BATTERY HUGER FOUNDATION INVESTIGATION

REPORT OF INVESTIGATION AND ANALYSIS

FORT SUMTER NATIONAL MONUMENT

SOUTH CAROLINA

U.S. ARMY CORPS OF ENGINEERS
CHARLESTON DISTRICT

SEPTEMBER 1, 1992

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1. SUMMARY. Battery Huger Foundation Investigation was undertaken in accordance with Interagency Agreement No. IA 5000-1-9505, between the National Park Service (NPS) and the U.S. Army Corps of Engineers (COE). The purpose of the investigation was to determine the effects on Fort Sumter from the demolition and removal of Battery Huger. The requirements of the agreement included a preliminary review of existing information concerning design and construction of Fort Sumter and Battery Huger, subsurface soils investigations, laboratory testing, an analysis of heave due to removal of Battery Huger, construction cost estimate, and a report.

To summarize what follows in this report, no significant movement of the walls and other structures to remain at Fort Sumter would be expected from the removal of Battery Huger. The estimated heave would vary from 1.8 inches near the center front (east side) of Battery Huger to about 0.7 inch at the rear corners next to the parade ground and 0.6 inch at the east side of the fill along the right flank of Fort Sumter. These differences in movements over the distances between them are within tolerable limits and will not be detrimental to remaining structures.

Damage could be done, however, during demolition depending upon the method used to remove Battery Huger. The method selected should create as little vibration as possible. It is recommended that the mass concrete be presplit by drilling and splitting with hydraulic splitters or expanding chemicals. Small and medium-size equipment should then be used to remove rubble and fill from inside the fort. Vibration and movement of walls should be monitored during construction.

The estimated construction cost for demolition and removal of Battery Huger and the earthfill is $4,305,000. Engineering costs are estimated to be $136,000.

It can also be concluded that 100 percent of primary consolidation has occurred, which means that, should Battery Huger be left in place, there would be no further detrimental effects on Fort Sumter from settlement caused by Battery Huger.

2. GENERAL. Fort Sumter, originally a 3-level structure around its perimeter walls, was severely damaged by artillery bombardment during the U.S. Civil War. After the war the rubble was cleaned up and reshaped and earthfill placed inside the walls, which now extend to just above the first level. Figure C-1 shows Fort Sumter in its present state. Only the first level gunrooms are remaining on the left flank and right face of the fort, while, on the left face, only the ruins of the first level gunrooms remain. Along the left gorge are what remain of the officers' quarters. Battery Huger and additional earthfill were constructed during a period from about 1895 to 1900. The battery was constructed primarily of mass concrete and included two 12-inch guns. Between

1950 and 1955, fill on the west side and north end of Battery Huger were excavated to about the original parade ground elevation.

The walls, casemate roofs, and other structures of what remains of the original Fort Sumter are showing cracks and other signs of deterioration, due to damage from artillery shelling, settlement, weathering, and other environmental factors. NPS is considering demolishing Battery Huger and removing the remaining earthfill in order to restore the fort to some semblence of its Civil War appearance. Any large-scale construction activity such as this would affect the structure, both during and after the work.

This report presents the results of an investigation of the effects of foundation heave or rebound on the walls and other structures of the fort which would remain after demolition and removal of Battery Huger. Also presented are recommended methods to be used for demolition, recommendations for monitoring construction activities, and a construction cost estimate for the demolition and removal of Battery Huger.

3. FOUNDATION CONDITIONS. Drilling was performed by Soil Consultants, Inc., of Charleston, South Carolina; laboratory testing was performed by the COE South Atlantic Division Laboratory, Marietta, Georgia. Subsurface investigations were begun with the drilling of three soil borings in March of 1992. Using a truck-mounted drill rig, the borings were made in the parade ground along the west side of Battery Huger. The boring locations are shown on the Site Plan, Figure C-1. The drill rig was lifted over the wall at the left face of the fort by a barge-mounted crane. Three split-spoon soil borings were made, two of which were 76.5 feet deep and the third was 77 feet deep. Undisturbed samples were taken in Boring No. FS-10-92 in strata containing significant amounts of highly plastic clay. All three borings were completed to the stiff to very stiff, green, calcareous, highly plastic clays and silts, locally known as Cooper marl, which is at depths of about 70 feet near the gorge (to the southwest) and 74 feet near the salient (to the northeast). Consolidation tests were conducted on undisturbed samples to obtain compression characteristics of the more plastic soils. Laboratory tests were performed on both disturbed and undisturbed samples to obtain gradation curves and determine Atterberg limits, moisture contents, and specific gravity.

The elevation of the parade ground where the borings were made is about El. 10 NGVD (National Geodetic Vertical Datum). Based on the soil borings, soils below Battery Huger are fairly consistent with the layers dipping from 1 to 2 degrees to the northeast. To generalize foundation materials below Battery Huger, the upper 10 to 13 feet is fill consisting of fine, loose poorly-graded sands with from 4 to 10 percent fines placed over what was once an underwater shoal. The northeast and southeast ends of Battery Huger are situated over portions of the stone foundation which was placed around the perimeter of Fort Sumter below its walls. The stone foundation consists of from 5 to 6 feet of dumped granite overlaid with about 6 feet of fitted stone. The foundation soils below the fill, to a depth of about 33 feet below

the surface of the parade ground, consist generally of medium dense to dense silty sands with from 7 to 42 percent fines. At a depth of about 30 feet, thin interbedded clay lenses, varying in thickness from 1/16 inch to 1/2 inch begin to appear. From a depth of about 33 feet to 35 feet, there is a layer of loose clayey sand with numerous clay lenses of up to about 1 inch thick. Below this layer to a depth of about 56 feet, soils consist of loose to medium dense silty sands with thin interbedded clay lenses of varying thicknesses. From a depth of about 56 feet to 60 feet are interbedded layers, 1 inch or more in thickness, of soft clay of high plasticity and loose clayey sands. Soils from 60 feet to 70 feet are loose to medium dense silty sands with thin interbedded layers of highly plastic clay. At a depth of approximately 70 feet is the top of stiff to very stiff, green, calcareous clays and silts of high plasticity.

Both Boring Nos. FS-8-92 and FS-9-92 penetrated about 4 feet of granite just beneath the surface indicating the presence of the mole foundation.

The soil profile is shown on Figure C-2. Logs of borings and results of laboratory testing are included in the appendix.

4. CONSOLIDATION TESTING. Consolidation tests were conducted on undisturbed samples obtained from Boring No. FS-10-92 which was located adjacent to Battery Huger near its northwest corner. The boring was taken within the parade ground area about 8 feet from the wall of the structure. Top of ground is about El. 10.0 NGVD as measured from the top of the wall. Fill in this portion of the parade ground was once at about El. 23.9 according to the survey made in August 1901, after the completion of Battery Huger. Foundation soils below the parade ground and above marl should therefore be slightly overconsolidated in their present state.

As discussed in Section 2, above, the soils above marl can be described, in general, as silty sands and clayey sands with thin interbedded clay lenses of varying thicknesses. The clayey sand layer about 35 feet deep contained a sufficient number of such lenses to allow a sample to be retrieved using a thin-walled tube sampler. The soil stratum at a depth of about 60 feet included a layer of clay 1.5 feet thick in Boring No. FS-8-92 and about 2.5 feet thick in Boring No. FS-9-92. Thin-walled tube samples of this material were also taken for laboratory examination and testing.

The results of consolidation testing are included in the appendix.

5. ANALYSIS OF HEAVE. The loading on foundation soils would be reduced with the demolition of Battery Huger and the removal of the earthfill located on its east side. Battery Huger is constructed of mass concrete which is as much as 28 feet high and 20 feet thick at the front (east side) of the structure, resulting in a load of up to 2.1 Tsf (Tons per square foot). Because of powder magazines, shot rooms, storage rooms, guardrooms, and hallways formed within Battery Huger, loads toward the rear are about 0.9 Tsf. Reinforcement consists of a structural steel mat placed directly on the foundation below the structure, and structural steel members and corrugated steel sheeting placed above the sto-

rage rooms and passageways formed inside the building. Earthfill, which is to be removed from the east side of Battery Huger, is a maximum of 21 feet deep at the front of the battery and about 18 feet deep at the wall on the right flank of the fort.

With the removal of these loads, the foundation soils would heave due to expansion. The estimated heave for several key points on Battery Huger are given in Table 1, below. These estimates are based on the results of consolidation tests on samples of clay and clayey sand strata, and a correlation for the remaining soils which are mostly silty sands. The correlation for sand provides for some conservatism in the final estimates because it is based on the compression index rather than the swelling index as obtained from testing a poorly-graded, although clean, river sand. Another indicator of potential heave, based on the Atterberg limits and clay fractions of the soils, is the activity of the clay, which is not high, suggesting that rebound will not be significant.

Because of the variation in the loads from one part of Battery Huger to another, differential movement will result. A method for measuring this difference is to use the ratio of differential movement between two points on the structure to the distance between the points, which is called angular distortion. Table 1, below, includes estimated heave at several representative locations and the associated angular distortion based on the maximum movement of 1.80 inches of heave, which is estimated to occur at Point G, near the center front portion of Battery Huger. Locations of points are shown on Figure C-1. Data given are for the northeast end of the building near the salient, but heave would be similar for the opposite end near the gorge because the existing loads are about the same. Complete settlement data are included in the appendix.

TABLE 1 -- ESTIMATED HEAVE AND ANGULAR DISTORTION WITH RESPECT TO POINT OF MAXIMUM HEAVE

POINT	LOCATION	ESTIMATED HEAVE (INCHES)	ANGULAR DISTORTION
G	Center front of Battery Huger	1.80	-
A	Northeast corner (near left face)	0.66	1/1368
B	North end (near salient)	1.10	1/1800
D	Southeast end of fill (near right shoulder angle)	0.58	1/1967

Angular distortion between other locations on the structure may be of concern. Since the estimated differential movement between points A and B at the end of Battery Huger is 0.44 inch and the distance between them is approximately 65 feet, the angular distortion between them would be about 1/1364. Also, the

heave at Point D' outside the fort wall 15 feet from Point D is estimated to be 0.50 inch, resulting in differential movement of 0.08 inch between points D and D' and an angular distortion of 1/2250. Heave or settlement at Point D', as at all other points, is based upon elastic theory which shows that vertical stresses are increased throughout the soil mass by an applied load.

Differential movement can cause structures to distort. Moderate differential movements can cause tilting and cracking in structures such as the masonry walls at Fort Sumter. Increasing differential movement may result in more extensive tilting and cracking affecting structural integrity or, at least, causing an increase in the rate of deterioration from environmental effects such as weathering. Recommended limits, defined in terms of angular distortion, are established for the amount of differential movement that a structure can tolerate without cracking. For long masonry structures of low to moderate height, such as those at Fort Sumter, the allowable would be 1/500 (0.002). Based on the estimated movements the minimum angular distortion would be about 1/1300 at the wall along the left face, which is within the allowable tolerance of 1/500. Therefore, no significant effects on walls, gunrooms, and other structures at Fort Sumter are expected to result from heave when Battery Huger is removed.

The calculated coefficient of compression, C_v, for clays in the foundation is 62.5 ft^2/year. Based on that, 100 percent of primary consolidation has been achieved. However, the void ratio of the soils will continue to decrease slightly, causing settlement, but at a very slow rate. This secondary compression is very low and any settlement will be negligible relative to settlement that has already occurred. Therefore, there would be no additional effects of a significant nature on Fort Sumter due to settlement, if Battery Huger were to remain in place.

6. DEMOLITION METHODS. The methods employed for demolition should be such that vibration is held below levels damaging to Fort Sumter structures. Existing conditions of the outer walls and casemates due to age, settlement, and environmental influences require that every effort be made to ensure no additional damage is done.

There are several methods to consider for demolishing Battery Huger, which is constructed almost entirely of mass concrete. Among these are wrecking ball, impact tools, hydraulic splitting, and expanding chemicals. The degree of control over impacts on Fort Sumter varies with each method.

Use of a wrecking ball, depending upon its weight and the drop height, within about 25 feet of the wall would create a particle velocity on the order of 0.5 ips (inches per second) and greater, which is considered to be a "disturbing" level of vibration on a loose sand or rubble foundation. One hundred feet away particle velocity would be about 0.2 ips and the vibration level would still be at least in the "strongly perceptible" range. Demolition using a wrecking ball would be difficult to control within such a low tolerance. The wrecking ball would break concrete into smaller pieces, which would increase costs for handling and removal, and would increase noise and dust.

Impact tools such as pavement breakers and large mounted rams are another method, but they tend to break concrete into small

pieces which increases handling costs. Increased noise, vibration, and dust would also be problems with this method. The use of impact tools for demolition also takes longer thereby increasing costs.

Another method of concrete demolition is the use of expanding chemicals. This method would require that holes be drilled on 2-foot centers over the entire structure. Noise and dust would be problems associated with drilling holes through concrete. This method would require a period of time between breaks while the chemical expands, but would allow for very good control of the demolition.

Splitting concrete using a hydraulic splitting cylinder is a method which would allow complete control of breakage with no damaging vibration. This equipment is small and hand-held. This method would require that up to 1.75-inch diameter holes be drilled through the concrete structure on 2-foot centers. Once holes are drilled breaks can be made in less than a minute with this equipment. Both reinforced and unreinforced concrete can be hydraulically split.

It is recommended that either expanding chemicals or hydraulic splitting be used to demolish concrete because of the reduced noise and vibration.

7. MONITORING VIBRATION AND MOVEMENT. Measurement of vibration and movement induced in structures during construction is necessary to control construction activities. Should vibration or structural movement exceed prescribed levels, then construction could be altered to correct the situation.

During demolition and removal, vibration should be monitored with velocity seismographs, one near each wall at the two ends of Battery Huger. Velocity seismographs are commonly used to monitor vibration during blasting operations. These instruments are recommended because particle velocity is measured directly, rather than inferred from displacement or acceleration from other types of seismographs. Also, velocity seismographs have a greater dynamic range and a better frequency range than displacement type seismographs.

Surface movements in walls and casemates should be observed using conventional level and position surveys. Vertical and horizontal movements should be measured to determine total movements with respect to a fixed datum located off the structures. Both translational and rotational movements would be of importance.

Lateral movement can also be measured using inclinometers securely attached to walls near the two ends of Battery Huger. Measurements should be carefully made by trained personnel at exactly the same locations in the casing during the construction period.

8. CONSTRUCTION COST ESTIMATE. Estimated quantities include demolishing 13,000 cubic yards of concrete in Battery Huger and removing 25,000 cubic yards of fill. Additional costs would be for removal and storage of such items as flagpoles. A summary of the costs is given below.

ESTIMATED COST FOR DEMOLITION

ITEM	QUANTITY	UNITS	UNIT COST	EXTENDED COST
1. Mobilization and Demobilization	Lump Sum			$ 50,000
2. Drill Holes for Presplitting	93,000	Lin. Ft.	$ 2.50	232,500
3. Splitting Concrete	13,000	cu. yd.	90.00	1,170,000
4. Demolition of Foundation	1,850	cu. yd.	450.00	832,500
5. Concrete Disposal	26,325	Tons	20.00	526,500
6. Sand Disposal	33,750	Tons	15.00	506,250
7. Remove and Store Flagpoles	Lump Sum			6,000
8. Supervision and Administration				120,000
Subtotal				3,443,750
Contingency (25%)				860,940
Total				$4,304,690
Rounded				$4,305,000

This estimate is based on offsite removal and could be reduced if portions of the materials were disposed at Fort Sumter. Some of the broken concrete may be needed for erosion protection or some of the sand may be needed for fill at locations adjacent to Fort Sumter. Permits may be necessary for such disposal. The quantities were estimated based on data from available drawings, which do not reflect recent modifications, and on observations made during site visits. A survey would be needed to refine these estimates. Engineering costs are estimated to be about $136,000.

9. CONCLUSIONS AND RECOMMENDATIONS. No significant effects on walls, gunrooms, and other structures at Fort Sumter are expected to occur due to heave resulting from the demolition and removal of Battery Huger. However, vibration from construction activities may be significant and cause damage to the remaining structures.

It is recommended that either expanding chemicals or hydraulic splitting be used to demolish concrete because of the reduced noise and vibration. Concrete should be broken into pieces that can be handled with equipment small enough to work inside Fort Sumter without causing excessive vibration. Large construction equipment should not be used inside the walls because of impact and vibration.

It is also recommended that vibration and movement be moni-

tored in the walls of Fort Sumter during construction using velocity seismographs, conventional surveys, and inclinometers.

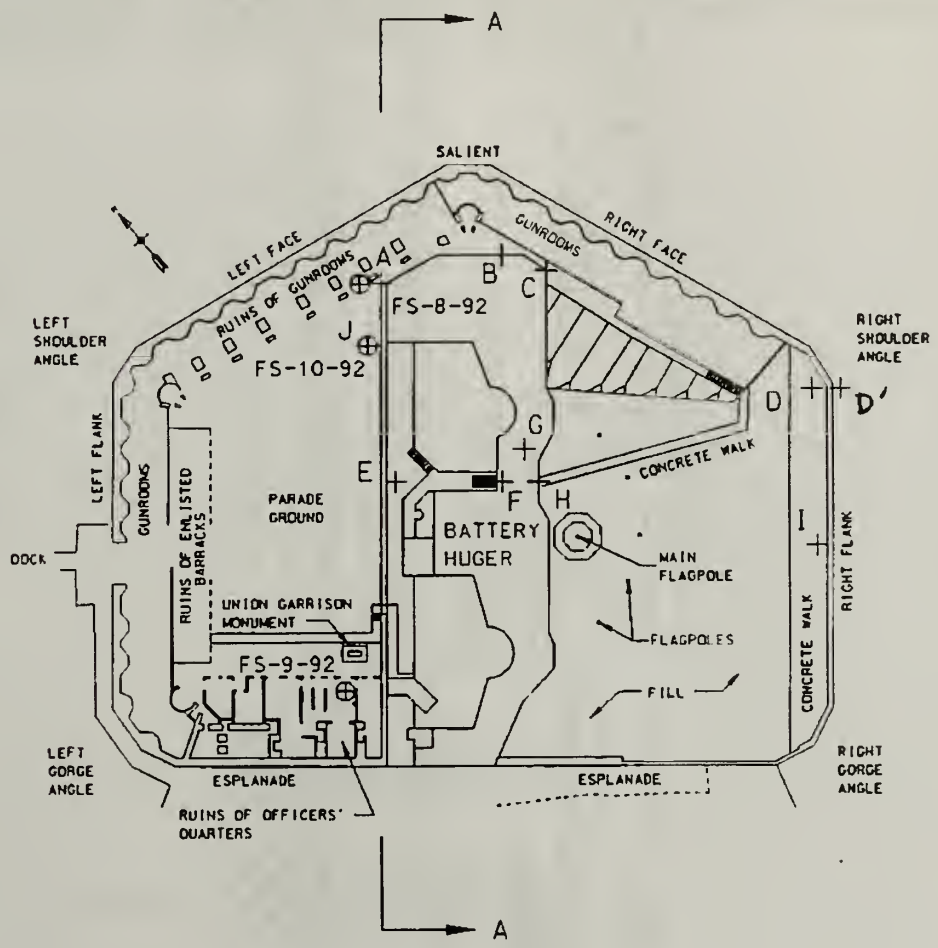


FIG. C-2

FORT SUMTER

100 50 0 100FT

SCALE: 1"= 100'

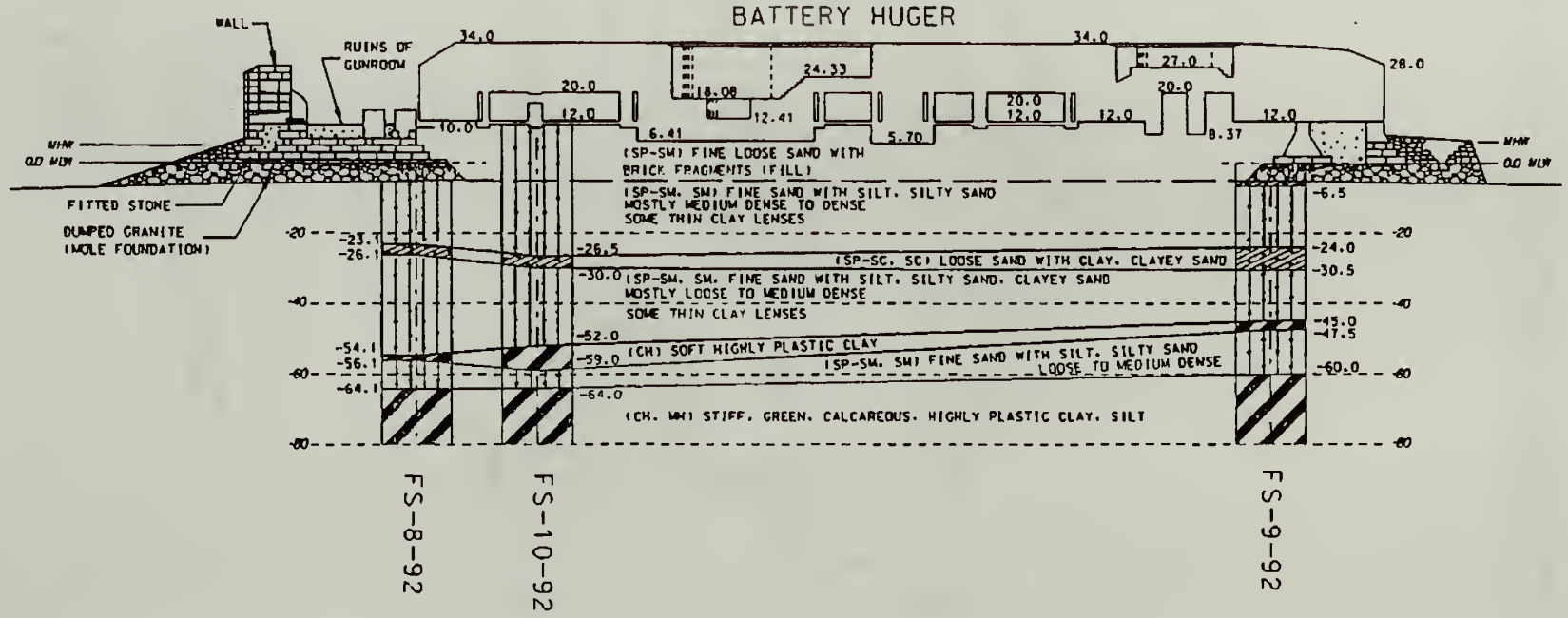
LEGEND

FS-9-92 ⊕	SOIL BORING
B +	LOCATION OF SETTLEMENT CALCULATION

bhcsp

SCALE: AS SHOWN	BATTERY HUGER FOUNDATION INVESTIGATION FORT SUMTER NATIONAL MONUMENT	SITE PLAN	C-1

NOTE: SOILS CLASSIFIED IN ACCORDANCE WITH UNIFIED SOIL CLASSIFICATION SYTEM.



