' Sampler refused at 15'2" note: HSA refusal at 6' CFA 6' - 15'
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
7.0	1:15p	2-9-89

SAMPLE TYPE

A - Drill 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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LOG OF TEST BORING NO. 25

JOB NO. E88-9 DATE 2-8-89

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1184.3
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	50/3"					Man-made FILL
				S	50/ 5 1/2"			GP	slightly moist hard	SAND, GRAVEL & COBBLES, some to considerable clay, trace of silt, subrounded to rounded, nonplastic, light brown
5				S	66			GC		
10									moist hard	CLAYEY GRAVEL, considerable sand, some cobbles, subrounded to subangular, weakly lime cemented, medium plasticity, brown
15										Auger refused at 9'6"
20										
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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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PROJECT 83rd Avenue Bridge Over Skunk Creek

LOG OF TEST BORING NO. 26

JOB NO. E88-9 DATE 2-9-89

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1170.6
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	28				moist firm to hard	CLAYEY SAND, considerable gravel, some silt, occasional cobbles, predominantly fine to medium grained, subrounded to subangular, medium plasticity, brown
5				S	38		8			
								SC		
10				S	50/4"					
15				S	50/3"					Stopped auger at 15' Sampler refused at 15'3"
20										
25										
30										
35										
40										
45										
50										

GROUNDWATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill 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. E88-9
W/O 4

HOLE NO	DEPTH	UNIFIED CLASS	L.L.	P.I.	#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
					SIEVE ANALYSIS-ACCUM % PASSING												
14	6'-9'	GC	50	28	25	29	33	36	40	50	55	57	59	67	74	79	
					86	90	96	97	100								8-9-180
17	6"-2'	GC	56	33	16	19	23	26	30	42	47	49	57	58	61	69	
					76	76	100										8-9-184
20	10'-11'	SC	63	32	48	58	68	74	80	91	95	97	100				8-9-191
22	10'-11'6"	MH	61	27	56	74	87	93	96								8-9-193
24	12'-14'	SC	45	29	41	47	54	60	65	79	85	87	100				8-9-198
26	5'-6'6"	SC	33	14	27	32	38	58	48	63	70	72	81	85	90	93	
					100												8-9-201

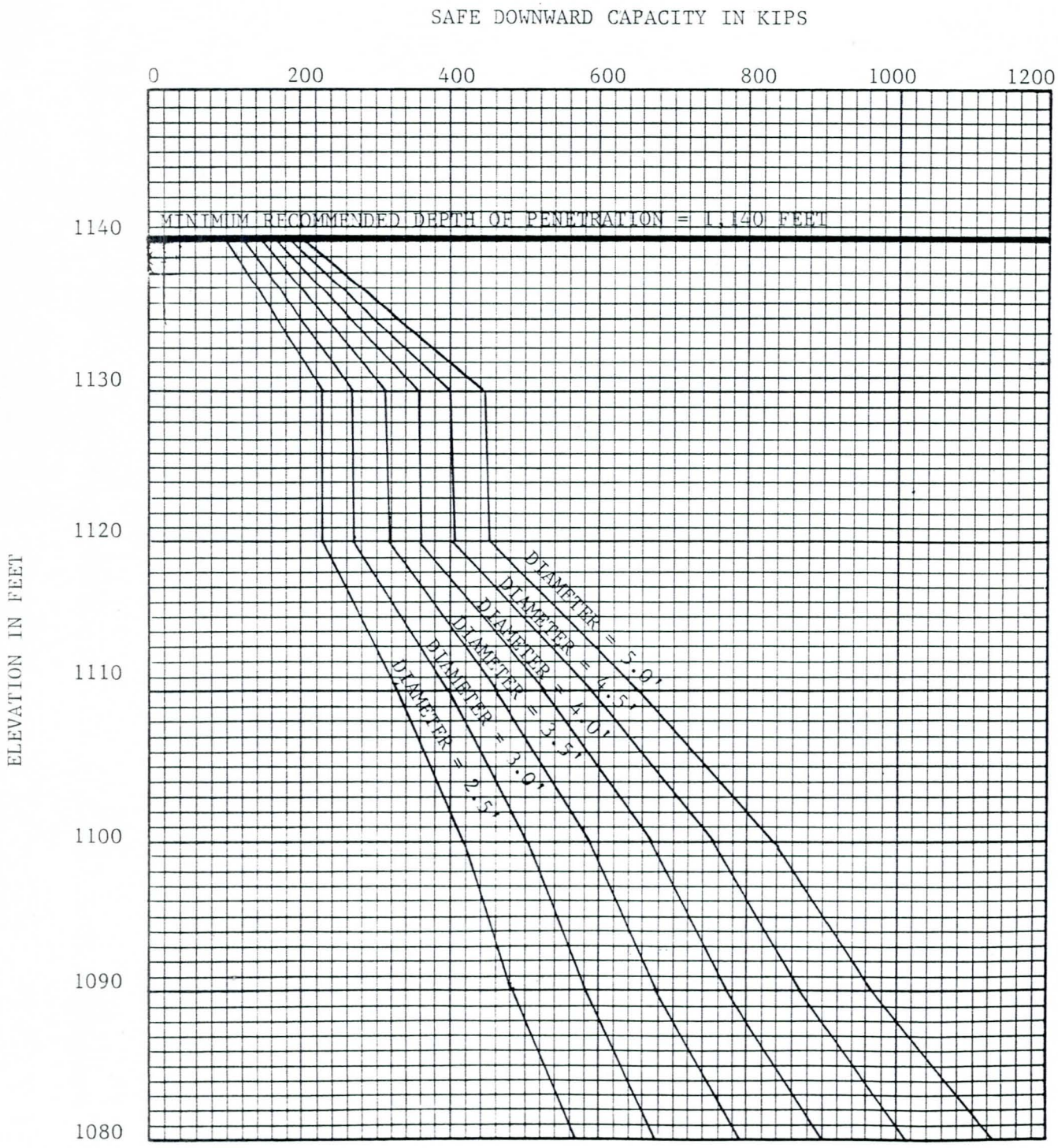
$D_{50} = \frac{16}{8} = 2mm$

$D_{50} = \frac{8}{8} = 1mm$

PROJECT 83rd Avenue Bridge Over Skunk Creek JOB NO. E88-9

FIGURE 1

SAFE DOWNWARD CAPACITIES FOR STRAIGHT, DRILLED CAST-IN-PLACE CONCRETE PIERS FOR THE UPSTREAM DROP STRUCTURE BASED ON END-BEARING ONLY