SECTION A-A

REF. FIG. C-1

50 25 0 50FT

SCALE: 1" = 50'

AUGUST 1992

SCALE: AS SHOWN

BATTERY HUGER FOUNDATION INVESTIGATION

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SOIL PROFILE

C-2

DRGSD

APPENDIX

A. HEAVE ANALYSIS
B. BORING LOGS
C. LABORATORY TEST RESULTS -- CONSOLIDATION TESTS
D. LABORATORY TEST RESULTS -- GRADATION CURVES, ATTERBERG LIMITS , MOISTURE CONTENT, SPECIFIC GRAVITY

HEAVE ANALYSIS

U.S. ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
CHARLESTON, SOUTH CAROLINA

Subject: Battery Huger

Computation _____ No. _____

Computed by DLH Checked by _____ Date 8-26-92

Angular Distortion Due to Foundation Heave

Point	Estimated Heave
A	0.66 inches
B	1.10
C	1.09
D	0.58
E	0.88
F	1.65
G	1.80
H	1.73
I	0.96
J	0.54

Max. heave $\Delta_{max} = 1.80$ inches @ Point G Center of B.H

Point	Distance, L, from Point G (Feet)	Estimated Heave, Δ (inches)	$\delta = \Delta_{max} - \Delta$ (inches)	δ/L
A	130	0.66	1.14	0.00073 ($\frac{1}{1368}$)
B	105	1.10	0.70	0.00056 ($\frac{1}{1800}$)
C	105	1.09	0.71	0.00056 ($\frac{1}{1775}$)
D	200	0.58	1.22	0.00051 ($\frac{1}{1947}$)
E	80	0.88	0.92	0.00096 ($\frac{1}{1043}$)
F	35	1.65	0.15	0.00036 ($\frac{1}{2800}$)
H	35	1.73	0.07	0.00017 ($\frac{1}{6000}$)
I	170	0.96	0.84	0.00041 ($\frac{1}{2429}$)
J	110	0.54	1.26	0.00095 ($\frac{1}{1048}$)

Max. Angular Distortion, $\frac{\delta}{L} = 0.00096$ (Point E)

Angular Distortion, $\frac{\delta}{L} = 0.00073$ (Point A)

BATTERY HUGER FOUNDATION INVESTIGATION 10-14-92
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SETTLEMENT AT: POINT A

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	1135		-715	420	0.0043		-0.0019	-0.0186
10	20	15	10	1593		-653	940	0.0043		-0.0010	-0.0099
20	33	27	13	2227		-597	1630	0.0043		-0.0006	-0.0076
33	35	34	2	2573		-573	2000	0.0062		-0.0007	-0.0013
35	46	41	11	2923		-553	2370	0.0043		-0.0004	-0.0043
46	56	51	10	3420		-530	2890	0.0043		-0.0003	-0.0031
56	60	58	4	3766		-516	3250	0.0310		-0.0020	-0.0079
60	70	65	10	4113		-503	3610	0.0043		-0.0002	-0.0024
										TOTAL	-0.0552
									=	-0.66	INCHES

SETTLEMENT AT: POINT B

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	1910		-1490	420	0.0043		-0.0028	-0.0283
10	20	15	10	2280		-1340	940	0.0043		-0.0017	-0.0165
20	33	27	13	2820		-1190	1630	0.0043		-0.0010	-0.0133
33	35	34	2	3120		-1120	2000	0.0062		-0.0012	-0.0024
35	46	41	11	3430		-1060	2370	0.0043		-0.0007	-0.0076
46	56	51	10	3873		-983	2890	0.0043		-0.0005	-0.0055
56	60	58	4	4185		-935	3250	0.0310		-0.0034	-0.0136
60	70	65	10	4502		-892	3610	0.0043		-0.0004	-0.0041
										TOTAL	-0.0913
									=	-1.10	INCHES

SETTLEMENT AT: POINT C

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	1800		-1380	420	0.0043		-0.0027	-0.0272
10	20	15	10	2220		-1280	940	0.0043		-0.0016	-0.0160
20	33	27	13	2810		-1180	1630	0.0043		-0.0010	-0.0132
33	35	34	2	3130		-1130	2000	0.0062		-0.0012	-0.0024
35	46	41	11	3450		-1080	2370	0.0043		-0.0007	-0.0077
46	56	51	10	3900		-1010	2890	0.0043		-0.0006	-0.0056
56	60	58	4	4220		-970	3250	0.0310		-0.0035	-0.0141
60	70	65	10	4540		-930	3610	0.0043		-0.0004	-0.0043
										TOTAL	-0.0905
									=	-1.09	INCHES

SETTLEMENT AT: POINT D

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	964		-544	420	0.0043		-0.0016	-0.0155
10	20	15	10	1473		-533	940	0.0043		-0.0008	-0.0084
20	33	27	13	2149		-519	1630	0.0043		-0.0005	-0.0067
33	35	34	2	2511		-511	2000	0.0062		-0.0006	-0.0012
35	46	41	11	2873		-503	2370	0.0043		-0.0004	-0.0040
46	56	51	10	3382		-492	2890	0.0043		-0.0003	-0.0029
56	60	58	4	3734		-484	3250	0.0310		-0.0019	-0.0075
60	70	65	10	4086		-476	3610	0.0043		-0.0002	-0.0023
										TOTAL	-0.0485
									=	-0.58	INCHES

SETTLEMENT AT: POINT E

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	1315		-895	420	0.0043		-0.0021	-0.0213
10	20	15	10	1826		-886	940	0.0043		-0.0012	-0.0124
20	33	27	13	2502		-872	1630	0.0043		-0.0008	-0.0104
33	35	34	2	2863		-863	2000	0.0062		-0.0010	-0.0019
35	46	41	11	3223		-853	2370	0.0043		-0.0006	-0.0063
46	56	51	10	3726		-836	2890	0.0043		-0.0005	-0.0047
56	60	58	4	4072		-822	3250	0.0310		-0.0030	-0.0121
60	70	65	10	4418		-808	3610	0.0043		-0.0004	-0.0038
										TOTAL	-0.0730
									=	-0.88	INCHES

SETTLEMENT AT: POINT F

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	3250		-2830	420	0.0043		-0.0038	-0.0382
10	20	15	10	3450		-2510	940	0.0043		-0.0024	-0.0243
20	33	27	13	3840		-2210	1630	0.0043		-0.0016	-0.0208
33	35	34	2	4070		-2070	2000	0.0062		-0.0019	-0.0038
35	46	41	11	4320		-1950	2370	0.0043		-0.0011	-0.0123
46	56	51	10	4680		-1790	2890	0.0043		-0.0009	-0.0090
56	60	58	4	4940		-1690	3250	0.0310		-0.0056	-0.0225
60	70	65	10	5210		-1600	3610	0.0043		-0.0007	-0.0069
										TOTAL	-0.1378
									=	-1.65	INCHES

SETTLEMENT AT: POINT G

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	4160		-3740	420	0.0043		-0.0043	-0.0428
10	20	15	10	3960		-3020	940	0.0043		-0.0027	-0.0269
20	33	27	13	4120		-2490	1630	0.0043		-0.0017	-0.0225
33	35	34	2	4280		-2280	2000	0.0062		-0.0020	-0.0041
35	46	41	11	4480		-2110	2370	0.0043		-0.0012	-0.0131
46	56	51	10	4800		-1910	2890	0.0043		-0.0009	-0.0095
56	60	58	4	5050		-1800	3250	0.0310		-0.0059	-0.0237
60	70	65	10	5300		-1690	3610	0.0043		-0.0007	-0.0072
										TOTAL	-0.1497
									=	-1.80	INCHES

SETTLEMENT AT: POINT H

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	3520		-3100	420	0.0043		-0.0040	-0.0397
10	20	15	10	3680		-2740	940	0.0043		-0.0025	-0.0255
20	33	27	13	4030		-2400	1630	0.0043		-0.0017	-0.0220
33	35	34	2	4240		-2240	2000	0.0062		-0.0020	-0.0040
35	46	41	11	4470		-2100	2370	0.0043		-0.0012	-0.0130
46	56	51	10	4520		-1630	2890	0.0043		-0.0008	-0.0084
56	60	58	4	5070		-1820	3250	0.0310		-0.0060	-0.0239
60	70	65	10	5340		-1730	3610	0.0043		-0.0007	-0.0073
										TOTAL	-0.1438
									=	-1.73	INCHES

SETTLEMENT AT: POINT I

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	1500		-1080	420	0.0043		-0.0024	-0.0238
10	20	15	10	1980		-1040	940	0.0043		-0.0014	-0.0139
20	33	27	13	2628		-998	1630	0.0043		-0.0009	-0.0116
33	35	34	2	2972		-972	2000	0.0062		-0.0011	-0.0021
35	46	41	11	3317		-947	2370	0.0043		-0.0006	-0.0069
46	56	51	10	3800		-910	2890	0.0043		-0.0005	-0.0051
56	60	58	4	4135		-885	3250	0.0310		-0.0032	-0.0130
60	70	65	10	4470		-860	3610	0.0043		-0.0004	-0.0040
										TOTAL	-0.0804
									=	-0.96	INCHES

SETTLEMENT AT: POINT J

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	649		-229	420	0.0043		-0.0008	-0.0081
10	20	15	10	1436		-496	940	0.0043		-0.0008	-0.0079
20	33	27	13	2228		-598	1630	0.0043		-0.0006	-0.0076
33	35	34	2	2615		-615	2000	0.0062		-0.0007	-0.0014
35	46	41	11	2988		-618	2370	0.0043		-0.0004	-0.0048
46	56	51	10	3501		-611	2890	0.0043		-0.0004	-0.0036
56	60	58	4	3851		-601	3250	0.0310		-0.0023	-0.0091
60	70	65	10	4200		-590	3610	0.0043		-0.0003	-0.0028
										TOTAL	-0.0454
									=	-0.54	INCHES

SETTLEMENT AT: POINT D' (OUTSIDE WALL)

SUBLAYER DEPTH TOP	BOT	AVG	Ho FT	Po PSF	Pp PSF	DP PSF	Pf PSF	Cer	Cec	Ez	DH FT
0	10	5	10	564		-144	420	0.0043		-0.0006	-0.0055
10	20	15	10	1317		-377	940	0.0043		-0.0006	-0.0063
20	33	27	13	2167		-537	1630	0.0043		-0.0005	-0.0069
[illegible]	35	34	2	2587		-587	2000	0.0062		-0.0007	-0.0014
35	46	41	11	2989		-619	2370	0.0043		-0.0004	-0.0048
46	56	51	10	3533		-643	2890	0.0043		-0.0004	-0.0038
56	60	58	4	3899		-649	3250	0.0310		-0.0025	-0.0098
60	70	65	10	4260		-650	3610	0.0043		-0.0003	-0.0031
										TOTAL	-0.0415
									=	-0.50	INCHES

BATTERY HUGER
STRESS CALCULATIONS

LOADS

): File Name : BHSTRESX.DAT Output File Name : BHSTRESX.OUT

Load	X	dX	Y	dY	Z	Magnitude
1	0	20	0	65	0	3000 psi
2	20	212	0	65	0	1800 psi
3	232	43	0	65	0	3000 psi
4	0	60	65	23	0	3300 psi
5	60	90	65	23	0	4200 psi
6	150	125	65	23	0	3200 psi
7	0	275	88	80	0	2400 psi
8	0	275	168	80	0	2200 psi

Summary of Results

File Name : BHSTRESS.DAT Output File Name : BHSTRESS.OUT

tress oint	X	Y	Z	Bous. Sigma2	Best. Sigma2	
1	0	0	0	750 psf	750 psf	A
2	0	0	5	748 psf	715 psf	
3	0	0	15	720 psf	653 psf	
4	0	0	27	668 psf	597 psf	
5	0	0	34	643 psf	573 psf	
6	0	0	41	625 psf	553 psf	
7	0	0	51	606 psf	530 psf	
8	0	0	58	597 psf	516 psf	
9	0	0	65	591 psf	503 psf	
10	0	65	0	1560 psf	1560 psf	B
11	0	65	5	1570 psf	1490 psf	
12	0	65	15	1510 psf	1341 psf	
13	0	65	27	1420 psf	1190 psf	
14	0	65	34	1360 psf	1120 psf	
15	0	65	41	1310 psf	1060 psf	
16	0	65	51	1240 psf	983 psf	
17	0	65	58	1200 psf	935 psf	
18	0	65	65	1170 psf	902 psf	
19	0	86	0	1450 psf	1450 psf	C
20	0	86	5	1460 psf	1360 psf	
21	0	86	15	1410 psf	1240 psf	
22	0	86	27	1340 psf	1100 psf	
23	0	86	34	1290 psf	1030 psf	
24	0	86	41	1250 psf	980 psf	
25	0	86	51	1200 psf	920 psf	
26	0	86	58	1170 psf	886 psf	
27	0	86	65	1150 psf	862 psf	
28	0	248	0	550 psf	544 psf	D
29	0	248	5	550 psf	544 psf	
30	0	248	15	550 psf	544 psf	
31	0	248	27	550 psf	544 psf	
32	0	248	34	551 psf	544 psf	
33	0	248	41	551 psf	543 psf	
34	0	248	51	551 psf	542 psf	
35	0	248	58	551 psf	484 psf	
36	0	248	65	551 psf	476 psf	
37	138	0	0	900 psf	900 psf	E
38	138	0	5	900 psf	895 psf	
39	138	0	15	903 psf	886 psf	
40	138	0	27	915 psf	872 psf	
41	138	0	34	926 psf	865 psf	
42	138	0	41	935 psf	859 psf	
43	138	0	51	950 psf	850 psf	
44	138	0	58	960 psf	844 psf	
45	138	0	65	975 psf	840 psf	
46	138	65	0	3000 psf	3000 psf	F
47	138	65	5	2990 psf	2990 psf	
48	138	65	15	2970 psf	2970 psf	
49	138	65	27	2870 psf	2870 psf	
50	138	65	34	2810 psf	2810 psf	
51	138	65	41	2760 psf	2760 psf	
52	138	65	51	2690 psf	2690 psf	
53	138	65	58	2650 psf	2650 psf	

[illegible]	105	77	0	4200 psi	4200 psi	
56	101	77	5	4140 psf	3740 psf	G
57	105	77	15	3620 psi	3020 psi	
58	105	77	27	3090 psi	1490 psi	
59	105	77	34	2880 psf	2280 psf	
60	105	77	41	2720 psi	2110 psi	
61	105	77	51	2520 psf	1910 psf	
62	105	77	58	2410 psf	1800 psf	
63	105	77	65	2310 psi	1690 psf	
64	138	88	0	3300 psi	3300 psi	
65	138	88	5	3290 psi	3100 psi	H
66	138	88	15	3150 psi	2740 psi	
67	138	88	27	2910 psf	2400 psf	
68	138	88	34	2780 psi	2240 psi	
69	138	88	41	2670 psf	2100 psf	
70	138	88	51	2520 psi	1930 psf	
71	138	88	58	2430 psi	1820 psi	
72	138	88	65	2340 psi	1730 psi	
73	138	248	0	1100 psi	1100 psi	
74	138	248	5	1100 psi	1080 psi	I
75	138	248	15	1100 psi	1040 psi	
76	138	248	27	1100 psi	998 psi	
77	138	248	34	1100 psi	972 psi	
78	138	248	41	1090 psi	947 psi	
79	138	248	51	1080 psi	910 psi	
80	138	248	58	1080 psi	881 psi	
81	138	248	65	1070 psi	840 psi	
82	64	-2	0	0 psi	[illegible] psi	
83	64	-2	5	64.2 psi	22[illegible] psi	J
84	2	-2	15	402 psf	4[illegible] psi	
85	64	-2	27	607 psi	5[illegible] psi	
86	64	-2	34	[illegible] psi	[illegible] psi	
[illegible]	64	-2	41	[illegible] psi	[illegible] psi	
88	64	-2	51	[illegible] psi	[illegible]	
89	64	-2	58	705 psi	661 psi	
90	64	-2	65	708 psi	[illegible] psi	

LOADS

a File Name : bhstresd.dat Output File Name : bhstresd.out

Load	X	dX	Y	dY	Z	Magnitude
1	0	20	0	65	0	3000 psf
2	20	212	0	65	0	1800 psf
3	232	43	0	65	0	3000 psf
4	0	60	65	23	0	3300 psf
5	60	90	65	23	0	4200 psf
6	150	125	65	23	0	3200 psf
7	0	275	88	80	0	2400 psf
8	0	275	168	80	0	2200 psf

Summary of Results

a File Name : bhstresd.dat Output File Name : bhstresd.out

POINT D'

Stress Point	X	Y	Z	Bous. SigmaZ	West. SigmaZ
1	138	263	0	0 psf	0 psf
	138	263	5	15.2 psf	144 psf
	138	263	15	199 psf	377 psf
4	138	263	27	445 psf	537 psf
5	138	263	34	546 psf	587 psf
6	138	263	41	620 psf	619 psf
7	138	263	51	695 psf	643 psf
8	138	263	58	732 psf	649 psf
9	138	263	65	758 psf	650 psf

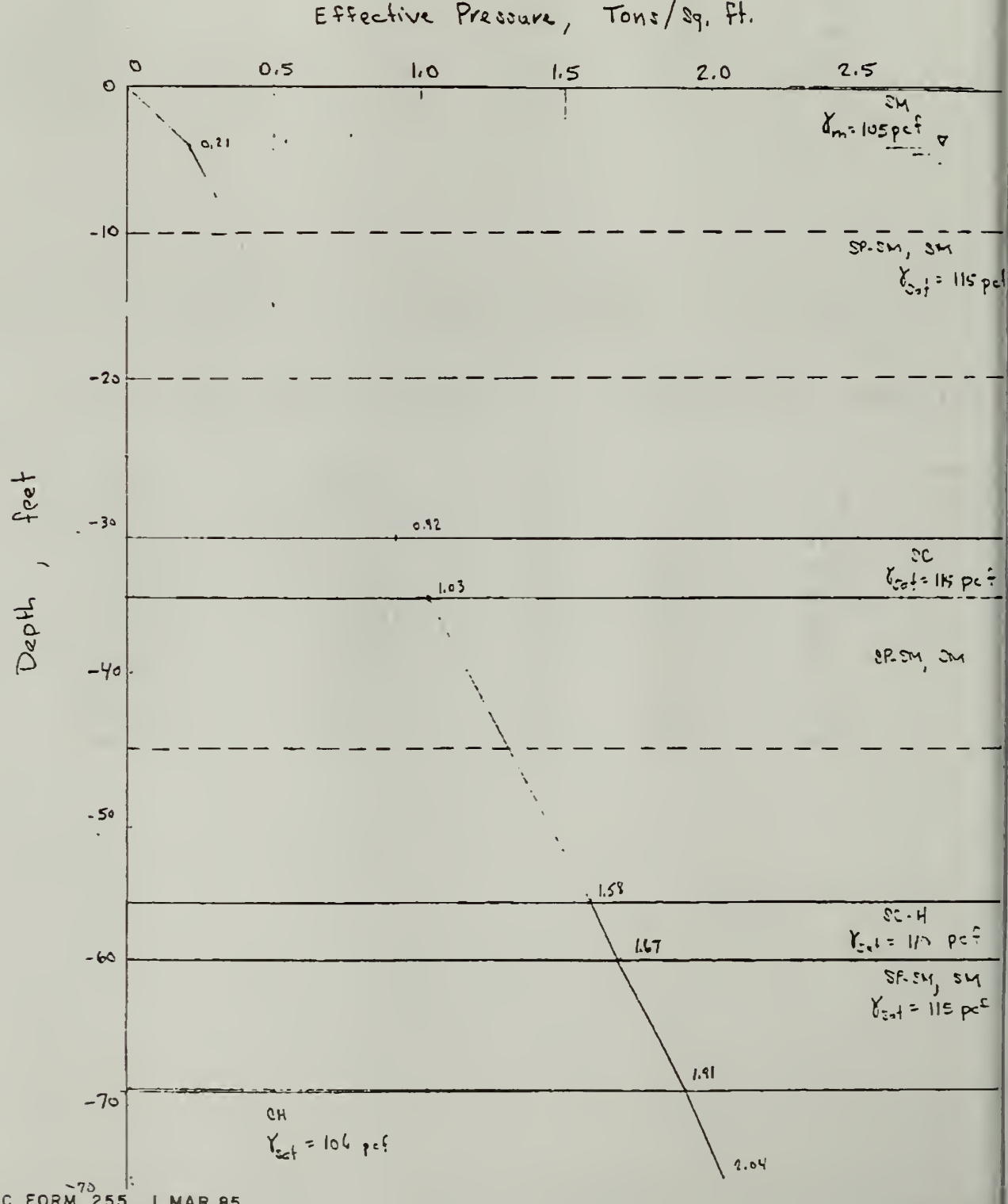
U.S. ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
CHARLESTON, SOUTH CAROLINA

Subject: _____

Computation _____ No. _____

Computed by _____ Checked by _____ Date _____

Effective Pressure (Without Battery Huger Loads)

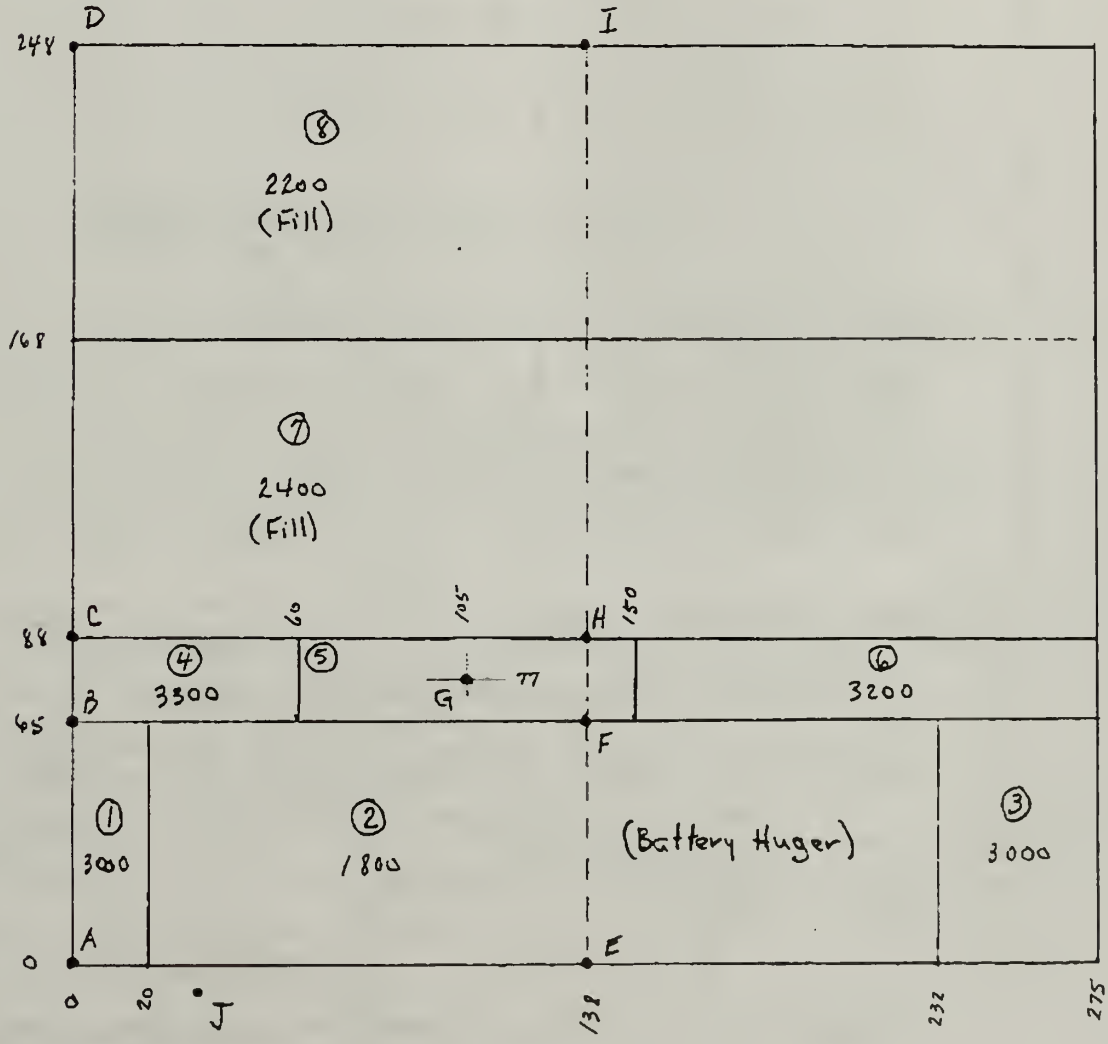


Subject: BATTERY HUGER

Computation _____ No. _____

Computed by _____ Checked by _____ Date _____

Loading arrangement (in lb/ft^2)



Subject: Fort Sumter - Battery Huger

Computation Consolidation - Heave No.