Bridge Over Skunk Creek
at 83rd Avenue
Peoria, Arizona

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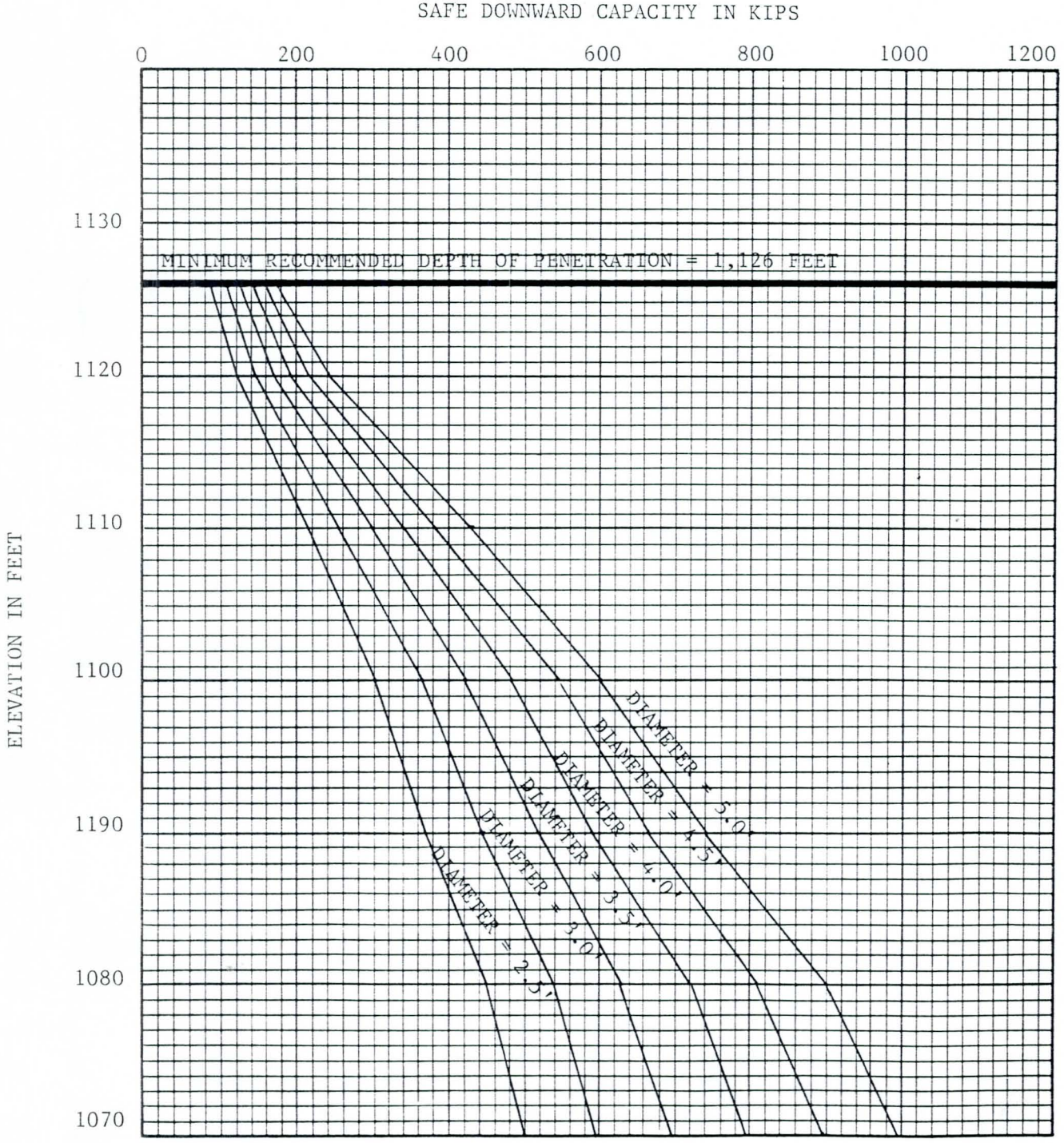
PROJECT 83rd Avenue Bridge Over Skunk Creek JOB NO. E88-9

FIGURE 2

SAFE DOWNWARD CAPACITIES FOR STRAIGHT, DRILLED, CAST-IN-PLACE CONCRETE PIERS FOR THE DOWNSTREAM DROP STRUCTURE BASED ON END-BEARING ONLY



Bridge Over Skunk Creek
at 83rd Avenue
Peoria, Arizona

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DESIGN OF DRILLED, CAST IN PLACE, CONCRETE PIERS FOR DROP STRUCTURES

SAFE DOWNWARD CAPACITY (FROM NAVFAC 7.2 pg 200-201)

A. CONSIDER END-BEARING ONLY

$$q_s = \frac{1}{9}\left(\frac{0.4\bar{N}D}{B}\right)2 \quad KSF$$

WHERE:

$\bar{N} = C_N \cdot N$

N = STANDARD PENETRATION RESISTANCE NEAR PILE TIP

$C_N = 0.77 \log_{10} 20/p$ WHERE p = EFFECTIVE OVERBURDEN STRESS AT PILE TIP.

D = DEPTH OF PILE TIP (FT)

B = DIAMETER OF PILE TIP (FT)

$$q_{SAFE} = \frac{0.09\bar{N}D}{B}\left(\frac{\pi B^2}{4}\right)$$

$$= 0.07\bar{N}DB$$

B. CONSIDER SIDE SHEAR ONLY

$$f_s = 0.5\left(\frac{N}{50}\right)0.333(2) \quad KSF$$

$$= 0.0067\ N_{AVE}$$

$$q_s = 0.0067\ N_{AVE}(D)\pi B$$

WHERE: D = DEPTH OF EMBEDMENT (FT)
B = PILE DIAMETER (FT)

$$q_s = 0.02094\ N_{AVE}(D)(B)$$

FIGURE C-1 PRESENTS A SUMMARY OF AVERAGE BLOW COUNTS (N_{AVE})

FIGURE C-2 PRESENTS A SUMMARY OF CORRECTED BLOW COUNTS ($\bar{N}$)

TABLES C-1 AND C-2 PRESENT THE ESTIMATED SAFE CAPACITIES

NOTE: BASED ON PREVIOUS BRIDGE CALCULATIONS, END BEARING ONLY PREDOMINATES

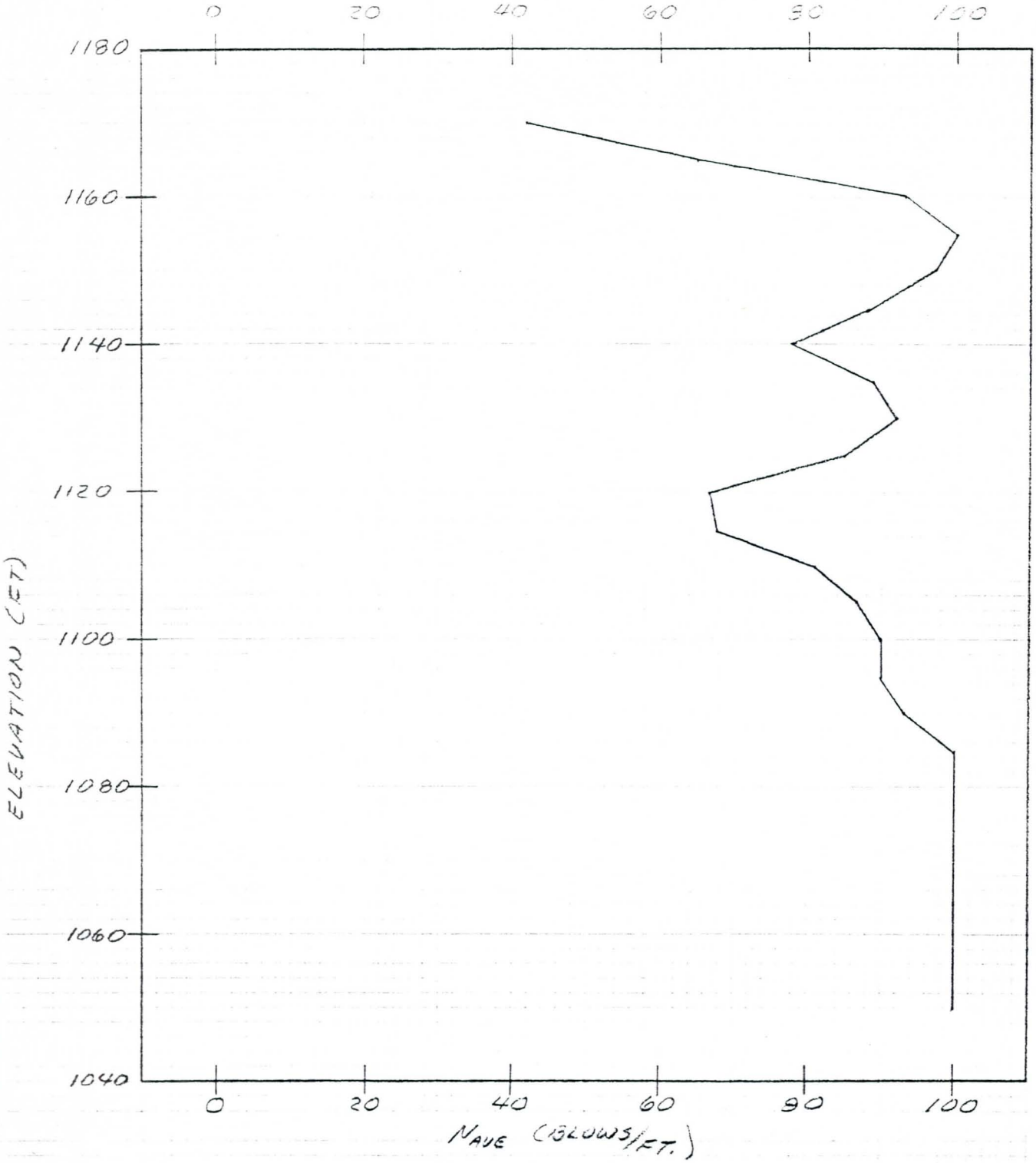

FIG. C-1 AVERAGE BLOWCOUNT PROFILE FOR DROP STRUCTURES BASED ON BRIDGE BORINGS 1 THROUGH 6

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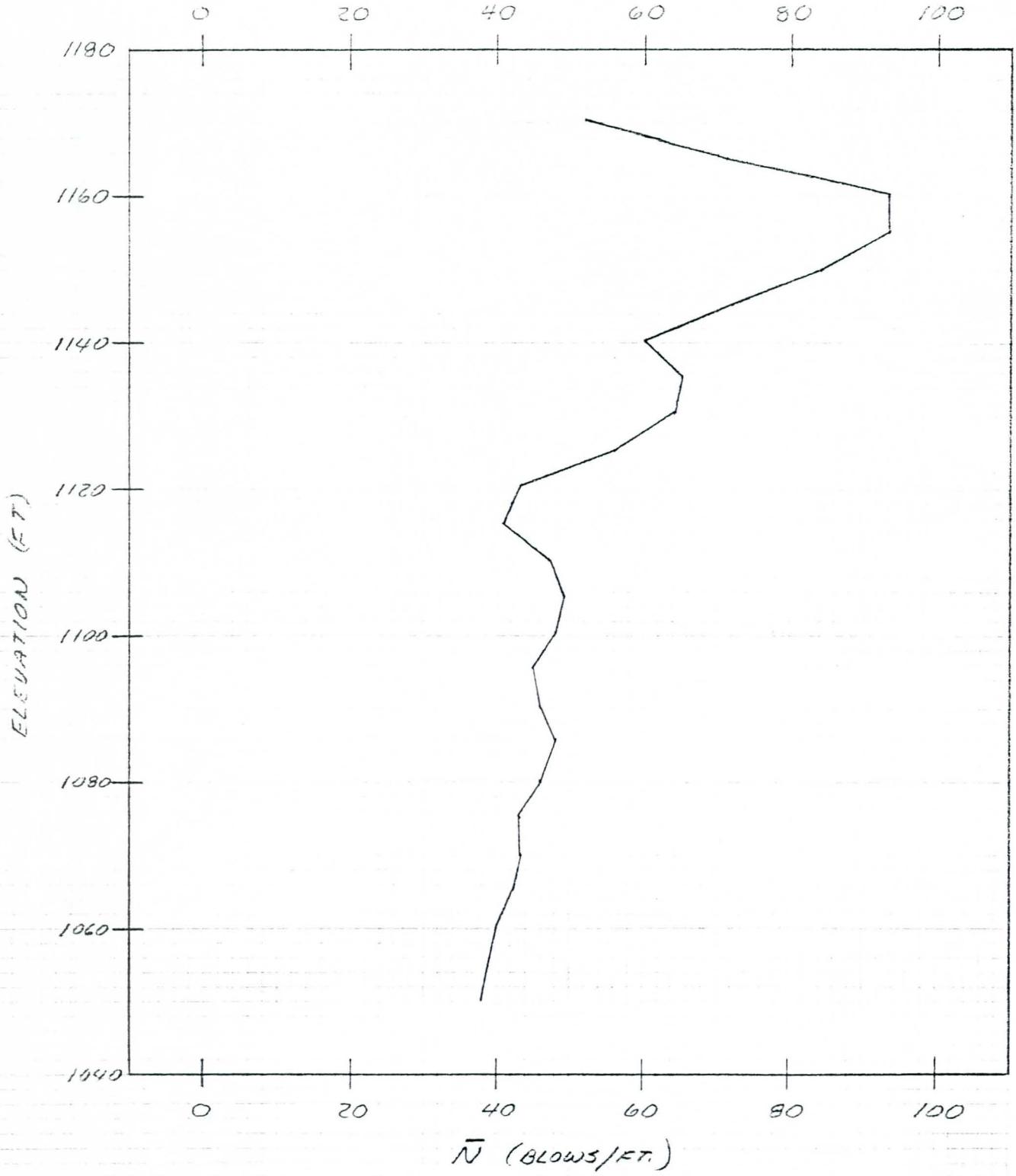