Computed by DLH Checked by Date 8-7-92

Boring FS-10-92 Sample # 6A (36.5'-38.5')

SC $w = 38.3\%$ $LL = 29$ $PI = 7$ Activity $= \frac{7}{7.5} = 0.93$

Compression Index, $C_c = \frac{0.9933 - 0.8308}{1} = 0.1625$

Correlation: $C_c = 0.009(LL-10)$

$C_c = 0.009(29-10) = 0.17$ O.K.

Virgin compression ratio, $C_{ec} = \frac{C_c}{1+e_o}$

$C_{ec} = \frac{0.1625}{1+1.031} = 0.0800$

Recompression Index, $C_r = \frac{0.8608 - 0.8483}{1} = 0.0125$

Recompression ratio, $C_{er} = \frac{C_r}{1+e_o} = \frac{0.0125}{1+1.031} = 0.00615$

$\gamma_{sat} = \frac{(1+w)\gamma_w}{w + 1/G_s} = \frac{(1+0.383)62.4}{0.383 + \frac{1}{2.69}} = 114.3 \text{ lb/ft}^3$

Effective Overburden Pressure

$P_o = 4(105) + 33.5(115-62.4) = 2180 \text{ lb/ft}^2$

$P_p \approx 3200 \text{ lb/ft}^2$ (from Consolidation Test)

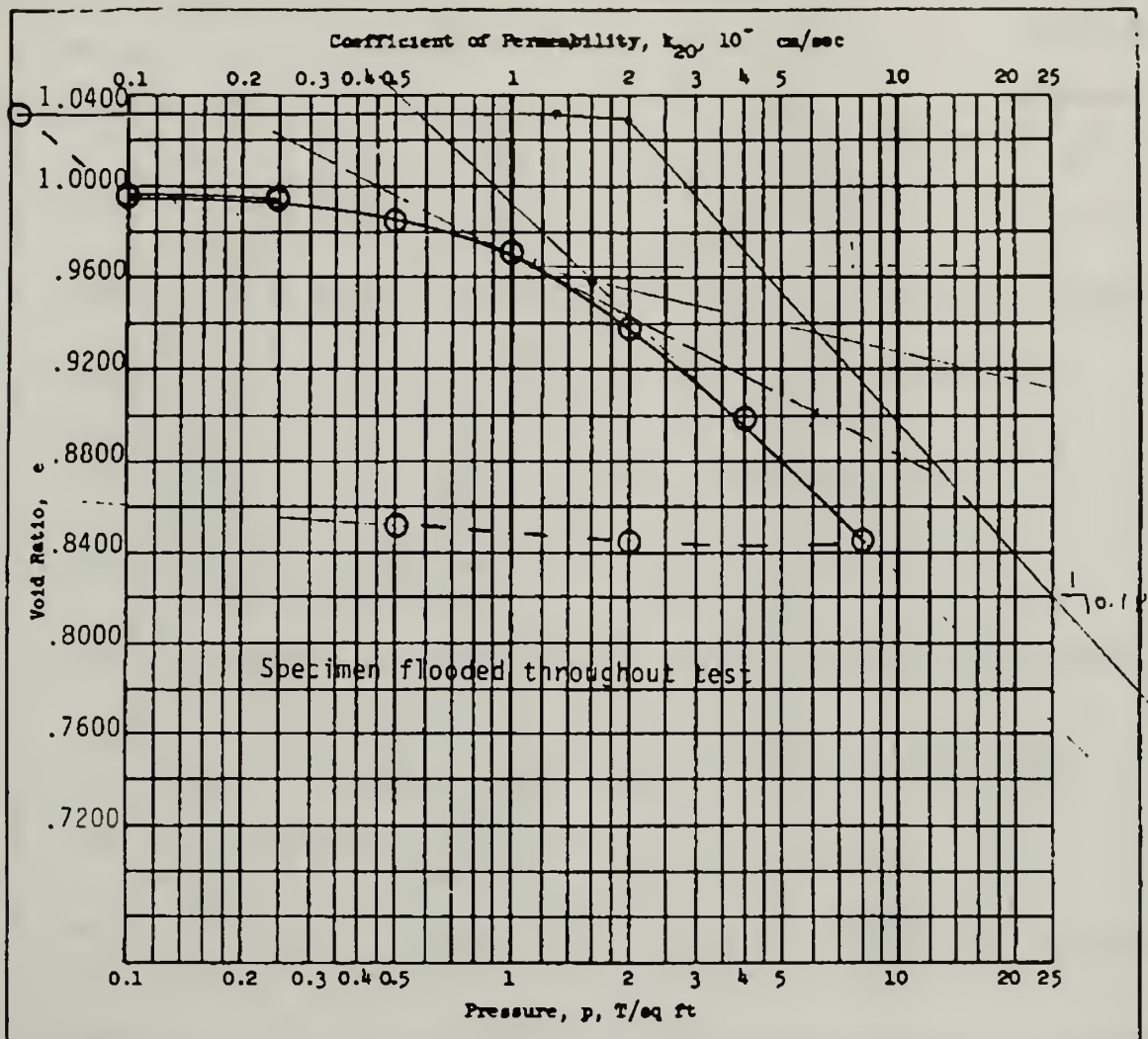
Coefficient of Consolidation

$C_v = \frac{0.197 D^2}{t_{50}}$

$t_{50} = 11.5$ min (from Consolidation test time curve)

$C_v = \frac{0.197(1 \text{ in})^2}{11.5 \text{ min}} \cdot \frac{1 \text{ ft}^2}{144 \text{ in}^2} \cdot \frac{1440 \text{ min.}}{1 \text{ day}} \cdot \frac{365 \text{ days}}{1 \text{ year}}$

$C_v = 62.5 \text{ ft}^2/\text{year}$



Type of Specimen undisturbed		Before Test		After Test	
Diam 2.49 in.	Ht 1.00 in.	Water Content, w_o	38.3 %	w_f	31.7 %
Overburden Pressure, p_o 1.3 T/sq ft		Void Ratio, e_o	1.031	e_f	.851
Preconsol. Pressure, p_c 2.0 T/sq ft		Saturation, S_o	100.0 %	S_f	100.0 %
Compression Index, C_c 0.188 Corrected		Dry Density, γ_d	82.7 lb/ft^3		
Classification SC C_r = .0125		k_{20} at e_o =	x 10^{-} cm/sec		
LL 29	G_s 2.69	Project Ft. Sumter, National Monument			
PL 22	D_{10} .0057mm	Lab No. 96/635			
Remarks See gradation curve		Area Battery Huger Investigation			
on ENG Form 2087.		Boring No. FS-10-92		Sample No. 6A	
		Depth 36.5-38.5'		Date 14 May 92	
		CONSOLIDATION TEST REPORT			

C_{ec} = 0.0724
C_{er} = 0.00615

ENG FORM 1 MAY 63 2990 PREVIOUS EDITIONS ARE OBSOLETE.

CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30601 SACW1-92-84 REQ. NO.

Subject: _____

Computation _____ No. _____

Computed by _____ Checked by _____ Date 8-7-92

Boring FS-10-92 Sample 11B (64.0'- 66.0')

SC-H $\omega = 45.8\%$ $LL = 55$ $PI = 33$

Compression Index $C_c = \frac{1.254 - 0.839}{1} = 0.4150$

Correlation, $C_c = 0.009 (LL-10)$

$C_c = 0.009 (55-10) = 0.41$

Virgin compression ratio, $C_{ec} = \frac{C_c}{1+e_o}$

$C_{ec} = \frac{0.415}{1+1.255} = 0.184$

Recompression Index $C_r = \frac{0.9110 - 0.8410}{1} = 0.070$

Recompression Ratio, $C_{er} = \frac{C_r}{1+e_o}$

$C_{er} = \frac{0.070}{1+1.255} = 0.0310$

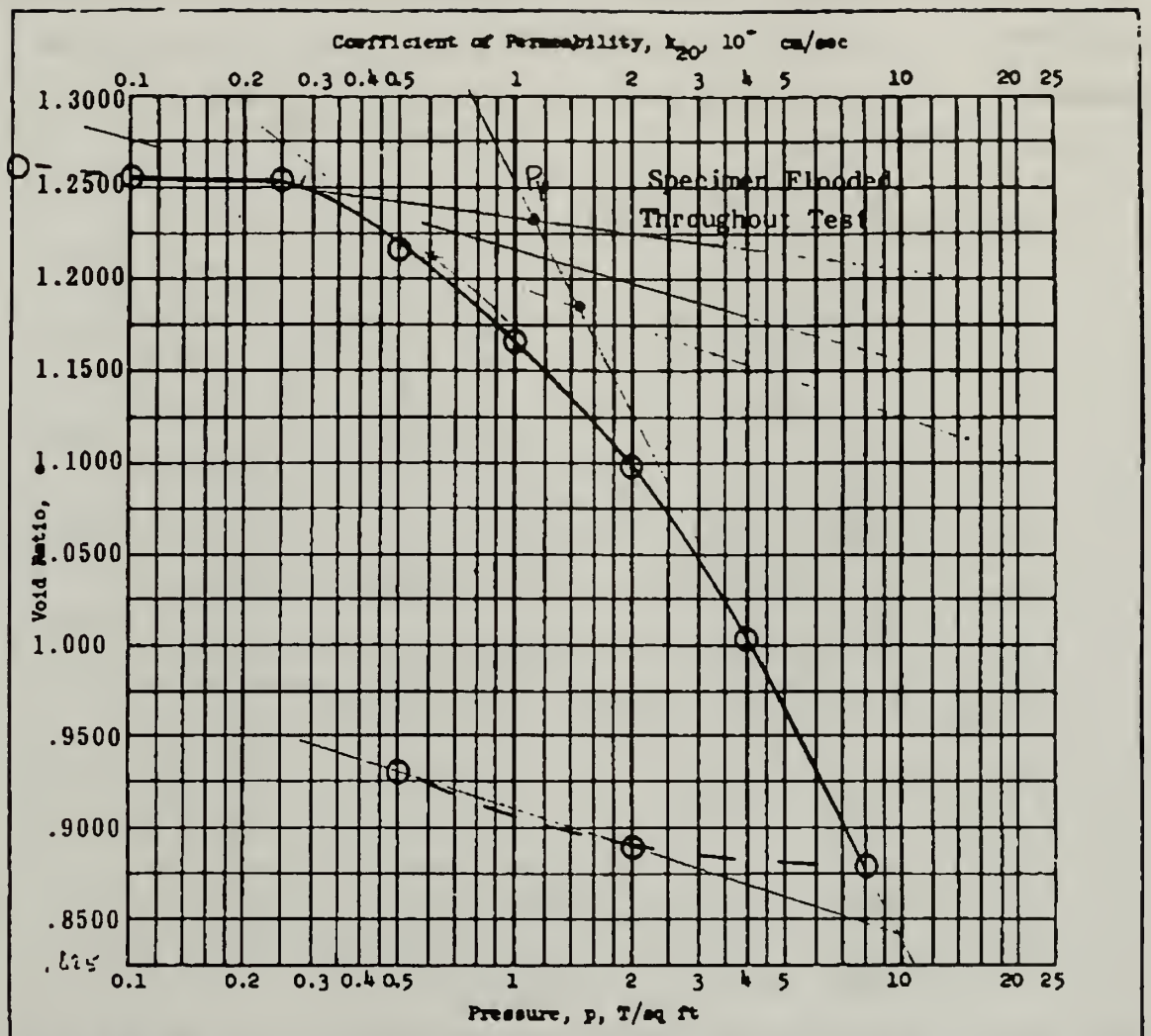
Saturated Unit Weight $\gamma_{sat} = 109.8 \text{ lb/ft}^3$

Effective Overburden Pressure

$P_o = 4(105) + 61(115-62.4) = 3630 \text{ lb/ft}^3$

Activity

$A = \frac{PI}{\% < 2\mu} = \frac{33}{15.5} = 2.1$



Type of Specimen	Undisturbed			Before Test		After Test	
Diam 2.50 in.	Ht 1.00 in.		Water Content, w_o	45.8 %	w_f	34.4 %	
Overburden Pressure, p_o	1.8 T/sq ft		Void Ratio, e_o	1.255	e_f	.928	
Preconsol. Pressure, p_c	1.5 (?) T/sq ft		Saturation, S_o	98.5 %	S_f	100.0 %	
Compression Index, C_c	C_r = 0.070		Dry Density, γ_d	74.7 lb/ft^3			
Classification	Gray, clayey sand high LL (SC-H)		k_{20} at e_o =	× 10^{-} cm/sec			
LL 55	G_s 2.70		Project	Ft. Sumter National Monument Charleston, SC			
PL 22	D_{10} <0.002MM			Lab. No. 96/637			
Remarks See gradation curve on ENG Form 2087.			Area Battery Huger Investigation				
			Boring No. FS-10-92		Sample No. 11 B		
			Depth 64.0-66.0'		Date 20 May 1992		
			CONSOLIDATION TEST REPORT				

γ_{cr} = 109.8 lb/

C_{ec} =

C_{er} = 0.0310

ENG FORM 1 MAY 63 2990 PREVIOUS EDITIONS ARE OBSOLETE.

CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061 REQ. NO. SACRM-92-84

Subject: _____

Computation _____ No. _____

Computed by _____ Checked by _____ Date _____

Boring FS-10-92

Sample No. 13 (75.0'-77.0')

Classification: CH $\omega = 52.5\%$

$LL = 88$
$PI = 51$

$$C_c = \frac{1.4317 - 1.1288}{1} = 0.3029$$

$$C_r = \frac{1.2717 - 1.2448}{1} = 0.0269$$

$\gamma_{sat} = 106.4 \text{ lb/ft}^3$

$$P_o = 4(105) + 61(115 - 62.4) + 11(110 - 62.4)$$
$$= 4150 \text{ lb/ft}^2 = 2.08 \text{ T/ft}^2$$

$P_p = 2.1 \text{ T/ft}^2$ from Consolidation Test

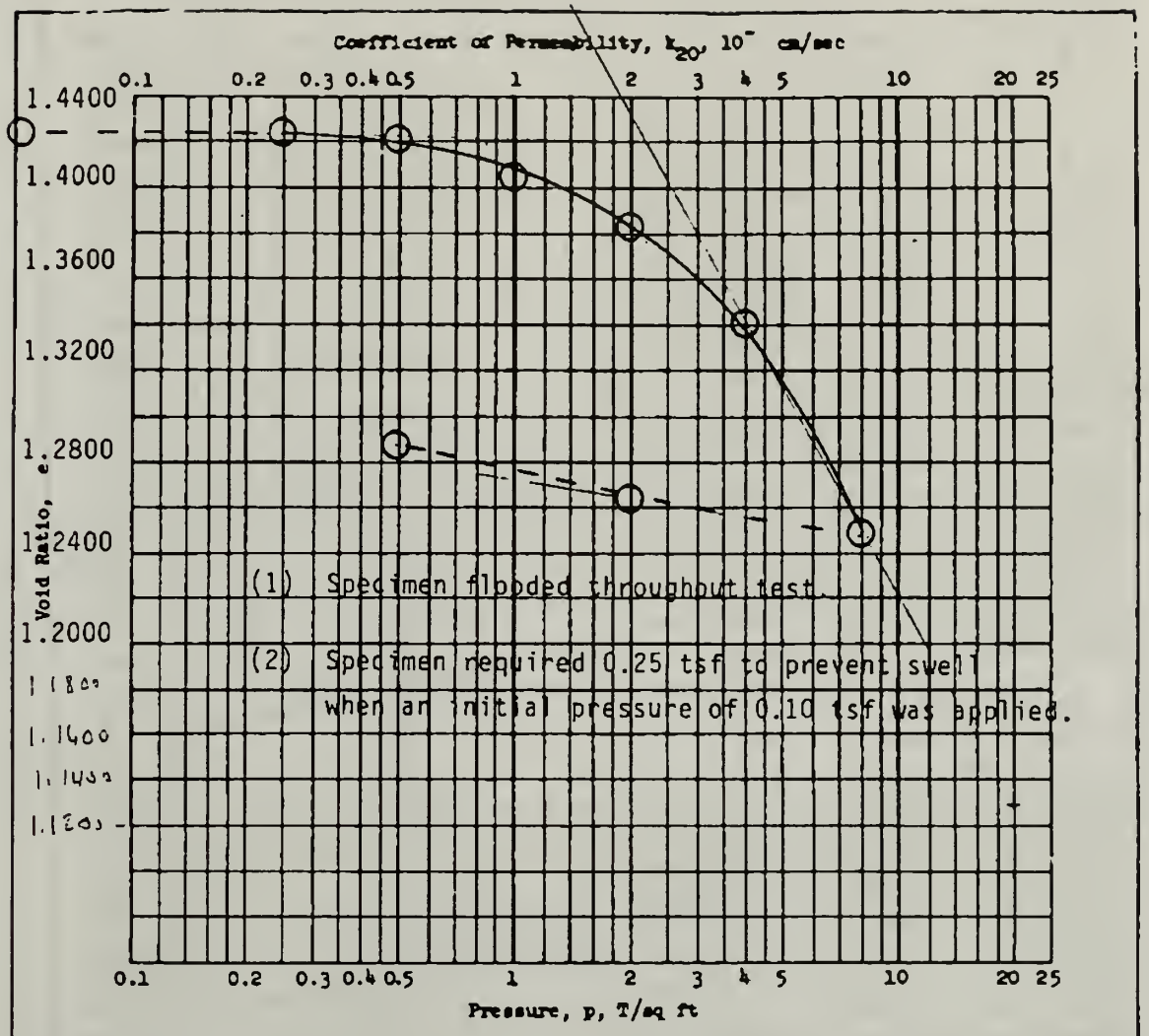
From Consolidation Test - Time curve $t_{50} = 0.24$ min

$$C_v = \frac{0.197 (1.00)^2}{0.24} \times 3450 = 3000 \text{ ft}^2/\text{yr}.$$

Check C_c by correlation:

$$C_c = 0.009(LL - 10)$$
$$= 0.009(88 - 10) = 0.70$$

Activity, $A = \frac{PI}{\% < \#200} = \frac{51}{25} = 2.0$



Type of Specimen Undisturbed		Before Test		After Test	
Diam 2.50 in.	Ht 1.00 in.	Water Content, w_o	52.5 %	w_f	47.6 %
Overburden Pressure, p_o 2.08 T/sq ft		Void Ratio, e_o	1.422	e_f	1.2895
Preconsol. Pressure, p_c 2.1 T/sq ft		Saturation, S_o	100.0 %	S_f	100.0 %
Compression Index, C_c = 0.3029		Dry Density, γ_d	69.9 lb/ft^3		
Classification CH	C_v = 0.0392	k_{20} at e_o =	x 10^{-} cm/sec		
LL 88	G_s 2.71	Project Ft. Sumpter National Monument			
PL 37	D_{10} -	Lab. No. 96/639			
Remarks See gradation curve on ENG Form 2087.		Area Battery Huger Investigation			
		Boring No. FS-10-92	Sample No. 13		
		Depth Mix 75.0 77.0'	Date 14 May 92		
		CONSOLIDATION TEST REPORT			

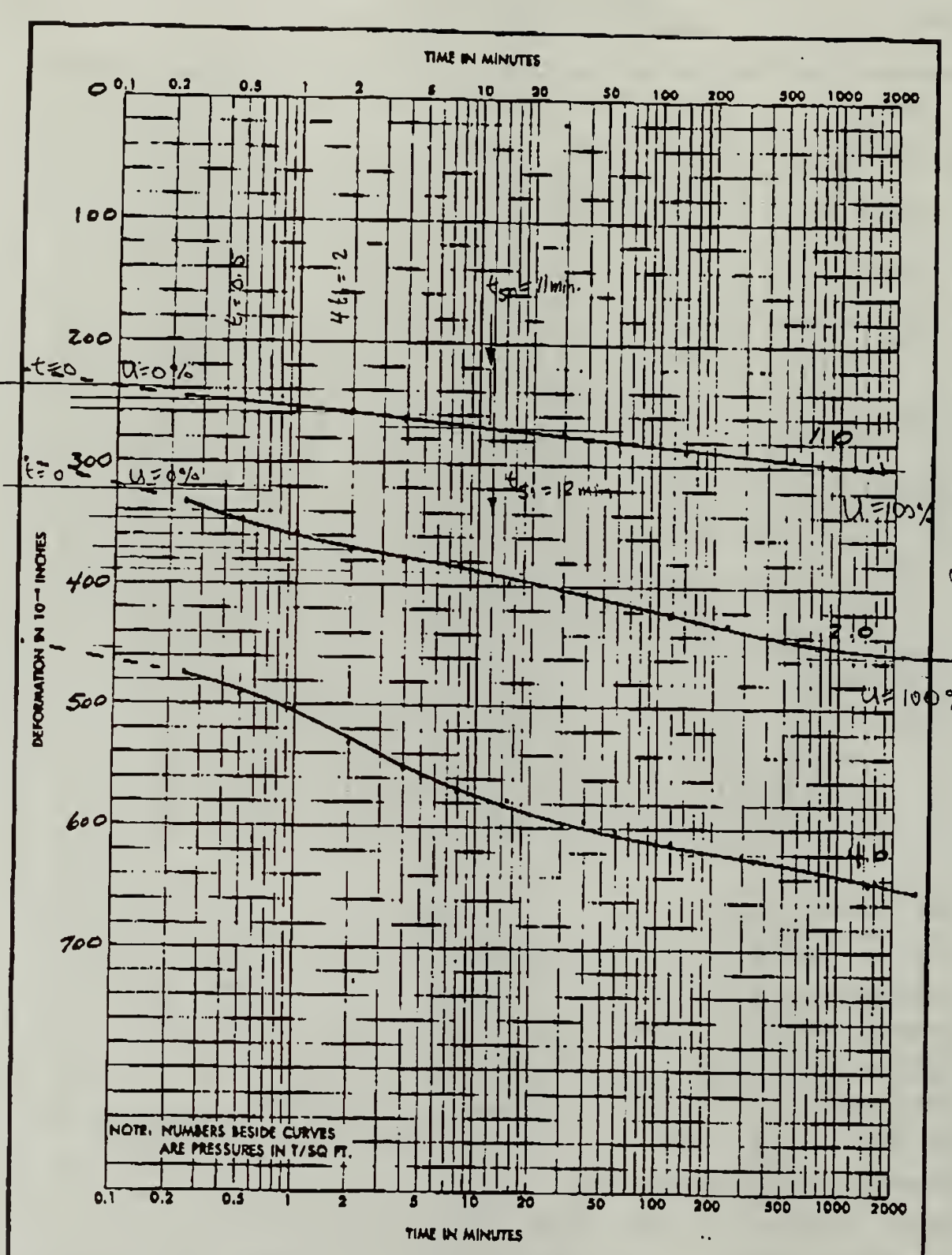
γ_{co} = 104.4 lb/ft^3

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.

CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MAR TA, GA. 30061 RFQ. NO. SACRM-92-84

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 31

RUHR UKDER NO. 00330
Req. No. SACRM - 92 - 84



PROJECT CHARLESTON SC, FT SUMTER NATIONAL MONUMENT
AREA BATTERY HUGER INVESTIGATION LAB. NO. 96/635
BORING NO. FS-10-92 SAMPLE NO 6A DEPTH ft 36.5 - 38.5' DATE 20 MAY 92
ENG FORM 2088 1 MAY 63 PREVIOUS EDITIONS ARE OBSOLETE. CONSOLIDATION TEST—TIME CURVES (TRANSLUCENT)

Compression Index Correlations for Sands

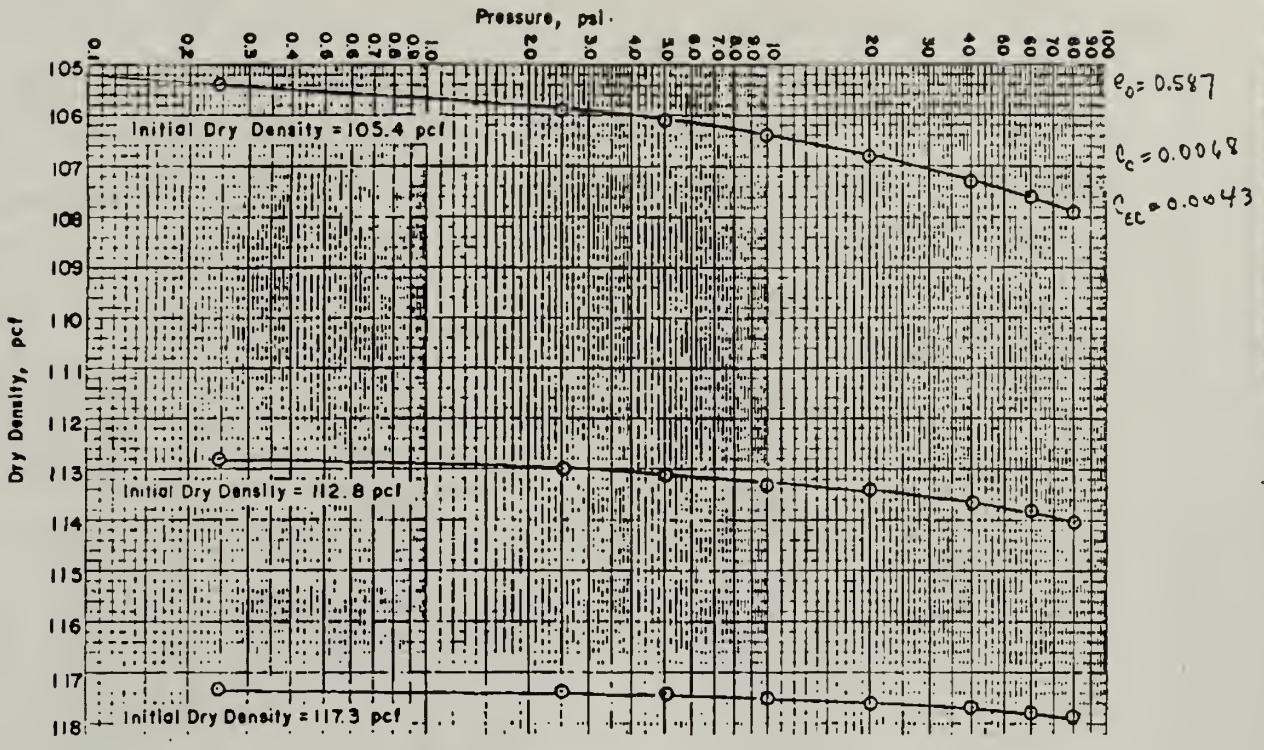


Figure 12. Consolidation test results for Platte River sand

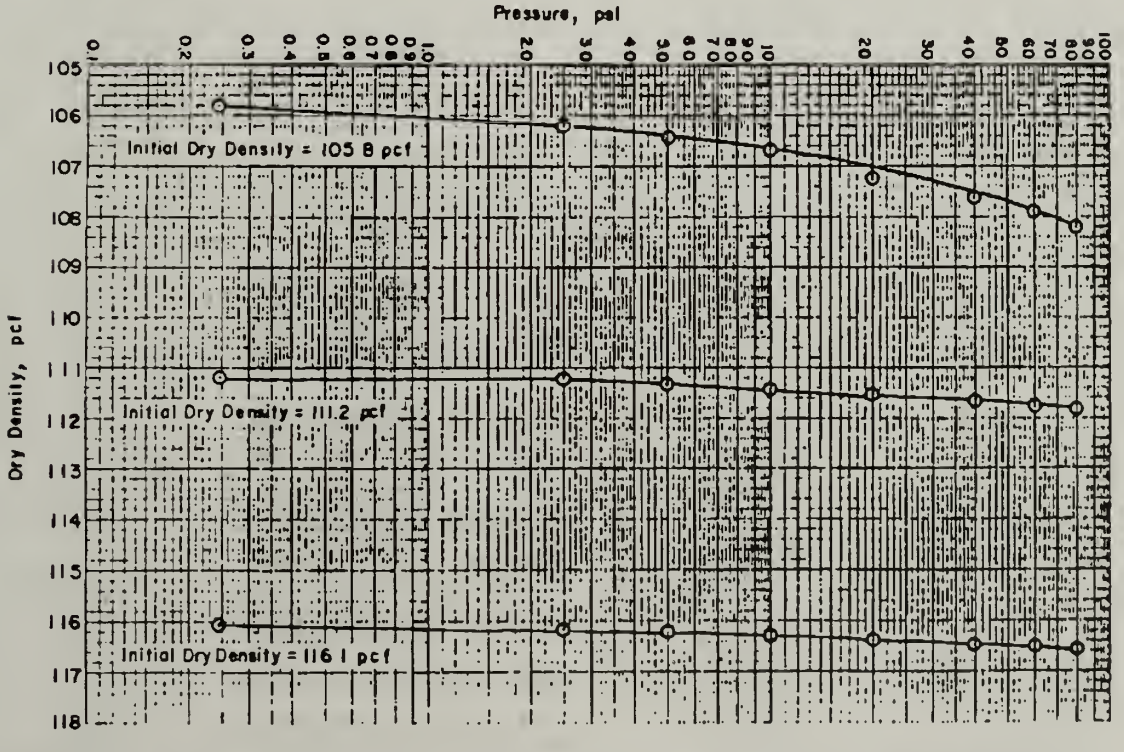


Figure 13. Consolidation test results for Standard Concrete sand

$$\gamma_d = \frac{G_s \gamma_w}{1+e} \Rightarrow e = \frac{G_s \gamma_w}{\gamma_d} - 1$$

BORING LOGS

CONTRACT NO. DACW60-92-M-0135 Hole No. FS-8-92

1 DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION FT. SUMTER NATIONAL MONUMENT	SHEET 1 of 3 SHEETS
1 PROJECT BATTERY HUGER FOUNDATION INVESTIGATION		10 SIZE AND TYPE OF BIT	
2 LOCATION (Coordinates or Station) FORT SUMTER NATIONAL MONUMENT		11 DATUM FOR ELEVATION SHOWN (TBM or MSVD) NONE	
3 DRILLING AGENCY SOIL CONSULTANTS, INC.		12 MANUFACTURER'S DESIGNATION OF DRILL	
4 HOLE NO (As shown on drawing title and file number) FS-8-92		13 TOTAL NUMBER OF OVERBURDEN SAMPLES TAKEN DISTURBED 33	UNDISTURBED
5 NAME OF DRILLER FRANK EATON		14 TOTAL NUMBER OF CORE BOXES NONE	
6 DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED _____ DEG FROM VERTICAL		15 ELEVATION GROUND WATER 4' - 0"	
		16 DATE HOLE STARTED 3/23/92	COMPLETED 3/26/92
7. THICKNESS OF OVERBURDEN		17 ELEVATION TOP OF HOLE 0' - 0" ASSUMED	
8. DEPTH DRILLED INTO ROCK		18 TOTAL CORE RECOVERY FOR BORING	%
9 TOTAL DEPTH OF HOLE 76' - 6"		19 SIGNATURE OF INSPECTOR	

a ELEVATION	b DEPTH	c LEGEND	d CLASSIFICATION OF MATERIALS (Description)	e % CORE RECOVERY	f BOX OR SAMPLE NO.	g REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	0					AUGER BORING 0'0" TO 5'0"
			BROWN FINE SAND WITH BRICK FRAGMENTS AND SHELL CONTENT. (SM WITH SHELL)		1	
	5		VERY LOOSE BROWN FINE SAND WITH HIGH SHELL CONTENT. (SM WITH SHELL)		2	1-2-1
					3	1-1-2
	10		GRANITE			
			MEDIUM GRAY FINE SAND WITH HIGH SHELL CONTENT. (SM WITH SHELL)		4	12-12-14
					5	9-10-12
	15				6	15-10-12
			MEDIUM GRAY FINE SAND WITH SLIGHT SHELL CONTENT. (SM)		7	4-12-15
			MEDIUM GRAY FINE SAND WITH VERY SLIGHT SHELL CONTENT (SM)		8	11-14-16
	20		DENSE GRAY FINE SAND WITH SLIGHT SHELL CONTENT. (SM)		9	4-14-17
					10	11-17-17
			MEDIUM GRAY FINE SAND WITH SLIGHT SHELL CONTENT (SM)		11	8-14-16
			MEDIUM GRAY FINE SAND WITH HIGH SHELL CONTENT. (SM)		12	9-14-13
	25		LOOSE GRAY FINE SAND WITH HIGH SHELL CONTENT (SM)		13	2-3-6
			MEDIUM GRAY FINE SAND (SM)		14	11-9-11
			MEDIUM GRAY FINE SAND WITH SLIGHT ORGANIC CLAY LENS. (SM)		15	6-7-8
	30		Continued on Sheet 2			BLOWS PER FOOT Number required to drive 1-3/8" ID splitspoon 12" with 140 lb hammer falling 30"

Note: Soils visually classified in accordance with Unified Soil Classification System.

CONTRACT NO. DACW60-92-M-0135

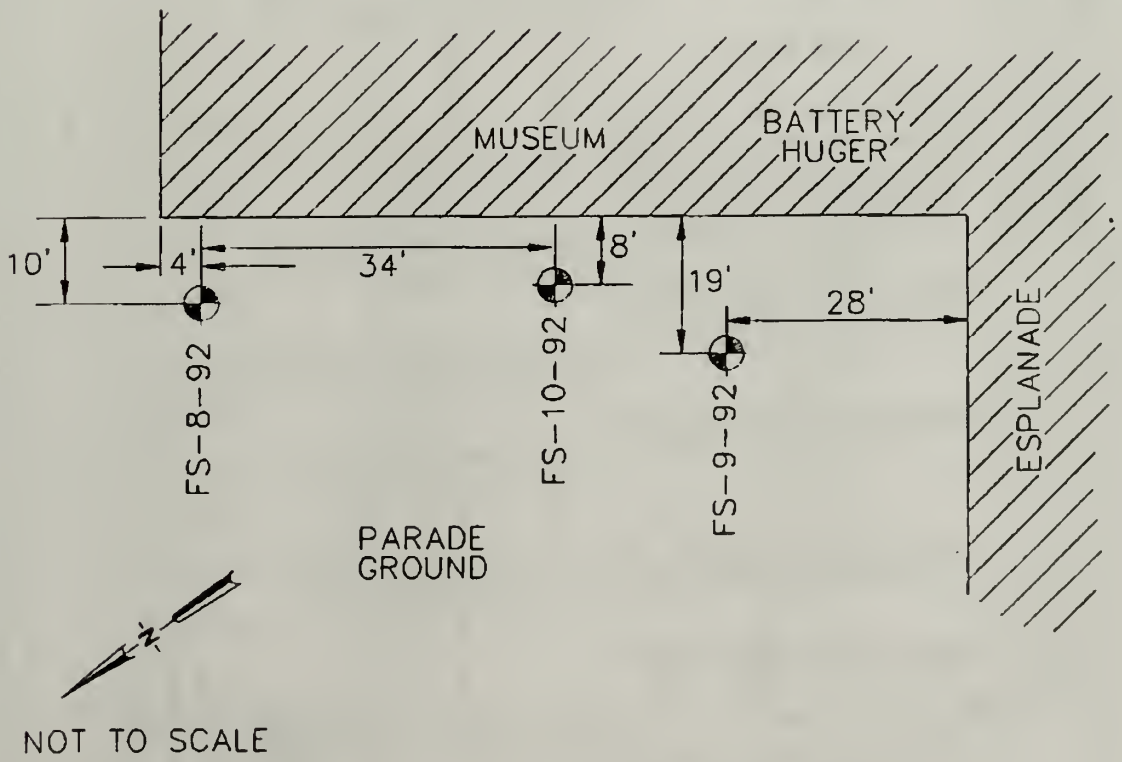
DRILLING LOG (Cont. Sheet)	ELEVATION TOP OF HOLE 0' - 0" ASSUMED	Hole No. FS-8-92
PROJECT BATTERY HUGER FOUNDATION INVESTIGATION	INSTALLATION FT. SUMTER NATIONAL MONUMENT	SHEET 2 OF 3 SHEETS

a ELEVATION	b DEPTH 30	c LEGEND	d CLASSIFICATION OF MATERIALS (Description)	e % CORE RECOVERY	f BOX OR SAMPLE NO	g REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
			LOOSE GRAY FINE SAND WITH ORGANIC ODOR. (SM)		16	1-2-3
			LOOSE GRAY FINE SAND WITH SLIGHT ORGANIC CLAY LENS (SM)		17	2-3-6
			LOOSE GRAY FINE SAND WITH HIGH ORGANIC CLAY LENS AND SHELL CONTENT. (SM)		18	3-3-4
	35		VERY LOOSE GRAY FINE SAND WITH HIGH ORGANIC CLAY LENS. (SM)		19	1-1-1
			LOOSE GRAY FINE SAND WITH SLIGHT SMALL ORGANIC CLAY LENS. (SM)		20	1-2-3
			LOOSE GRAY FINE SAND WITH SLIGHT SMALL ORGANIC CLAY LENS. (SM)		21	3-3-2
			LOOSE GRAY FINE SAND WITH SLIGHT SMALL ORGANIC CLAY LENS CONTENT. (SM)		22	1-2-4
	40					
			LOOSE GRAY FINE SAND WITH SLIGHT SMALL ORGANIC CLAY LENS AND SHELL CONTENT. (SM)		23	3-4-5
	45					
			LOOSE GRAY FINE SAND WITH SLIGHT SMALL ORGANIC CLAY LENS AND SHELL CONTENT. (SM)		24	2-3-4
	50		MEDIUM GRAY FINE SAND WITH SLIGHT SMALL ORGANIC CLAY LENS AND SHELL CONTENT. (SM)		25	5-6-8
			MEDIUM GRAY FINE SAND WITH VERY SLIGHT ORGANIC CLAY LENS AND VERY SLIGHT SMALL DECAYED WOOD. (SM)		26	1-3-14
	55		VERY LOOSE GRAY FINE SAND WITH SLIGHT LARGE ORGANIC CLAY LENS (SM)		27	1-1-3
			MEDIUM GRAY FINE SAND WITH ORGANIC ODOR. (SM)		28	3-4-7
	60		MEDIUM GRAY FINE SAND WITH SLIGHT ORGANIC CLAY LENS. (SM)		29	3-4-5
	65		MEDIUM GRAY INORGANIC CLAY WITH SLIGHT SAND CONTENT. (CH)		30	2-2-3
			LOOSE GRAY FINE SAND WITH VERY SLIGHT SMALL ORGANIC CLAY LENS AND SHELL CONTENT. (SM)		31	2-3-6
	70		VERY LOOSE GRAY FINE SAND WITH VERY SLIGHT ORGANIC CLAY CONTENT. (SM)		32	1-1-3
			VERY STIFF BROWNISH GREEN CALCAREOUS CLAY WITH SIGHT SAND CONTENT. (MH) LOCALLY CALLED MARL BORING TERMINATED AT 76'6" AS DIRECTED BY MR. DOUG HOLMES.		33	1-8-11

ENG FORM 1836-A (CH)

CONTRACT NO. DACW60-92-M-0135

DRILLING LOG (Cont. Sheet)	ELEVATION TOP OF HOLE 0' - 0" ASSUMED	Hole No. FS-8-92
PROJECT BATTERY HUGER FOUNDATION INVESTIGATION	INSTALLATION FT. SUMTER NATIONAL MONUMENT	SHEET 3 OF 3 SHEETS



CONTRACT NO. DACW60-92-M-0135

Hole No. FS-9-92

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: FT. SUMTER NATIONAL MONUMENT	SHEET 1 of 3 SHEETS

1 PROJECT: BATTERY HUGER FOUNDATION INVESTIGATION	10. SIZE AND TYPE OF BIT
2 LOCATION (Coordinates or Station): FORT SUMTER NATIONAL MONUMENT	11 DATUM FOR ELEVATION SHOWN (TBM or MSVD): NONE
3. DRILLING AGENCY: SOIL CONSULTANTS, INC.	12 MANUFACTURER'S DESIGNATION OF DRILL
4 HOLE NO (As shown on drawing title and file number): FS-9-92	13 TOTAL NUMBER OF OVERBURDEN SAMPLES TAKEN: DISTURBED 32 / UNDISTURBED
5 NAME OF DRILLER: FRANK EATON	14 TOTAL NUMBER OF CORE BOXES: NONE
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED _____ DEG. FROM VERTICAL	15 ELEVATION GROUND WATER: 3' - 0"
7. THICKNESS OF OVERBURDEN	16 DATE HOLE: STARTED 3/23/92 COMPLETED 3/24/92
8 DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE: 0' - 0" ASSUMED
9 TOTAL DEPTH OF HOLE: 76' - 6"	18 TOTAL CORE RECOVERY FOR BORING: %
	19. SIGNATURE OF INSPECTOR

a ELEVATION	b DEPTH	c LEGEND	d CLASSIFICATION OF MATERIALS (Description)	e % CORE RECOVERY	f BOX OR SAMPLE NO	g REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	0					AUGER BORING 0'0" TO 5'0"
			BROWN, TAN FINE SAND			
	5		LOOSE GRAY FINE SAND (SM)		1	3-3-2
			LOOSE GRAY FINE SAND. (SM)		2	2-3-7
			VERY DENSE GRAY FINE SAND WITH CEMENTED MATERIAL (SM)		3	5-2-37/3"
	10		SOLID GRANITE			
			LOOSE GRANITE			
	13		LOOSE GRAY FINE SAND WITH SLIGHT ORGANIC CLAY CONTENT (SM)		4	5-4-2
	15		VERY LOOSE GRAY FINE SAND WITH HIGH ORGANIC CLAY CONTENT. (SC)		5	3-2-1
			MEDIUM GRAY FINE SAND WITH ORGANIC CLAY AND SHELL CONTENT (SM)		6	1-8-14
			DENSE GRAY FINE SAND CHANGING AT 18'-6" TO VERY LOOSE GRAY FINE SAND WITH SLIGHT ORGANIC CLAY CONTENT. (SM)		7	32-15-4
	20				8	8-17-11
			MEDIUM GRAY FINE SAND WITH SLIGHT SHELL CONTENT. (SM)		9	7-18-15
					10	3-3-11
	25				11	3-8-19
			DENSE GRAY FINE SAND WITH VERY SLIGHT SHELL CONTENT. (SM)		12	4-15-22
					13	6-16-18
			MEDIUM GRAY FINE SAND WITH VERY SLIGHT SHELL CONTENT. (SM)		14	5-7-7
	30		Continued on Sheet 2			BLOWS PER FOOT Number required to drive 1-3/8" ID splitspoon 12" with 140 lb. hammer falling 30"

Note: Soils visually classified in accordance with Unified Soil Classification System.