FIG C-2 CORRECTED BLOW COUNT PROFILE FOR DROP STRUCTURES BASED ON BRIDGE BORINGS 1 THROUGH 6

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TABLE C-1 SAFE COMPRESSIVE CAPACITY FOR UPSTREAM CROSS STRUCTURE BASED ON END BEARING PILE

PILE TIP ELEV. (FT)	$\bar{N}$ BLOWS/FT	CAPACITY, KIPS					
		B=2.5'	3.0'	3.5'	4.0'	4.5'	5.0'
1140	60	105	126	147	168	189	210
1130	64	224	269	314	358	403	448
1120	43	226	271	316	361	406	452
1110	47	329	395	461	526	592	658
1100	48	420	504	588	672	756	840
1090	46	483	580	676	773	869	966
1080	46	564	676	789	902	1014	1127
1070	43	602	722	843	963	1084	1204
1060	40	630	756	882	1008	1134	1260
1050	38	665	798	931	1064	1197	1330

TABLE C-2 SAFE COMPRESSIVE CAPACITY FOR DOWNSTREAM CROSS STRUCTURE BASED ON END BEARING PILE

PILE TIP ELEV. (FT)	$\bar{N}$ BLOWS/FT	CAPACITY, KIPS					
		B=2.5'	3.0'	3.5'	4.0'	4.5'	5.0'
1130	64	67	81	94	108	121	134
1120	43	120	145	169	193	217	241
1110	47	214	257	299	342	385	428
1100	48	302	363	423	484	544	605
1090	46	370	444	518	593	667	741
1080	46	451	541	631	721	811	902
1070	43	497	596	695	795	894	993
1060	40	532	638	745	851	958	1064
1050	38	572	686	801	915	1029	1144

SETTLEMENT ANALYSIS

INSTANTANEOUS SETTLEMENTS (FROM NAVFAC DM-7.1 FIG 6, PAGE 219)

$$\Delta H_i = \frac{2qB^2}{K_{vi}(B+1)^2}$$

WHERE: ΔH_i = IMMEDIATE SETTLEMENT OF PILE (FT)

q = PILE UNIT LOAD (KSF)

B = PILE DIAMETER (FT)

K_{vi} = MODULUS OF VERTICAL SUBGRADE REACTION IN KIPS/FT^3

TO PRESENT SETTLEMENT IN TERMS OF INCH/KIP VERTICAL LOAD

$$\Delta H_i(\text{IN})/\text{KIP} = \frac{2(q\ \text{KIP/FT}^2)(B^2\ \text{FT}^2)}{(K_{vi}\ \text{KIP/FT}^3)((B+1)^2\ \text{FT}^2)(\frac{\pi B^2}{4}\ \text{FT}^2)}\left(\frac{12\ \text{IN}}{1\ \text{FT}}\right)$$

$$= \frac{2B^2(12)(4)}{K_{vi}(B+1)^2\pi B^2} = \frac{30.56}{K_{vi}(B+1)^2}$$

K_{vi} = 500 KIPS/FT^3 (FOR RELATIVE DENSITY = 80%)

THEN:

$$\Delta H_i/\text{KIP} = \frac{0.0611\,2}{(B+1)^2}$$

FIGURE C-3 IS A SUMMARY OF INSTANTANEOUS SETTLEMENTS FOR PILE DIAMETERS OF 2.5 TO 5.0 FEET AND PILE LOADS OF 0 TO 600 KIPS