ENG FORM 1836 (CH)

CONTRACT NO. DACW60-92-M-0135

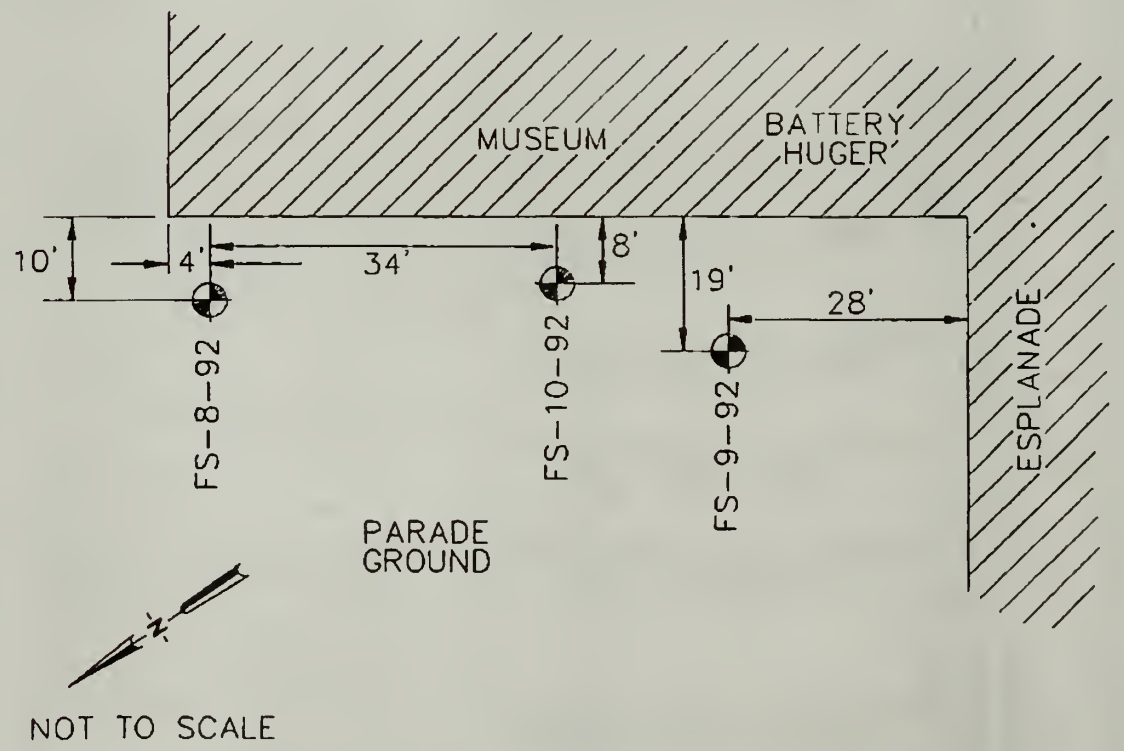
DRILLING LOG (Cont. Sheet)	ELEVATION TOP OF HOLE	Hole No. FS-9-92
PROJECT	INSTALLATION	SHEET 2 OF 3 SHEETS

a ELEVATION	b DEPTH	c LEGEND	d CLASSIFICATION OF MATERIALS (Description)	e % CORE RECOVERY	f BOX OR SAMPLE NO	g REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	30		MEDIUM GRAY FINE SAND WITH VERY SLIGHT SHELL AND ORGANIC CLAY CONTENT. (SM)		15	7-6-6
			VERY LOOSE GRAY FINE SAND WITH SLIGHT SHELL & ORGANIC CLAY CONTENT. (SM)		16	1-2-2
			LOOSE GRAY FINE SAND WITH SLIGHT ORGANIC CLAY & SHELL CONTENT. (SM)		17	1-1-6
	35		VERY LOOSE GRAY FINE SAND WITH HIGH ORGANIC CLAY CONTENT. (SC)		18	2/18"
			VERY LOOSE GRAY FINE SAND WITH VERY SLIGHT ORGANIC CLAY CONTENT. (SM)		19	1-1-2
			MEDIUM GRAY FINE SAND WITH VERY SLIGHT SMALL ORGANIC CLAY LENS. (SM)		20	1-4-13
	40				21	3-3-8
			LOOSE GRAY FINE SAND WITH SLIGHT ORGANIC CLAY LENS (SM)		22	2-4-6
	45		VERY DENSE GRAY FINE SAND. (SM)		23	20-36
			MEDIUM GRAY FINE SAND WITH VERY SLIGHT SMALL ORGANIC CLAY LENS. (SM)		24	3-5-6
	50		LOOSE GRAY FINE SAND WITH SLIGHT SMALL ORGANIC CLAY LENS (SM)		25	2-3-3
	55		SOFT GRAY ORGANIC CLAY WITH SLIGHT SAND LENS. (OL)		26	1/12" 3/6"
			LOOSE GRAY FINE SAND WITH SLIGHT ORGANIC CLAY LENS AND SHELL CONTENT (SM)		27	1-1-7
	60		MEDIUM GRAY FINE SAND WITH SLIGHT ORGANIC CLAY AND SHELL LENS CONTENT. (SM)		28	3-5-9
	65		MEDIUM GRAY FINE SAND WITH SLIGHT ORGANIC CLAY LENS AND SHELL CONTENT. (SM)		29	3-12-12
			MEDIUM GRAY FINE SAND WITH HIGH SHELL AND SLIGHT ORGANIC CLAY LENS (SM)		30	14-12-14
	70		MEDIUM BROWNISH GREEN CALCAREOUS CLAY WITH SLIGHT SAND AND SHELL CONTENT. (MH) LOCALLY CALLED MARL			

CONTRACT NO. DACW60-92-M-0135

DRILLING LOG (Cont. Sheet)	ELEVATION TOP OF HOLE	Hole No. FS-9-92
PROJECT	INSTALLATION	SHEET 3 OF 3 SHEETS

a ELEVATION	b DEPTH	c LEGEND	d CLASSIFICATION OF MATERIALS (Description)	e % CORE RECOVERY	f BOX OR SAMPLE NO.	g REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	75		STIFF BROWNISH GREEN CALCAREOUS CLAY WITH SLIGHT SAND CONTENT. (MH) LOCALLY CALLED MARL BORING TEMINATED AT 76'6" AS DIRECTED BY MR. DOUG HOLMES		32	4-5-9
	80					



ENG FORM 1836-A (CH)

CONTRACT NO. DACW60-92-M-0135 Hole No. FS-10-92

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION FT. SUMTER NATIONAL MONUMENT	SHEET 1 OF 3 SHEETS

1 PROJECT BATTERY HUGER FOUNDATION INVESTIGATION	10 SIZE AND TYPE OF BIT
2 LOCATION (Coordinates or Station) FORT SUMTER NATIONAL MONUMENT	11. DATUM FOR ELEVATION SHOWN (TBM or MSVD) NONE
3 DRILLING AGENCY SOIL CONSULTANTS, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL
4 HOLE NO (As shown on drawing title and file number) FS-10-92	13. TOTAL NUMBER OF OVERBURDEN SAMPLES TAKEN: DISTURBED 13 / UNDISTURBED
5 NAME OF DRILLER FRANK EATON	14 TOTAL NUMBER OF CORE BOXES NONE
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED _____ DEG FROM VERTICAL	15 ELEVATION GROUND WATER 3' - 8"
7. THICKNESS OF OVERBURDEN	16 DATE HOLE STARTED 3/30/92 COMPLETED 3/30/92
8 DEPTH DRILLED INTO ROCK	17 ELEVATION TOP OF HOLE 0' - 0" ASSUMED
9 TOTAL DEPTH OF HOLE 77'	18 TOTAL CORE RECOVERY FOR BORING %
	19 SIGNATURE OF INSPECTOR

a ELEVATION	b DEPTH	c LEGEND	d CLASSIFICATION OF MATERIALS (Description)	e % CORE RECOVERY	f BOX OR SAMPLE NO	g REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	0					AUGER BORING 0'0" TO 10'0"
	5		BROWN FINE SAND WITH BRICK FRAGMENT LOOSE GRAY FINE SAND WITH ONE SMALL ORGANIC CLAY LENS. (SM)			
	10				1	1-2-6
	15				2	5-13-21
			DENSE GRAY FINE SAND WITH VERY SLIGHT SAND & ORGANIC ORDR. (SM)			
	20		DENSE GRAY FINE SAND WITH SLIGHT SAND CONTENT. (SM)		3	8-15-31
	25		MEDIUM GRAY FINE SAND WITH MEDIUM SHELL CONTENT (SM WITH SHELL)		4	9-11-6
			MEDIUM GRAY FINE SAND WITH SLIGHT SHELL & VERY SLIGHT SMALL ORGANIC CLAY LENS. (SM)		5	6-11-12
	30		Continued on Sheet 2			BLOWS PER FOOT Number required to drive 1-3/8" ID splitspoon 12" with 140 lb. hammer falling 30".

Note Soils visually classified in accordance with Unified Soil Classification System.

FORM 1836 (CH)

CONTRACT NO. DACW60-92-M-0135

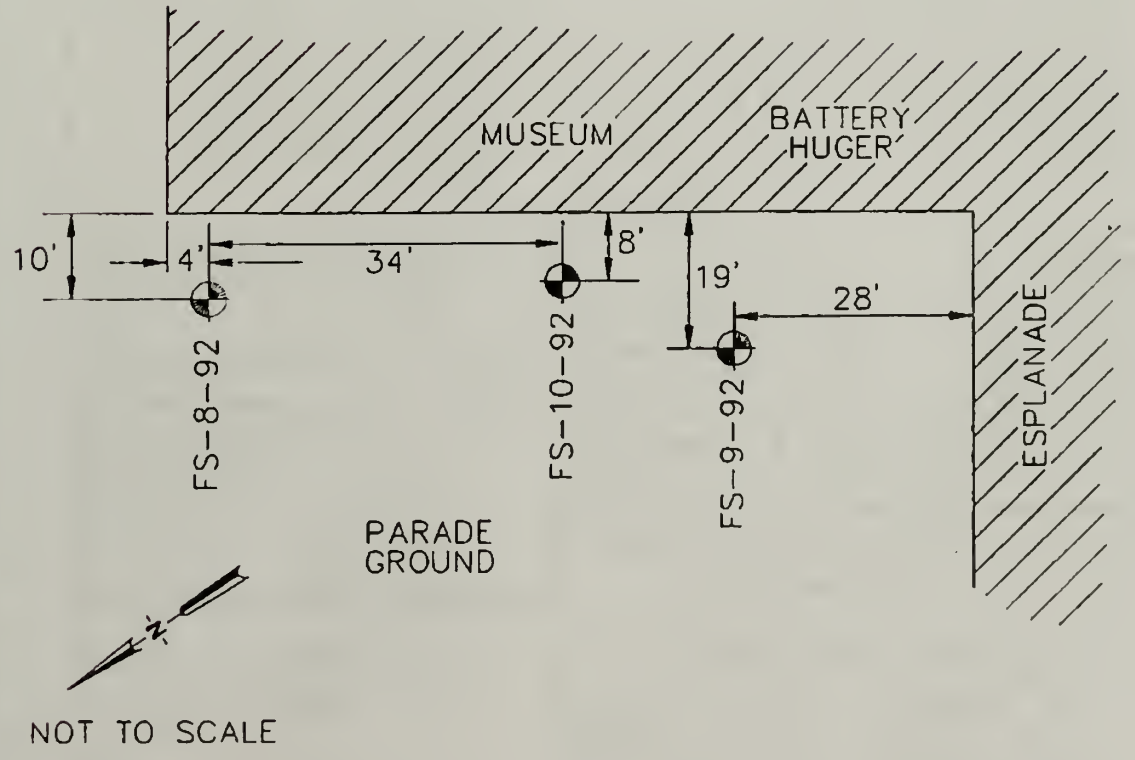
DRILLING LOG (Cont. Sheet)	ELEVATION TOP OF HOLE 0' - 0" ASSUMED	Hole No. FS-10-92
PROJECT BATTERY HUGER FOUNDATION INVESTIGATION	INSTALLATION FT. SUMTER NATIONAL MONUMENT	SHEET 2 OF 3 SHEETS

a ELEVATION	b DEPTH	c LEGEND	d CLASSIFICATION OF MATERIALS (Description)	e % CORE RECOVERY	f BOX OR SAMPLE NO.	g REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	30				6	
	35		LOOSE GRAY FINE SAND WITH HIGH 1/8" ORGANIC CLAY LENS AND SOME 1" ORGANIC CLAY LENS.			
			SHELBY TUBE 3" X 30" PUSHED - 24" RECOVERY - 19"		6A	PUSHED
	40		LOOSE GRAY FINE SAND WITH HIGH SAMLL ORGANIC CLAY LENS. (SM)		7	3-3-3
	45		MEDIUM GRAY FINE SAND WITH SLIGHT SHELL, HIGH SMALL 1/8" TO 1/4" ORGANIC CLAY LENS AND ONE SMALL PIECE OF DECAYED WOOD CONTENT. (SM)		8	2-6-7
	50		VERY LOOSE GRAY FINE SAND WITH HIGH SMALL 1/8" ORGANIC CLAY LENS (SM)		9	1/11" - 1/1" - 2/6"
	55		MEDIUM GRAY FINE SAND WITH VERY SLIGHT SMALL 1/8" ORGANIC CLAY LENS. (SM)		10	4-8-12
	60		MEDIUM GRAY FINE SAND WITH SLIGHT SHELL AND VERY SLIGHT SMALL 1/8" ORGANIC CLAY LENS (SM)		11	12-14-11
			SHELBY TUBE 3" X 30" PUSHED - 24" RECOVERED - 24"		11A	PUSHED
	65		SHELBY TUBE 3" X 30" PUSHED - 24" RECOVERED - 22"		11B	PUSHED
			SHELBY TUBE 3" X 30" PUSHED - 24" RECOVERED - 24"		11C	PUSHED
	70		MEDIUM GRAY FINE SAND WITH HIGH SMALL 1/8" ORGANIC CLAY LENS (SM)		12	3-5-9
			SHELBY TUBE 3" X 30" PUSHED - 24" RECOVERED - 24" (CALCAREOUS CLAY)		13	PUSHED

ENG FORM 1836-A (CH)

CONTRACT NO. DACW60-92-M-0135

DRILLING LOG (Conl. Sheet)	ELEVATION TOP OF HOLE 0' - 0" ASSUMED	Hole No. FS-10-92
PROJECT BATTERY HUGER FOUNDATION INVESTIGATION	INSTALLATION FT. SUMTER NATIONAL MONUMENT	SHEET 3 OF 3 SHEETS

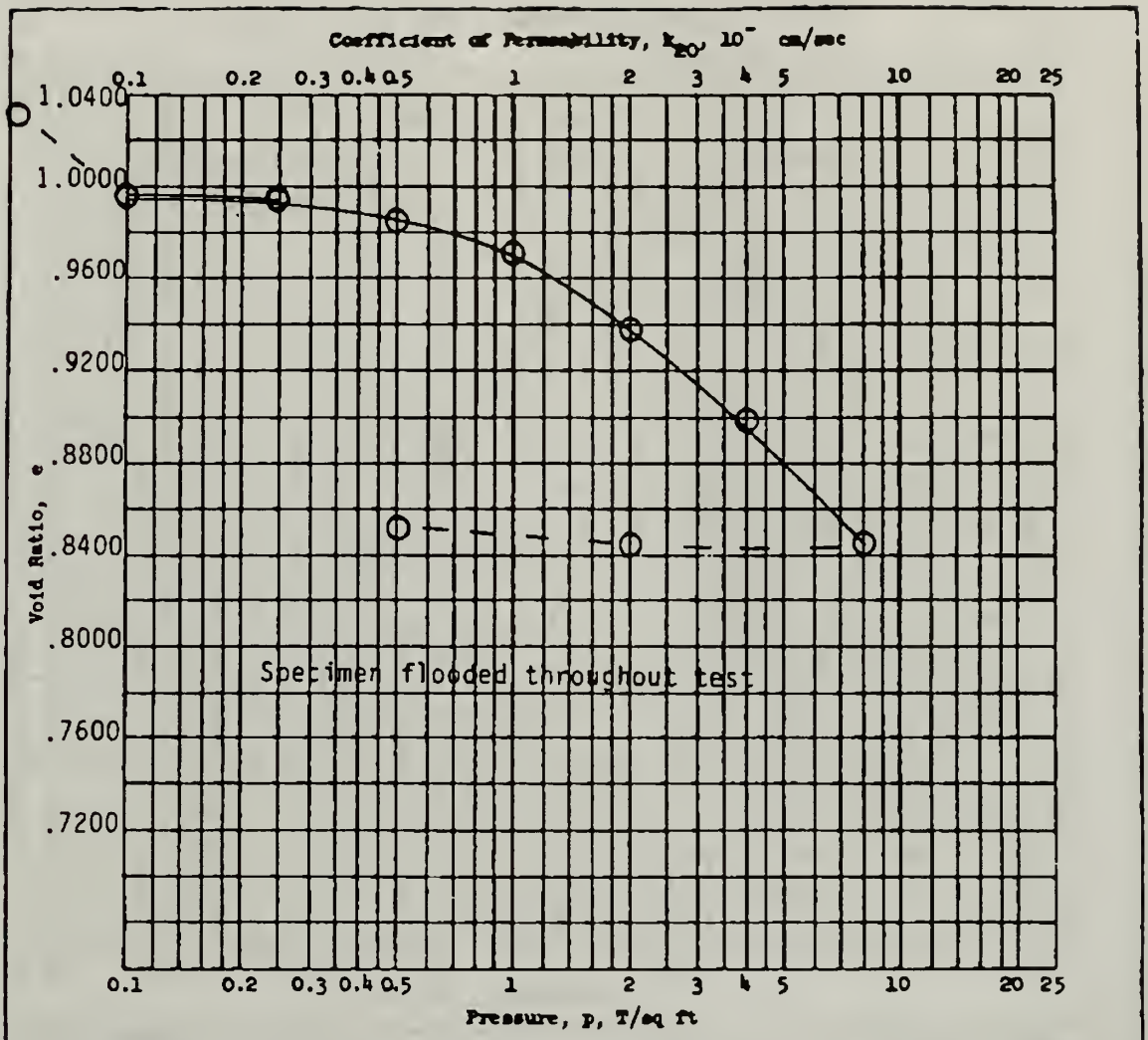


LABORATORY TEST RESULTS

CONSOLIDATION TESTS

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 6636
REQ. NO. SACRM-92-84

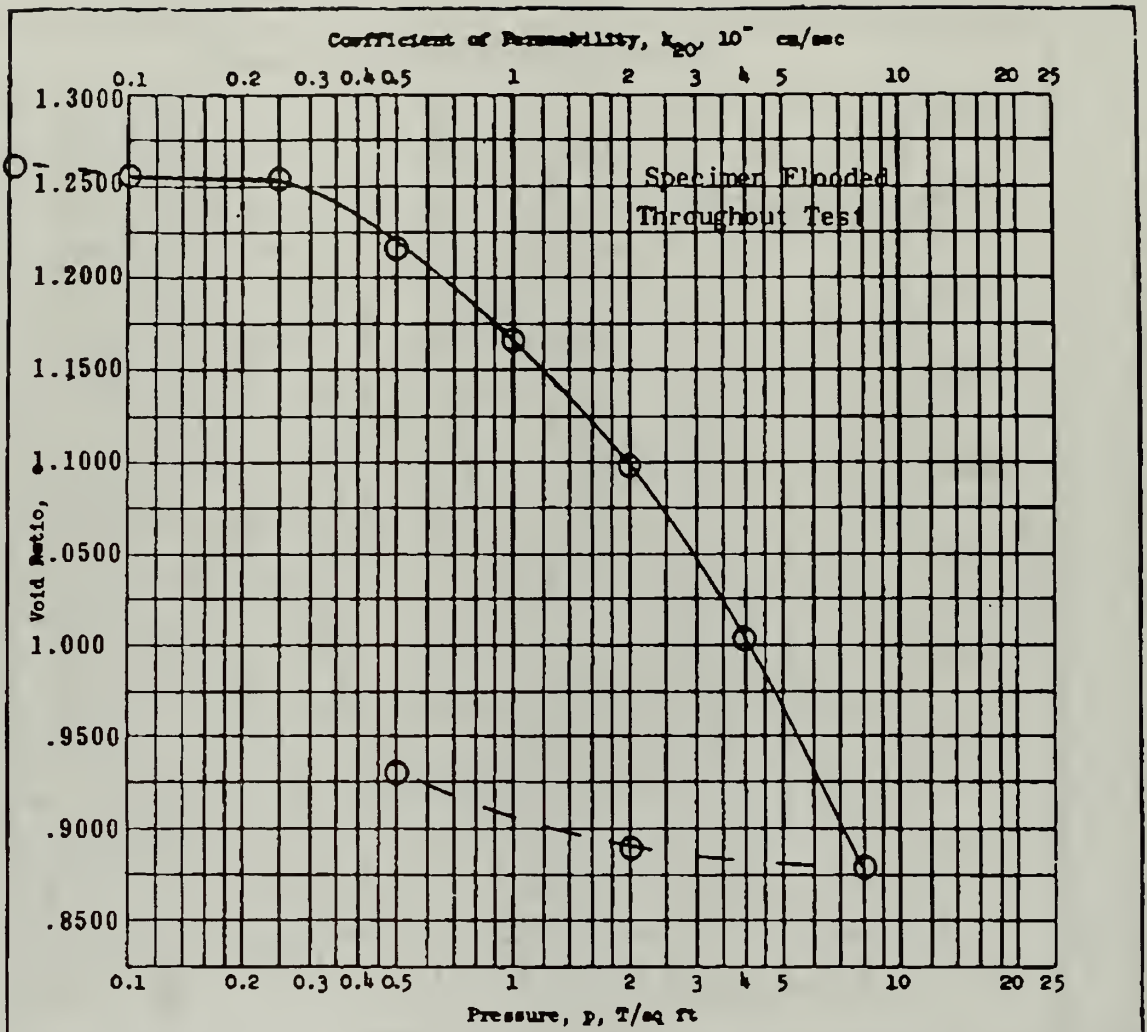


Type of Specimen undisturbed		Before Test		After Test	
Diam 2.49 in.	Ht 1.00 in.	Water Content, w_o	38.3 %	w_f	31.7 %
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o	1.031	e_f	.851
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	100.0 %	S_f	100.0 %
Compression Index, C_c		Dry Density, γ_d	82.7 lb/ft^3		
Classification		k_{20} at e_o =	x 10^{-} cm/sec		
LL 29	G_s 2.69	Project Ft. Sumter National Monument			
PL 22	D_{10} .0057mm	Lab No. 96/635			
Remarks See gradation curve on ENG Form 2087.		Area Battery Huger Investigation			
		Boring No. FS-10-92	Sample No. 6A		
		Depth 36.5-38.5'	Date 14 May 92		
		CONSOLIDATION TEST REPORT			

ENG FORM 1 MAY 83 2090 PREVIOUS EDITIONS ARE OBSOLETE.

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 6636
REQ. NO. SACRM-92-84



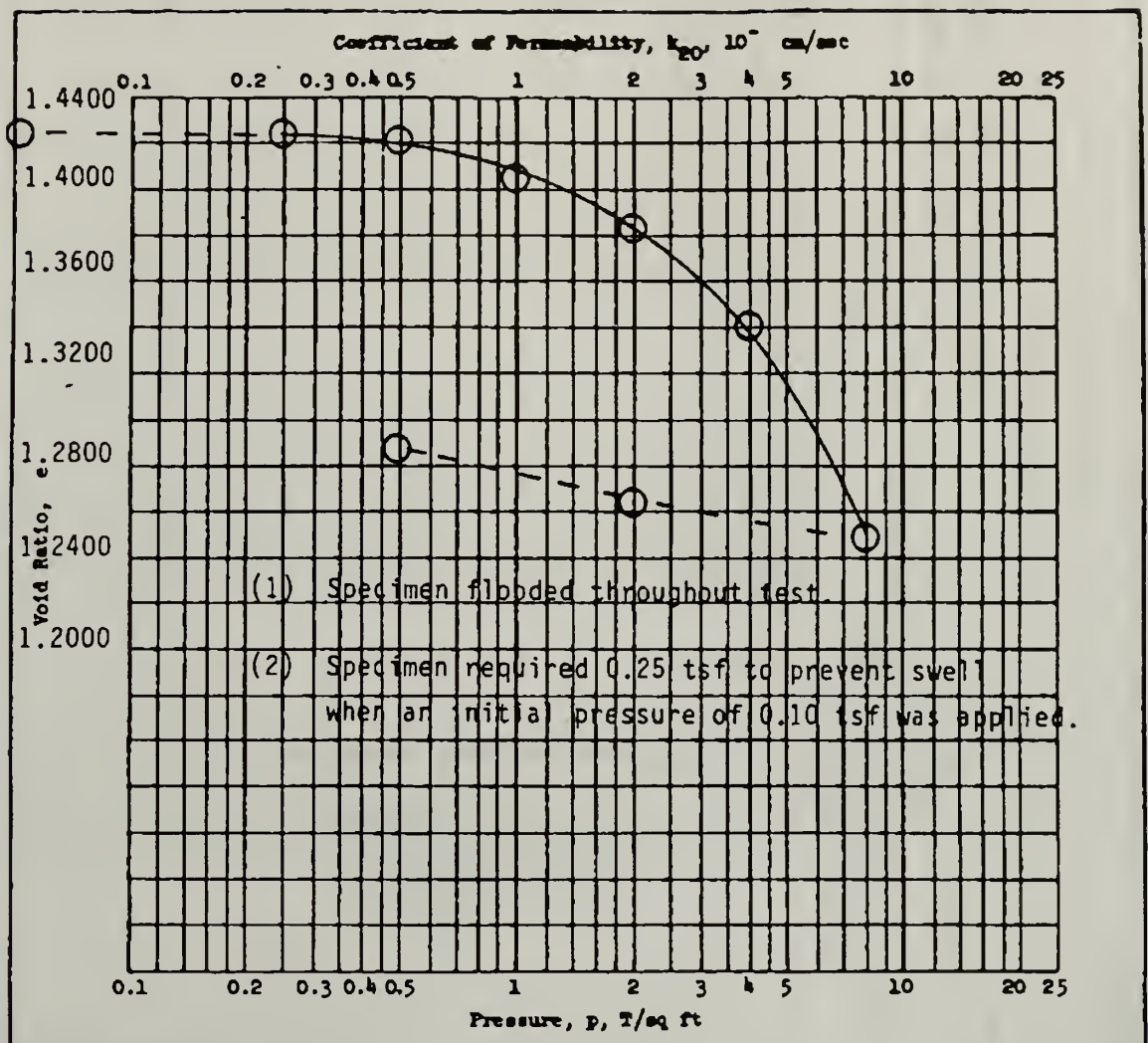
Type of Specimen: Undisturbed		Before Test		After Test	
Diam 2.50 in.	Ht 1.00 in.	Water Content, w_o	45.8 %	w_f	34.4 %
Overburden Pressure, Po T/sq ft		Void Ratio, e_o	1.255	e_f	.928
Preconsol. Pressure, Pc T/sq ft		Saturation, S_o	98.5 %	S_f	100.0 %
Compression Index, C_c		Dry Density, γ_d	74.7 lb/ft^3		
Classification: Gray, clayey sand high LL (SC-H)		k_{20} at e_o =	x 10^{-} cm/sec		
LL 55	G_s 2.70	Project: Ft. Sumter National Monument, Charleston, SC			
PL 22	D_{10} <0.002MM	Lab. No. 96/637			
Remarks: See gradation curve on ENG Form 2087.		Area: Battery Huger Investigation			
		Boring No. FS-10-92	Sample No. 11 B		
		Depth Elev. 64.0-66.0'	Date 20 May 1992		

CONSOLIDATION TEST REPORT

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 6636
REQ. NO. SACRM-92-84



Type of Specimen	Undisturbed			Before Test		After Test	
Diam 2.50 in.	Ht 1.00 in.			Water Content, w_o	52.5 %	w_f	47.6 %
Overburden Pressure, p_o			T/sq ft	Void Ratio, e_o	1.422	e_f	1.2895
Preconsol. Pressure, p_c			T/sq ft	Saturation, S_o	100.0 %	S_f	100.0 %
Compression Index, C_c				Dry Density, γ_d	69.9 lb/ft^3		
Classification				k_{20} at e_o =	x 10^{-} cm/sec		
LL 88	G_s 2.71			Project Ft. Sumter National Monument			
PL 37	D_{10} -			Lab. No. 96/639			
Remarks See gradation curve				Area Battery Huger Investigation			
on ENG Form 2087.				Boring No. FS-10-92		Sample No. 13	
				Depth Mix 75.0 77.0'		Date 14 May 92	
				CONSOLIDATION TEST REPORT			

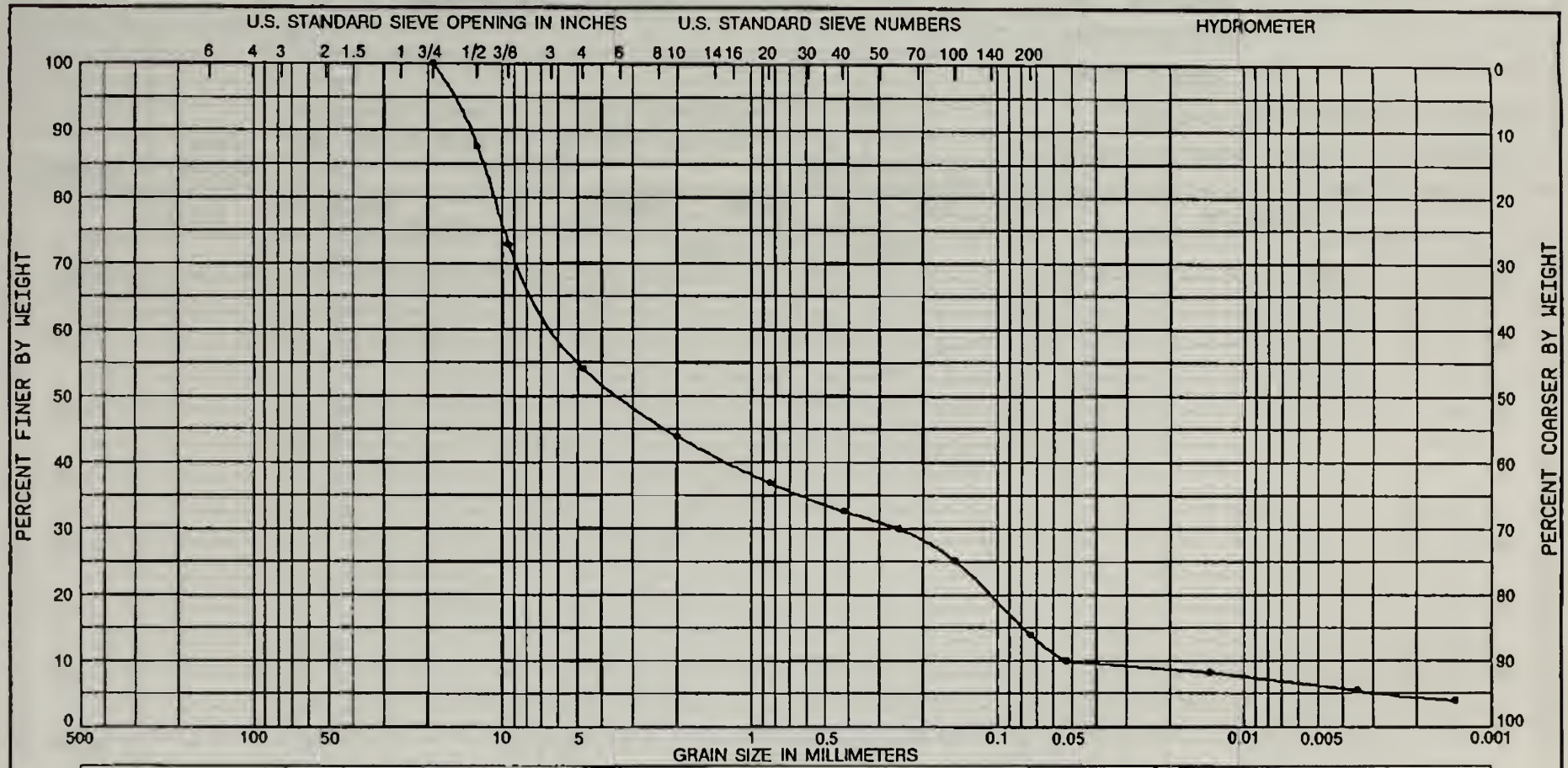
ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.

LABORATORY TEST RESULTS

GRADATION CURVES
ATTERBERG LIMITS
MOISTURE CONTENT
SPECIFIC GRAVITY

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



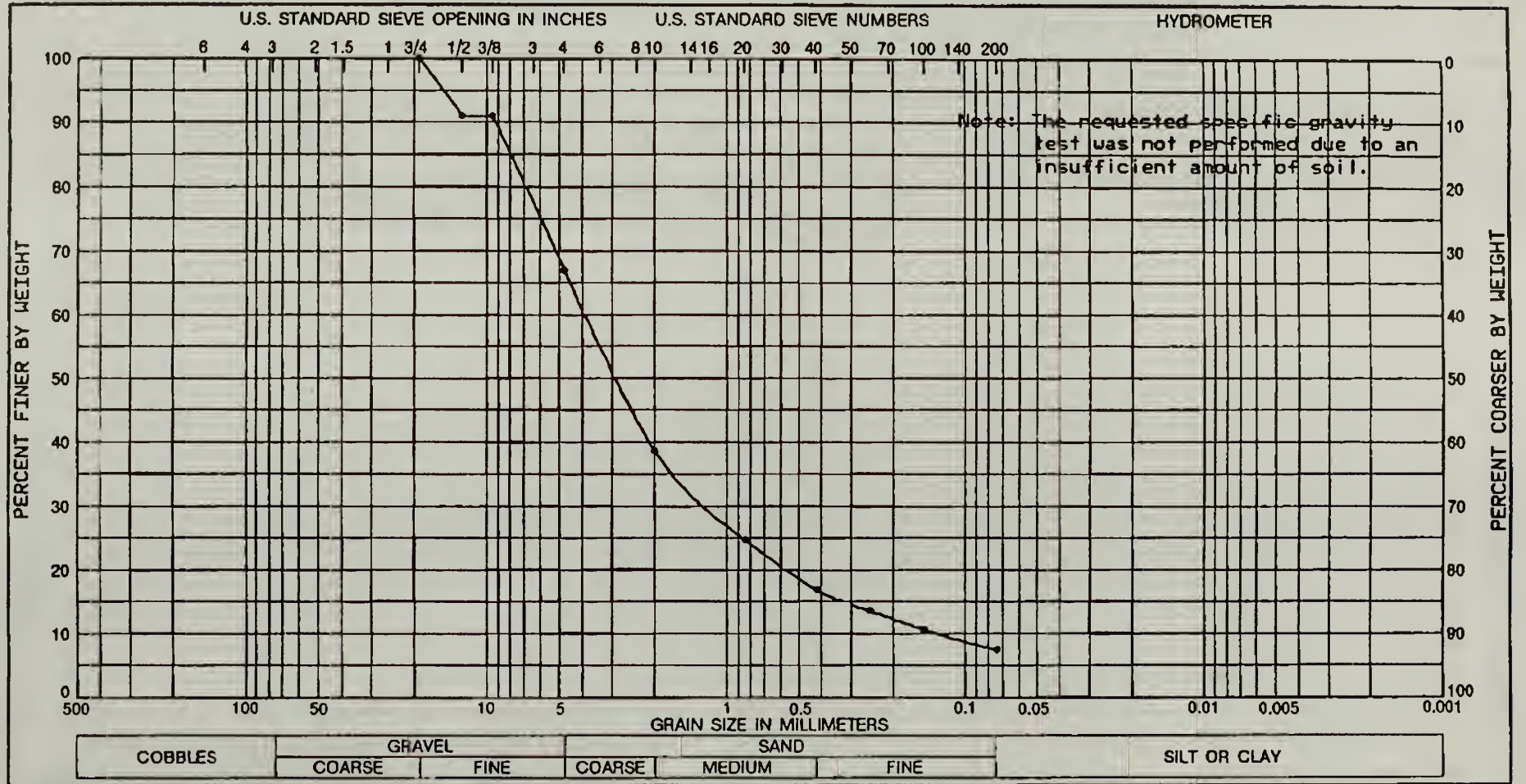
Sample No.	Depth/Elev	Visual Classification	Nat w%	LL	PL	PI
2	5.0-6.5'	Tannish gray silty gravel sizes (GM), sandy, with a trace of mica.	23.4	–	–	–

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3986
Boring No. FS-8-92
Date 07/16/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



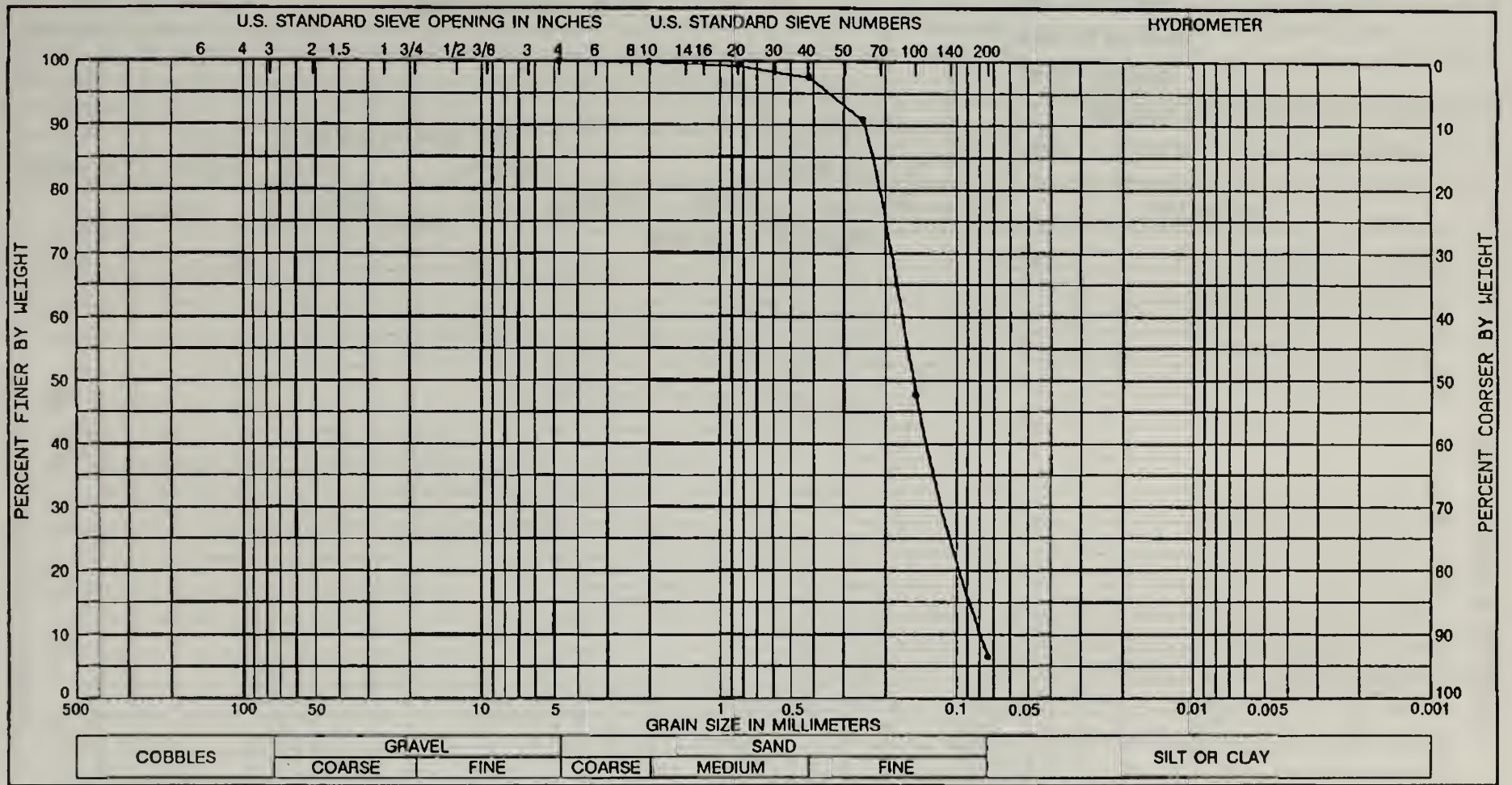
Sample No.	Depth/Elev	Visual Classification	Nat w%	LL	PL	PI
3	6.5-8.0'	Tan poorly graded silty sand (SP-SM), with some gravel size shell fragments.	28.4	-	-	-

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3987
Boring No. FS-8-92
Date 07/16/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



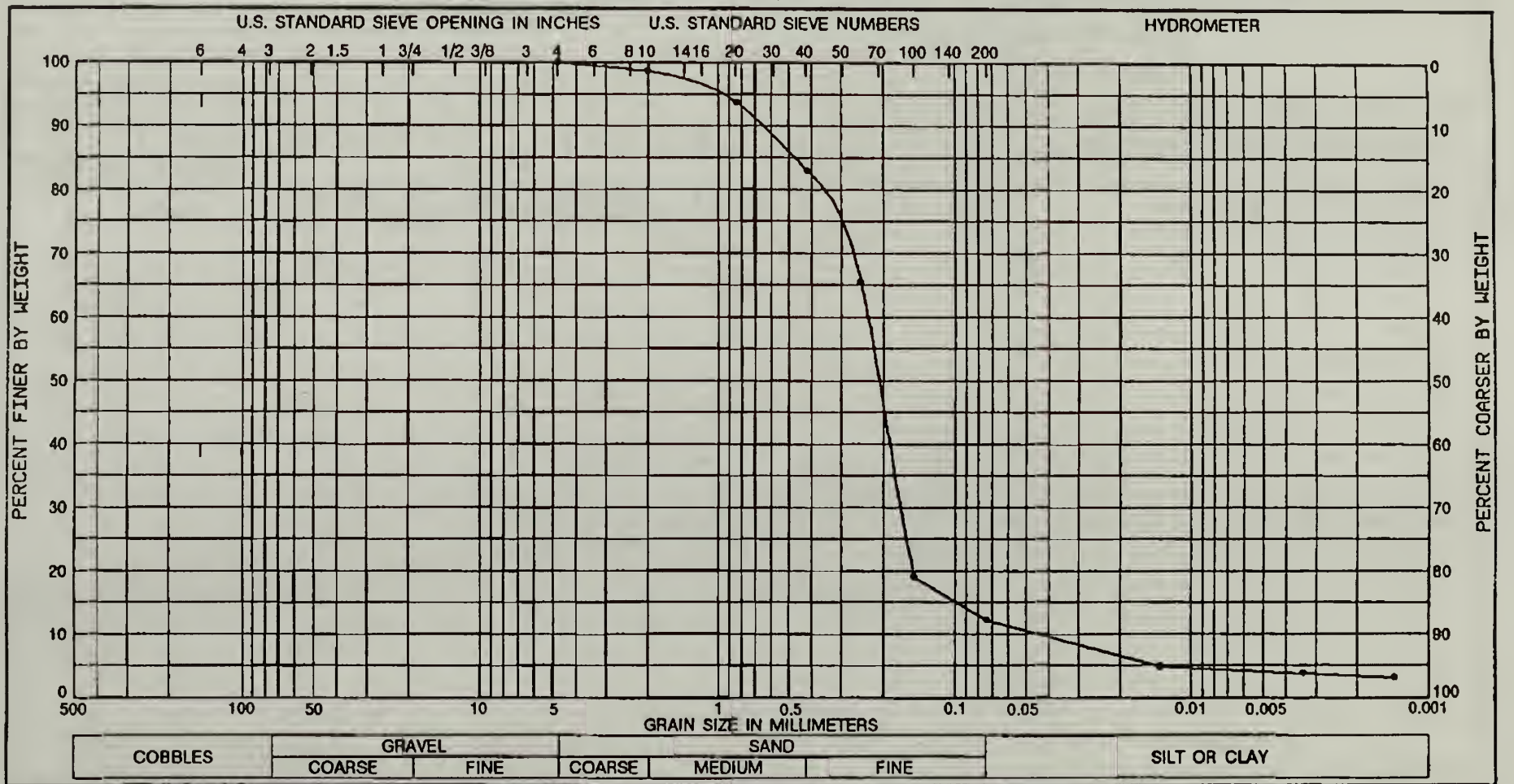
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
4	12.0-13.5'	Gray poorly graded silty sand (SP-SM).	24.0	NP	NP	NP

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3988
Boring No. FS-8-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



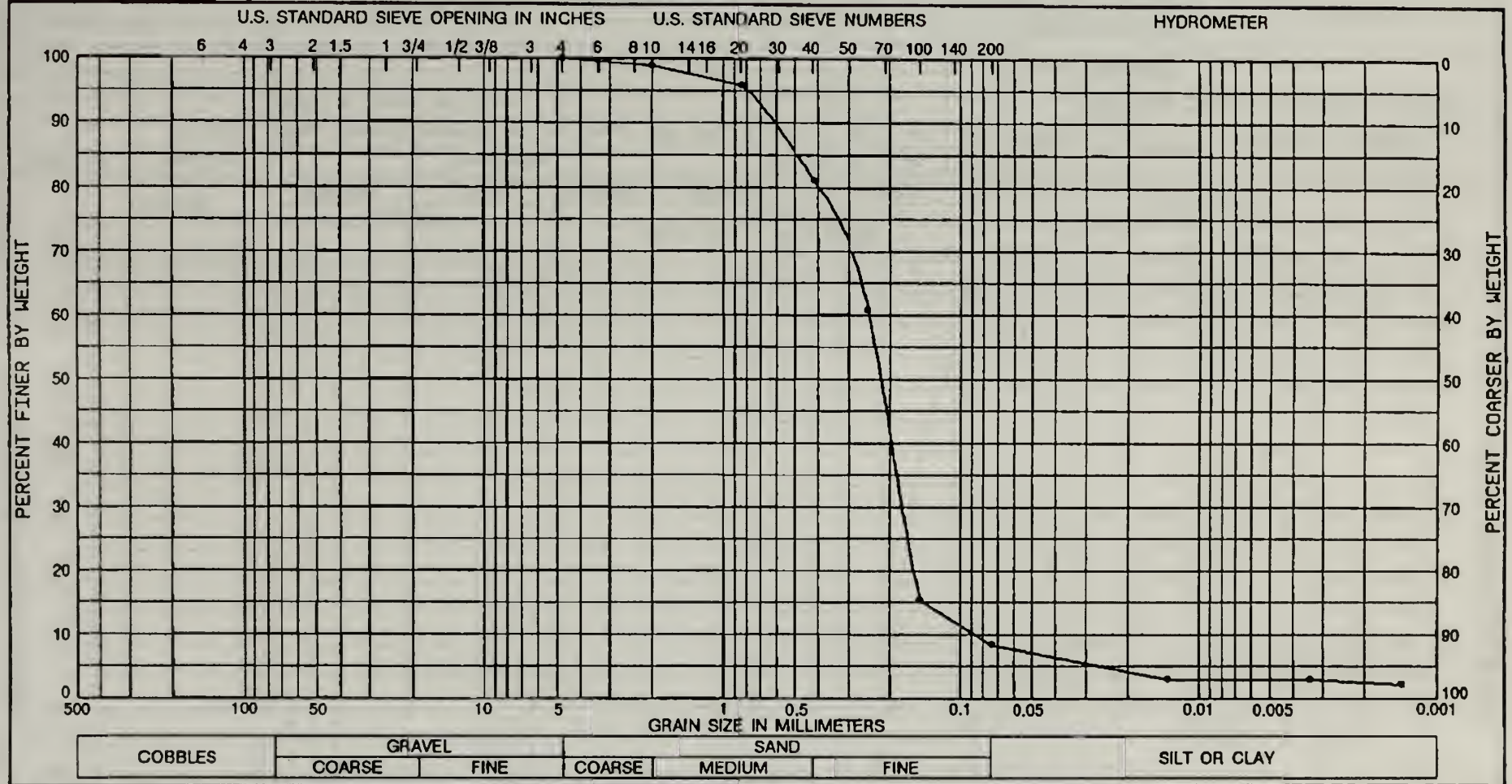
Sample No.	Depth/Elev	Visual Classification	Nat w%	LL	PL	PI
5	13.5-15.0'	Gray silty sand (SM).	15.8	-	-	-