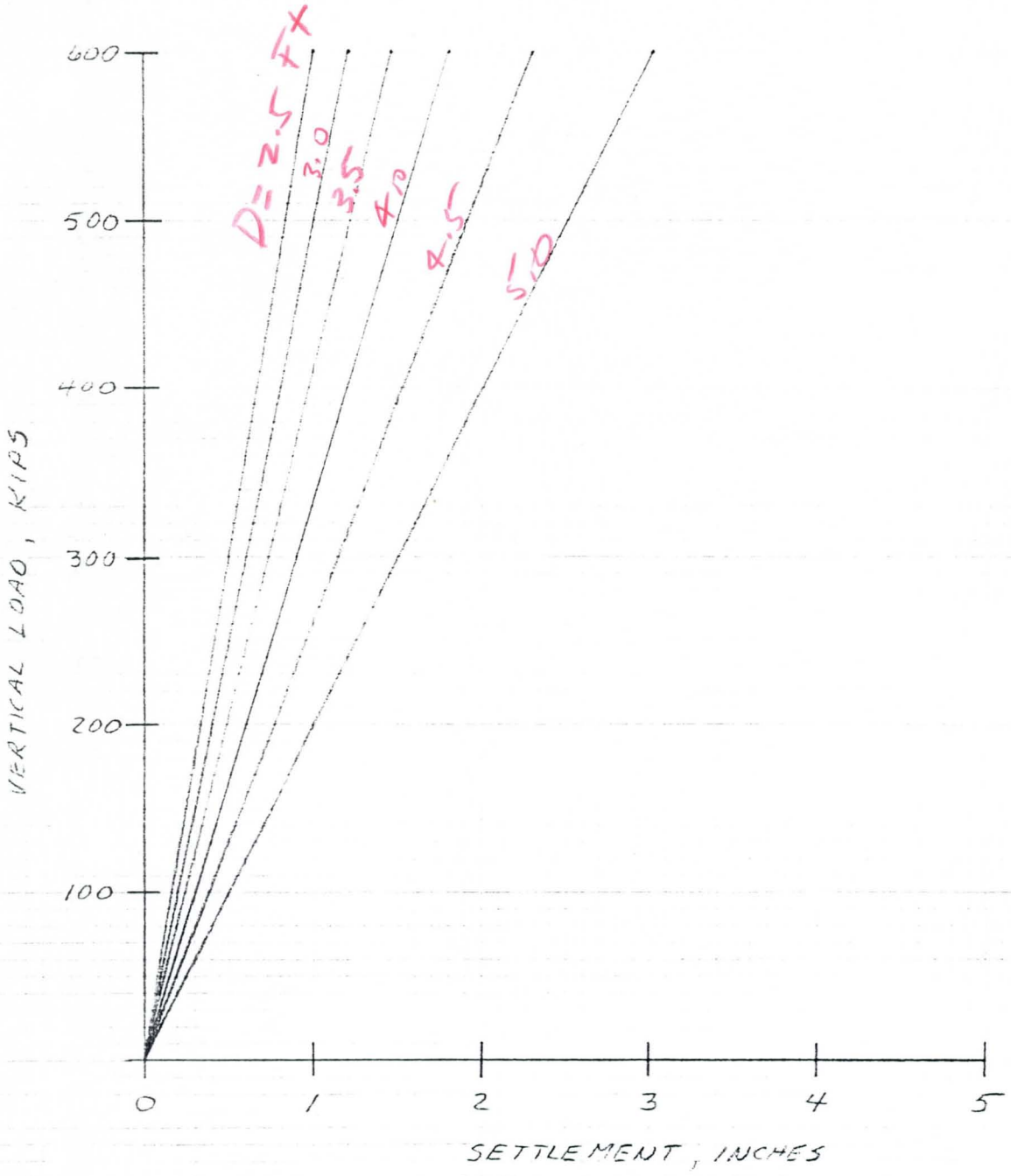

FIGURE C-3 INSTANTANEOUS SETTLEMENTS

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DESIGN OF SPREAD FOOTINGS FOR CBDA STRUCTURES

SAFE DOWNWARD CAPACITY

ASSUMPTIONS:

FRICTION ANGLE $\phi = 25°$
DENSITY $\gamma = 110$ pcf
COHESION $C = 1000$ psf

GENERAL BEARING CAPACITY RELATIONSHIP

$q_{ULT} = CN_c + \gamma D$

WHERE D = EMBEDDED DEPTH (FT)

FROM NAVFAC DM-7.2, 1982, PG. 131, FIG. 1

$N_c = 21$

THEREFORE:

$q_{ULT} = (1)(33) + (0.110)(D)$
$= 21 + .110\,D$

FOR SAFE BEARING CAPACITIES

SAFETY FACTOR = 3.0

THE FOLLOWING TABLE PRESENTS SAFE BEARING CAPACITIES FOR DIFFERENT DEPTHS OF EMBEDMENT.

DEPTH OF EMBEDMENT (FT)	SAFE BEARING CAPACITY KSF
5	7.2
10	7.4
15	7.6
20	7.7
25	7.9