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3989
Boring No. FS-8-92
Date 07/16/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



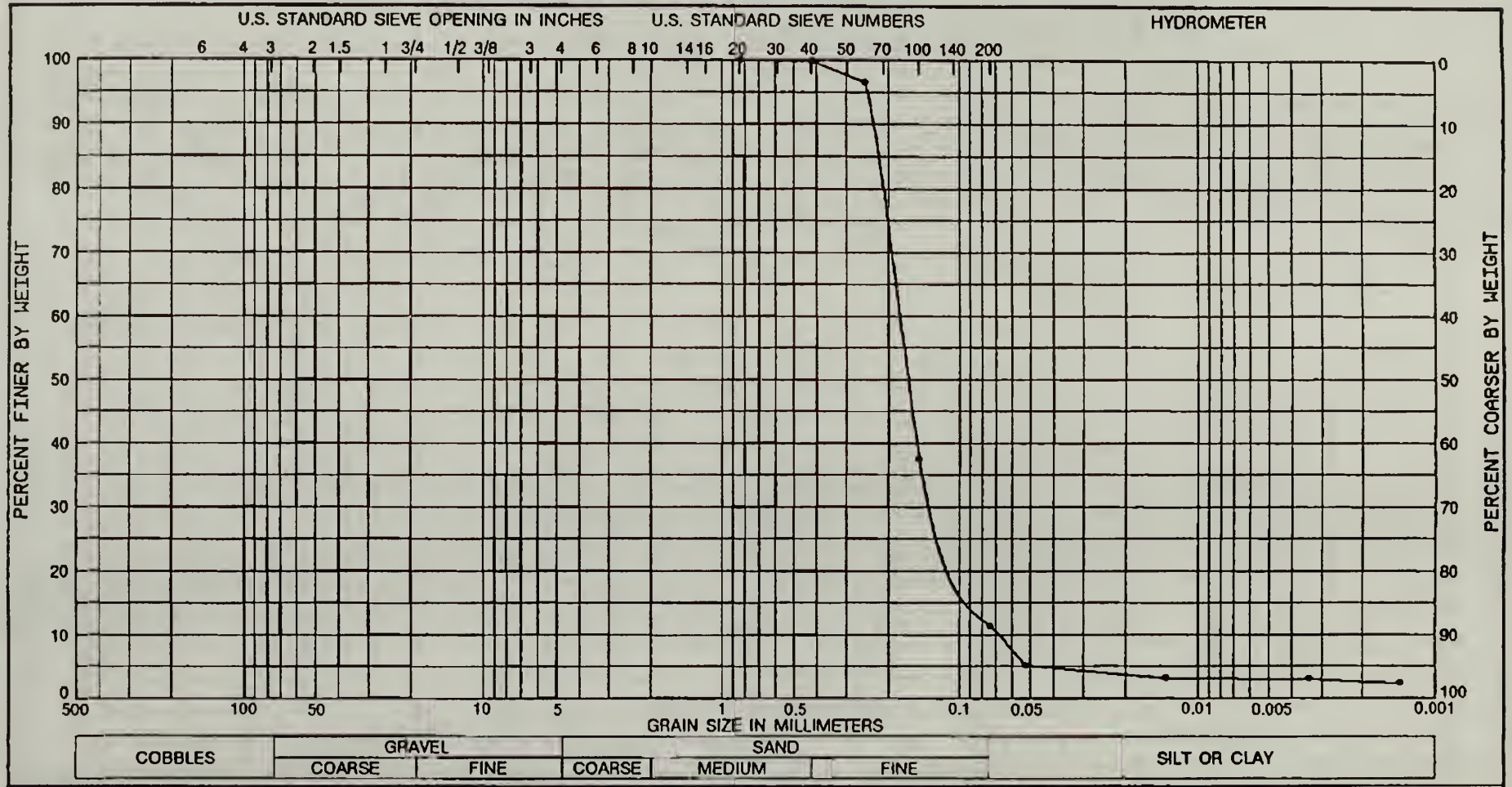
Sample No.	Depth/Elev	Visual Classification	Nat w%	LL	PL	PI
10	21.0-22.5'	Gray poorly graded silty sand (SP-SM).	19.5	--	--	--

GRADATION CURVES

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3991
Boring No. FS-8-92
Date 07/16/92

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



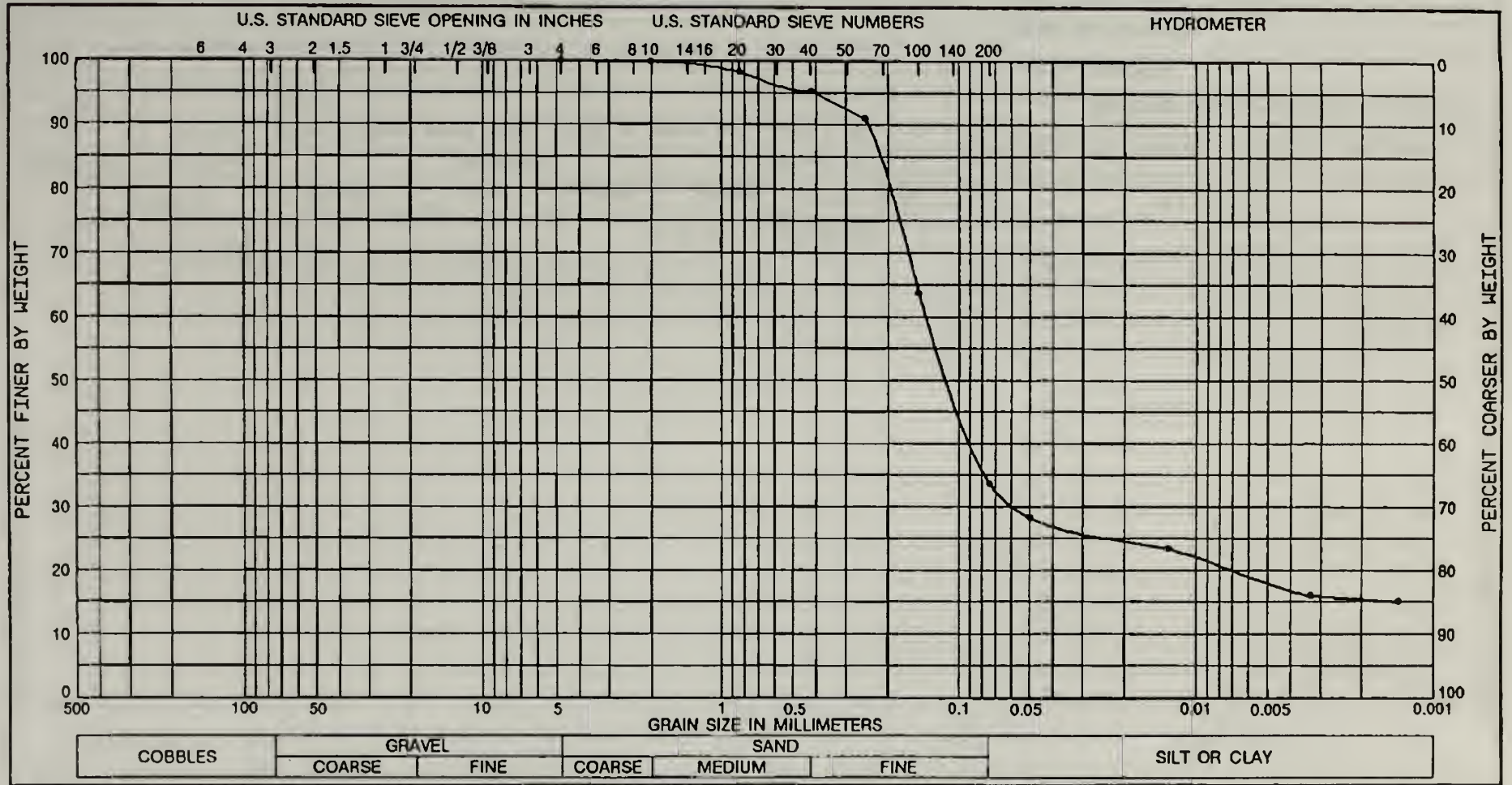
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
15	28.5-30.0'	Gray poorly graded silty sand (SP-SM), with a trace of mica.	23.6	NP	NP	NP

GRADATION CURVES

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3992
Boring No. FS-8-92
Date 07/15/92

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



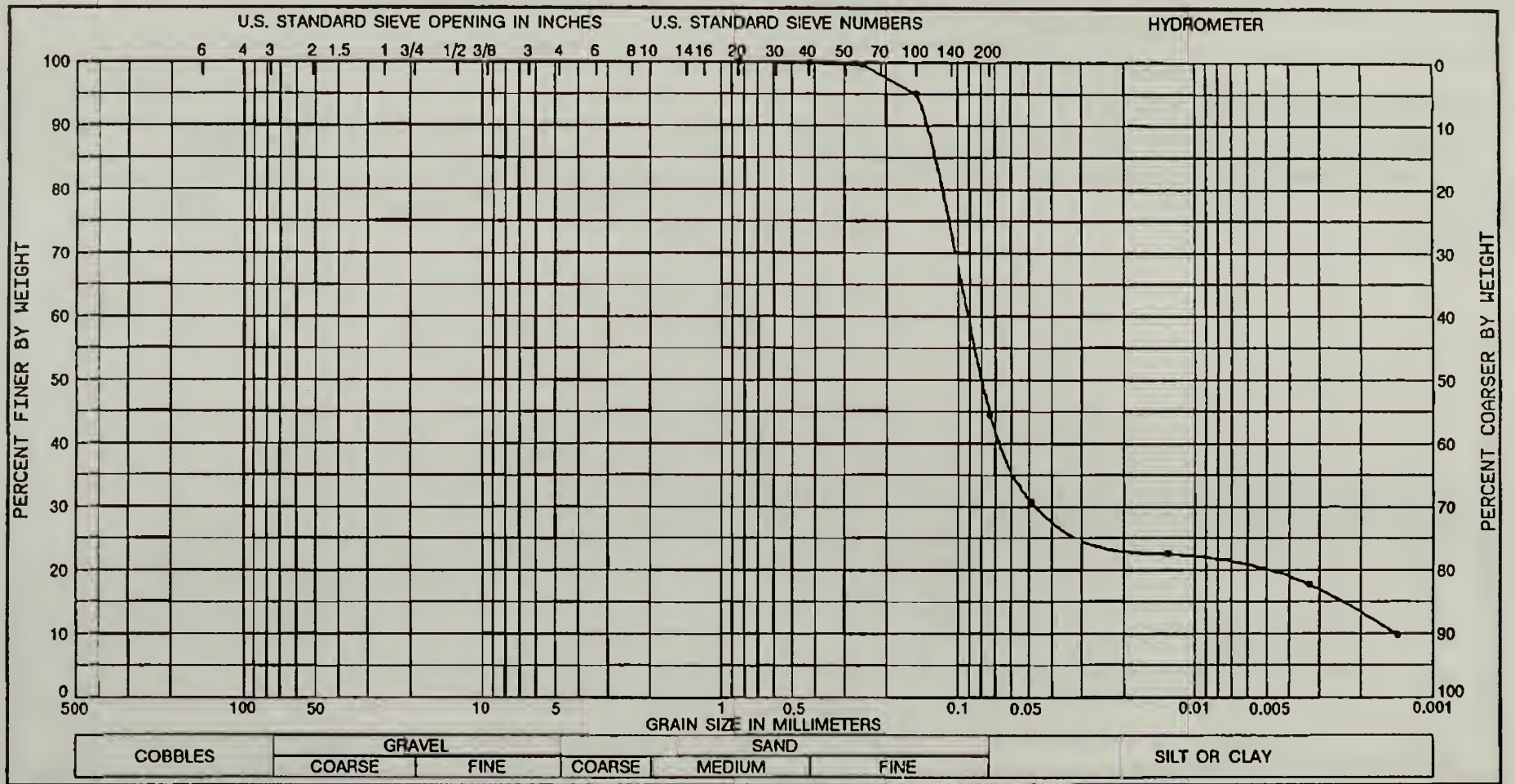
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
18	33.0-34.5'	Gray clayey sand (SC), with a trace of mica.	47.6	47	21	26
		Specific Gravity = 2.67				

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3993
Boring No. FS-8-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
19	34.5-36.0'	Gray clayey sand (SC), with a trace of mica.	42.4	40	20	20

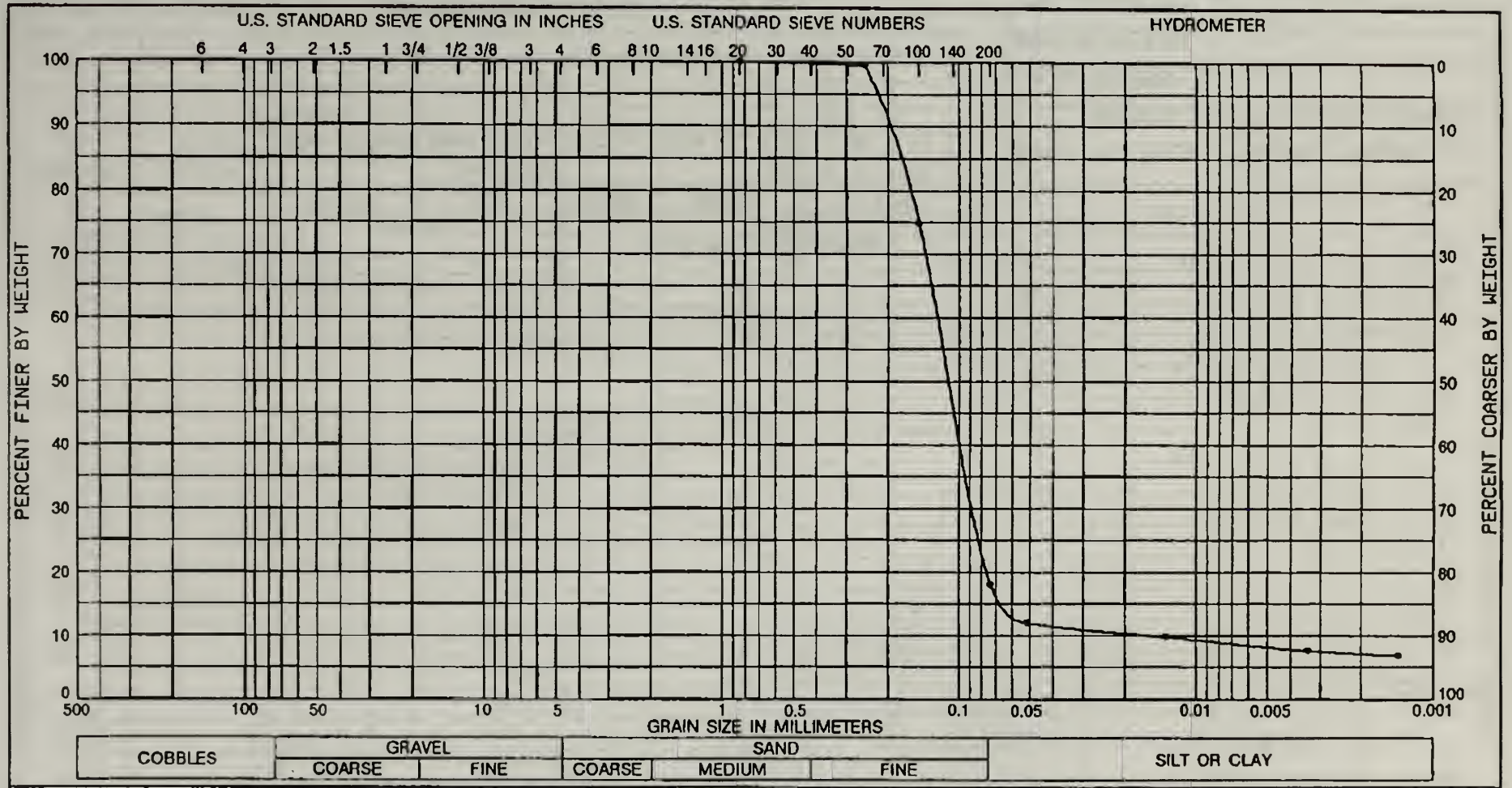
Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3994
Boring No. FS-B-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
WORK ORDER: 6636

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



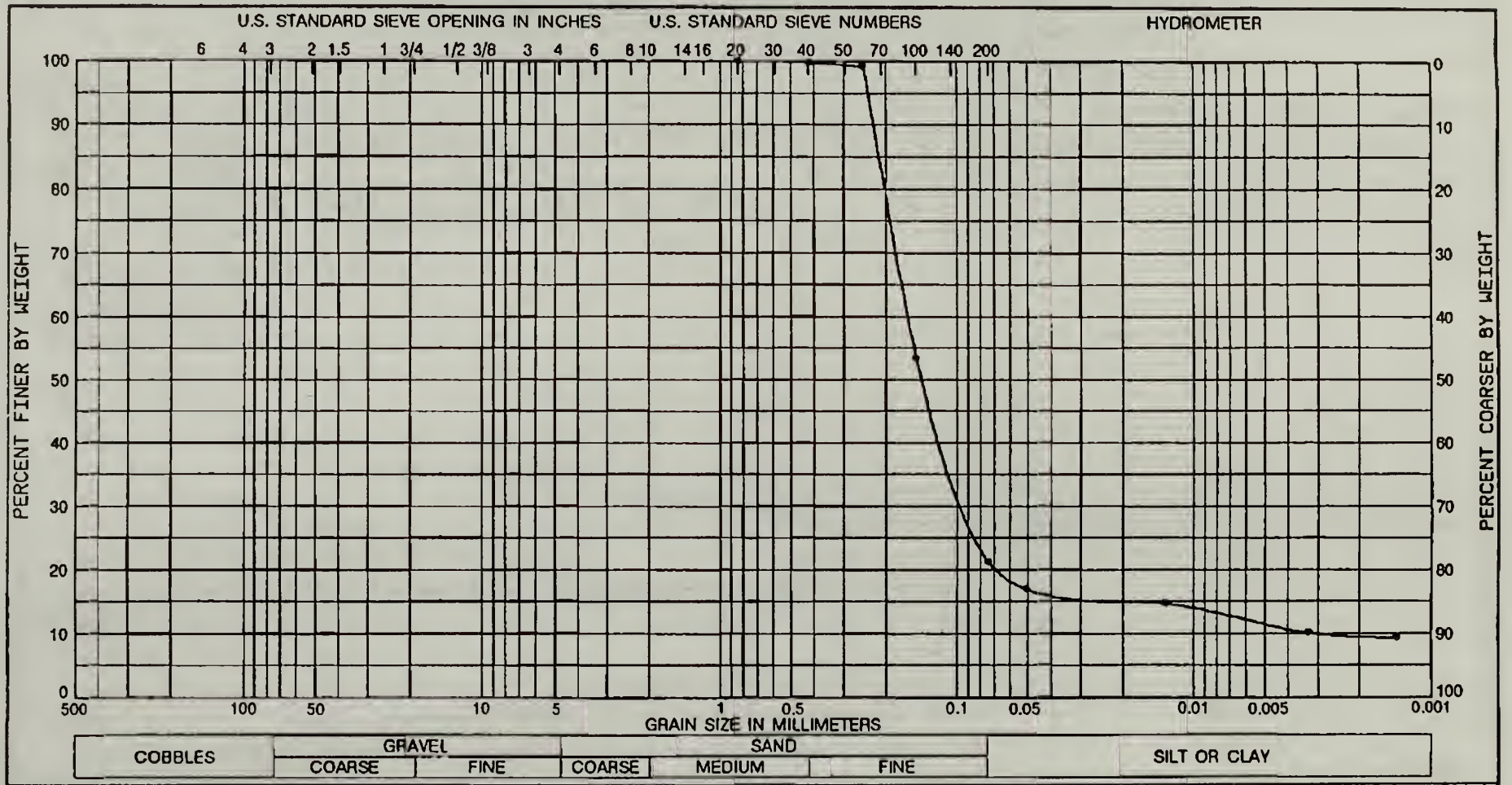
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
21	37.5-39.0'	Gray silty sand (SM), with a trace of mica.	31.4	25	23	2

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3995
Boring No. FS-8-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
25	49.0-50.5'	Gray clayey sand (SC), with a trace of mica.	36.1	30	20	10

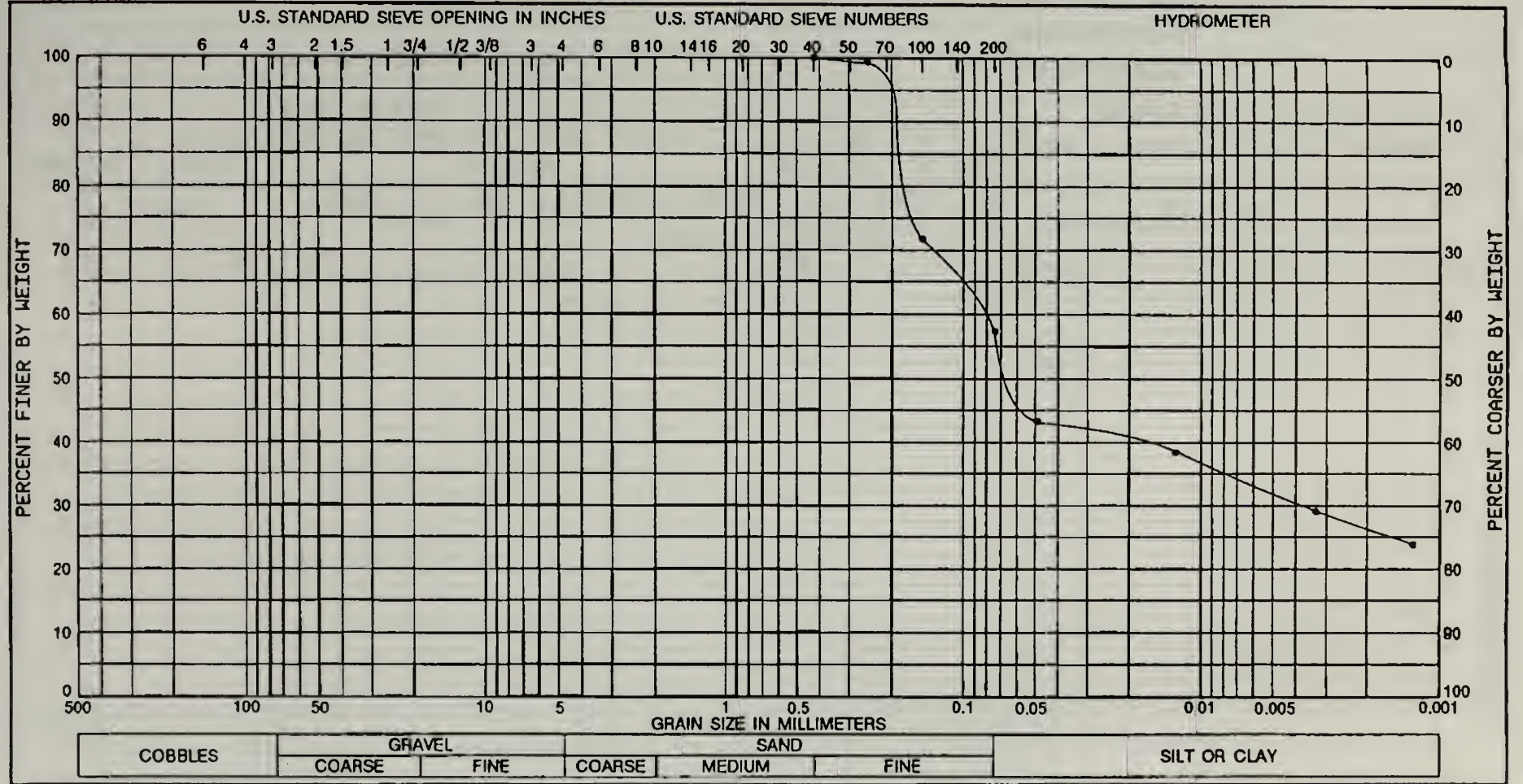
GRADATION CURVES

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3996
Boring No. FS-8-92
Date 07/15/92

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
WORK ORDER: 6636

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



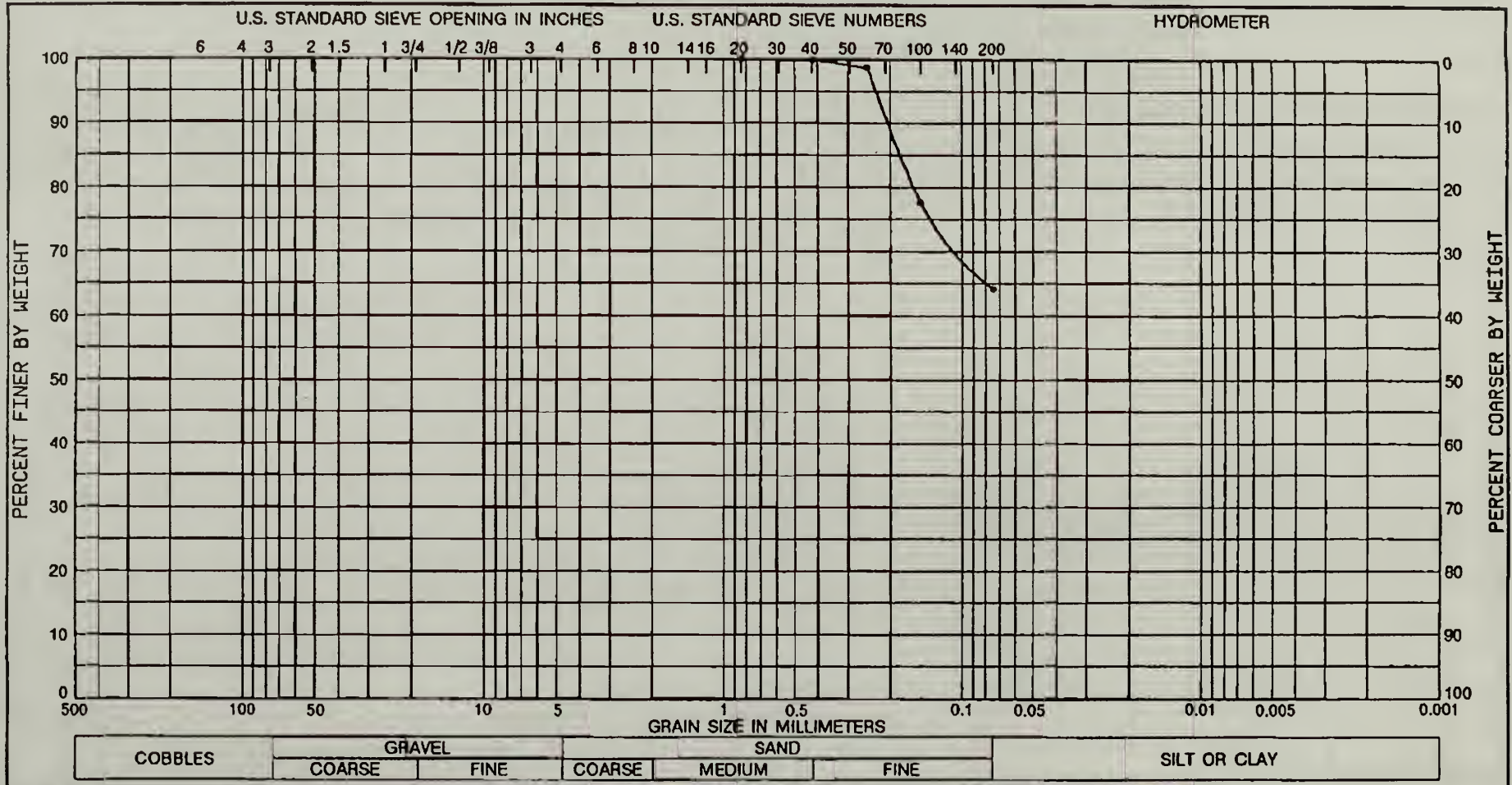
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
27	55.0-56.5'	Gray fat clay (CH), sandy, with a trace of mica.	45.8	68	25	43

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3997
Boring No. FS-8-92
Date 07/16/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
30	64.0-65.5'	Gray fat clay (CH), sandy, with a trace of mica.	3.7	65	25	40
		Specific Gravity = 2.69				

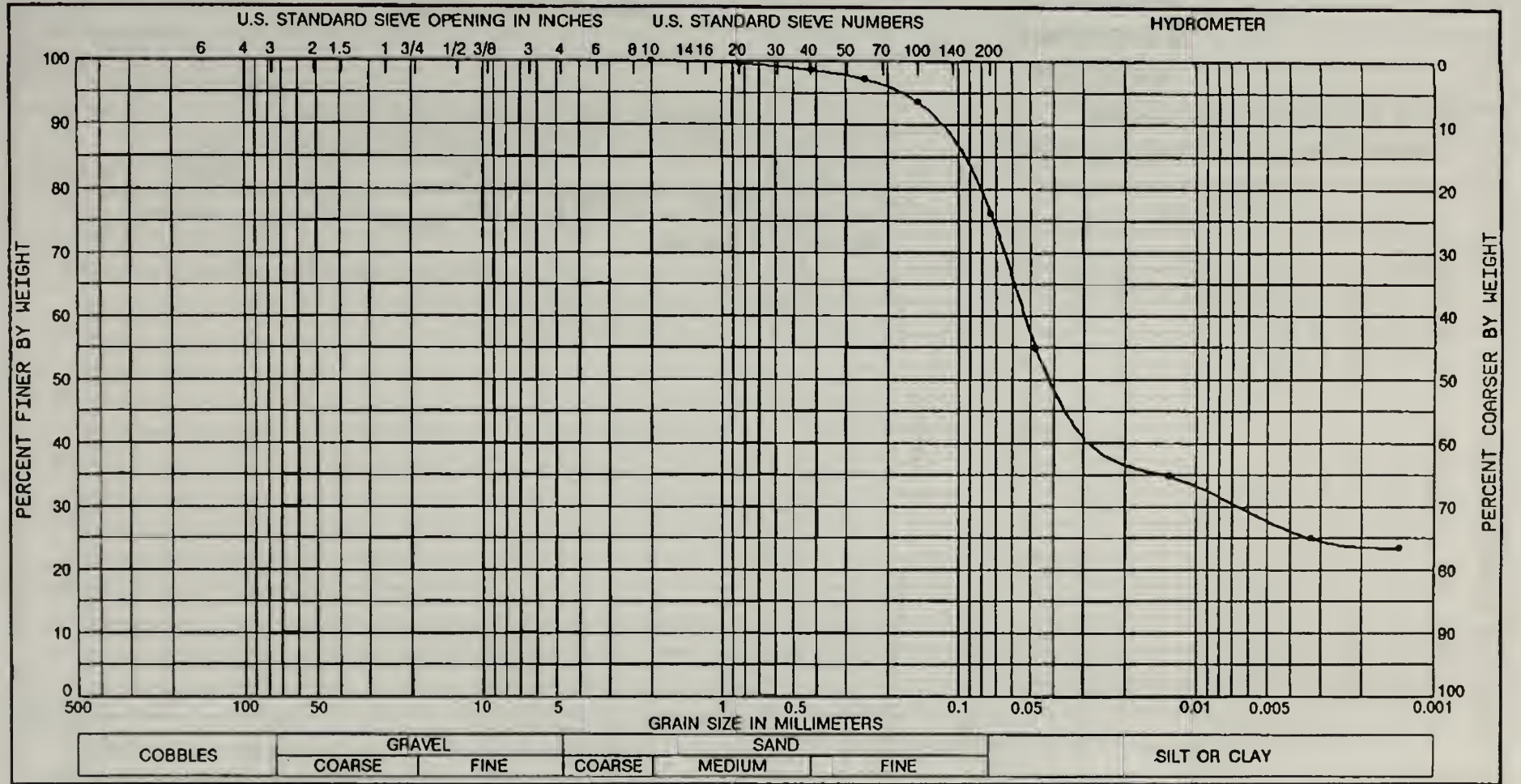
GRADATION CURVES

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/3999
Boring No. FS-8-92
Date 07/15/92

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
WORK ORDER: 6636

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



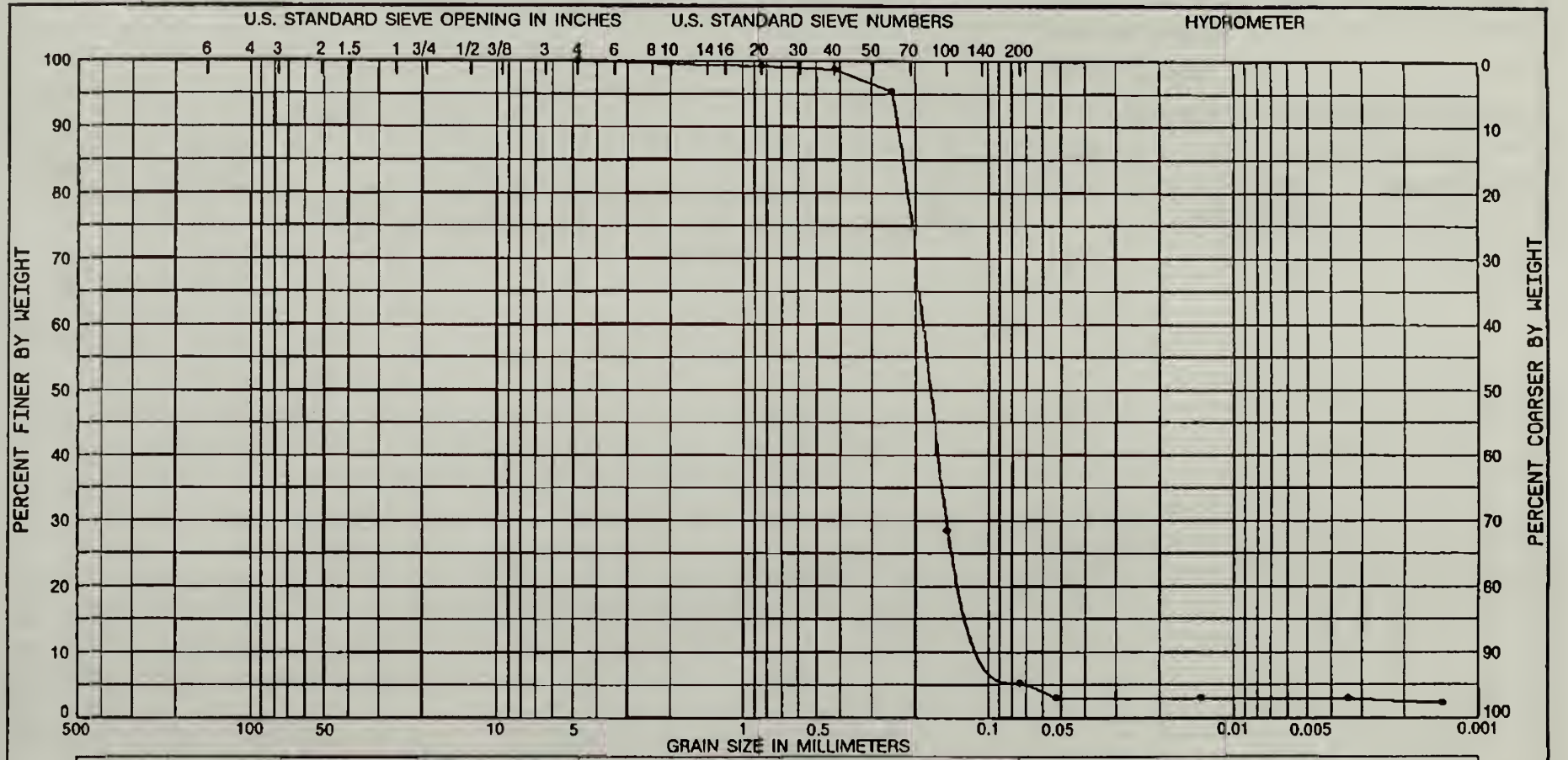
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
33	75.0-76.5'	Gray inorganic silt high LL (MH), clayey, with some sand.	50.7	83	37	46
		Specific Gravity = 2.66				

GRADATION CURVES

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4001
Boring No. FS-B-92
Date 07/16/92

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth/Elev	Visual Classification	Nat w%	LL	PL	PI
1	5.0-6.5'	Tannish gray poorly graded silty sand (SP-SM), with weathered rock fragments.	19.5	--	--	--

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4002
Boring No. FS-9-92
Date 07/15/92

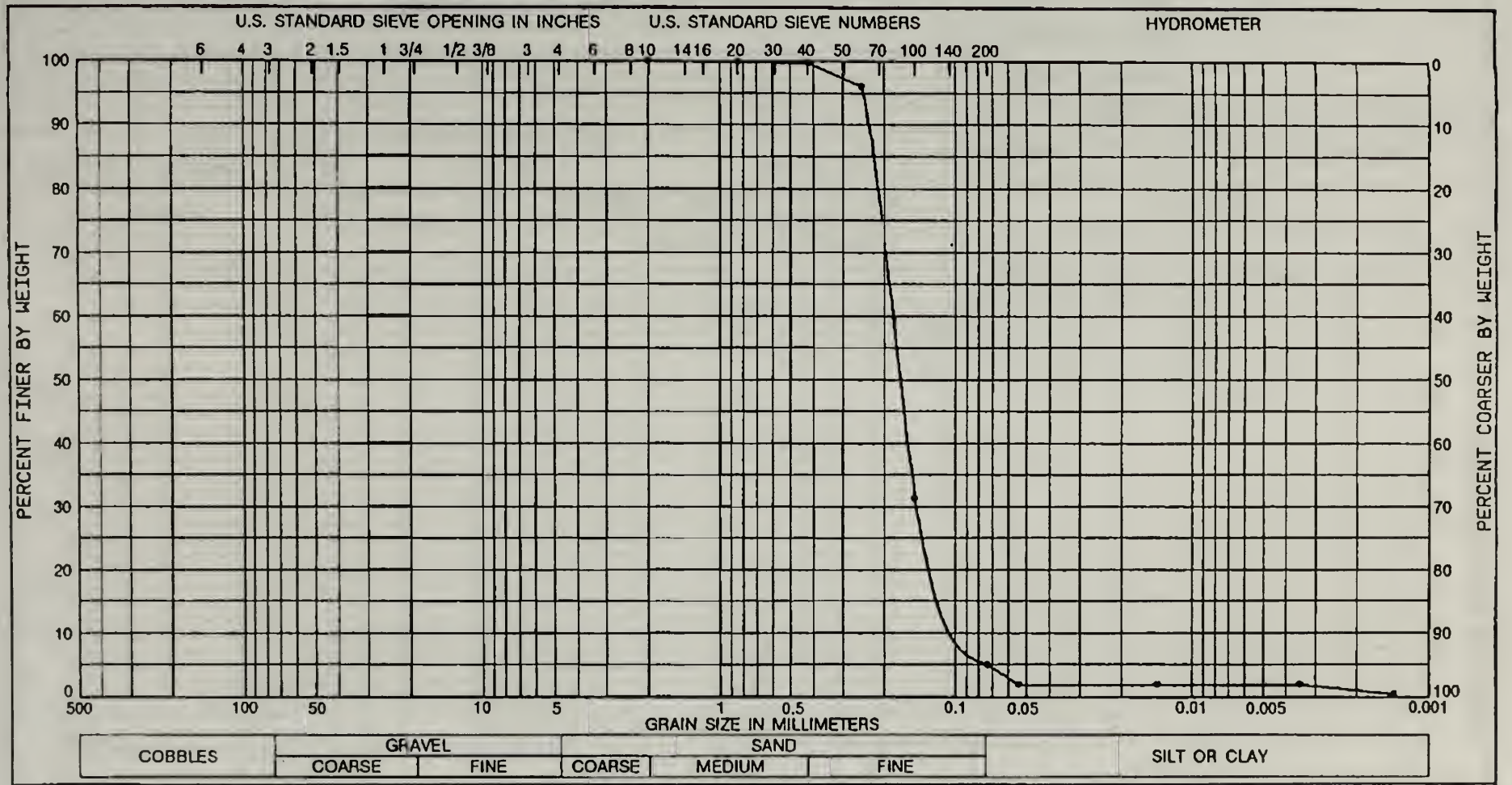
GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



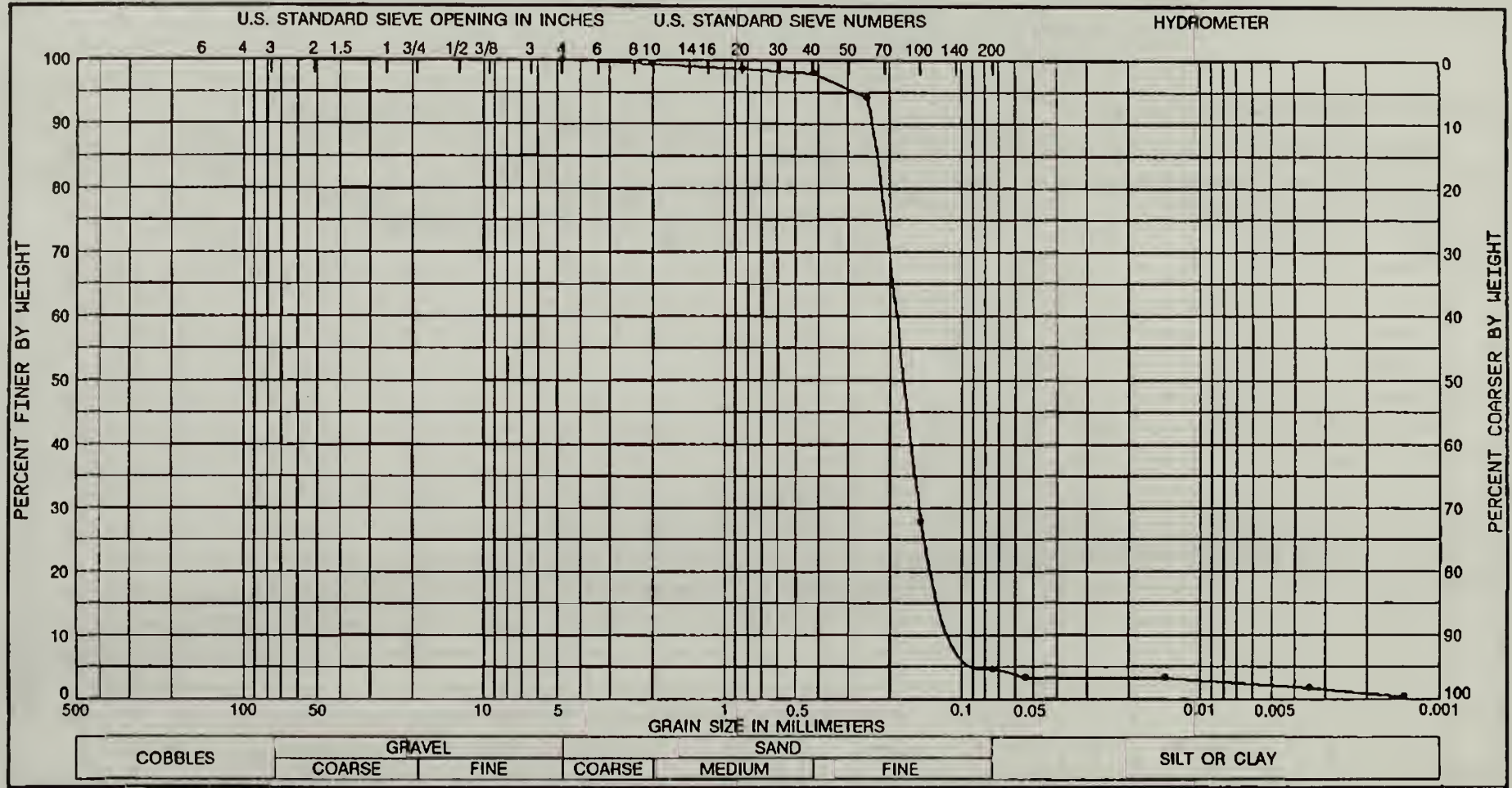
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
2	6.5-8.0'	Gray poorly graded silty sand (SP-SM), with a trace of organic matter.	20.9	NP	NP	NP

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4003
Boring No. FS-9-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



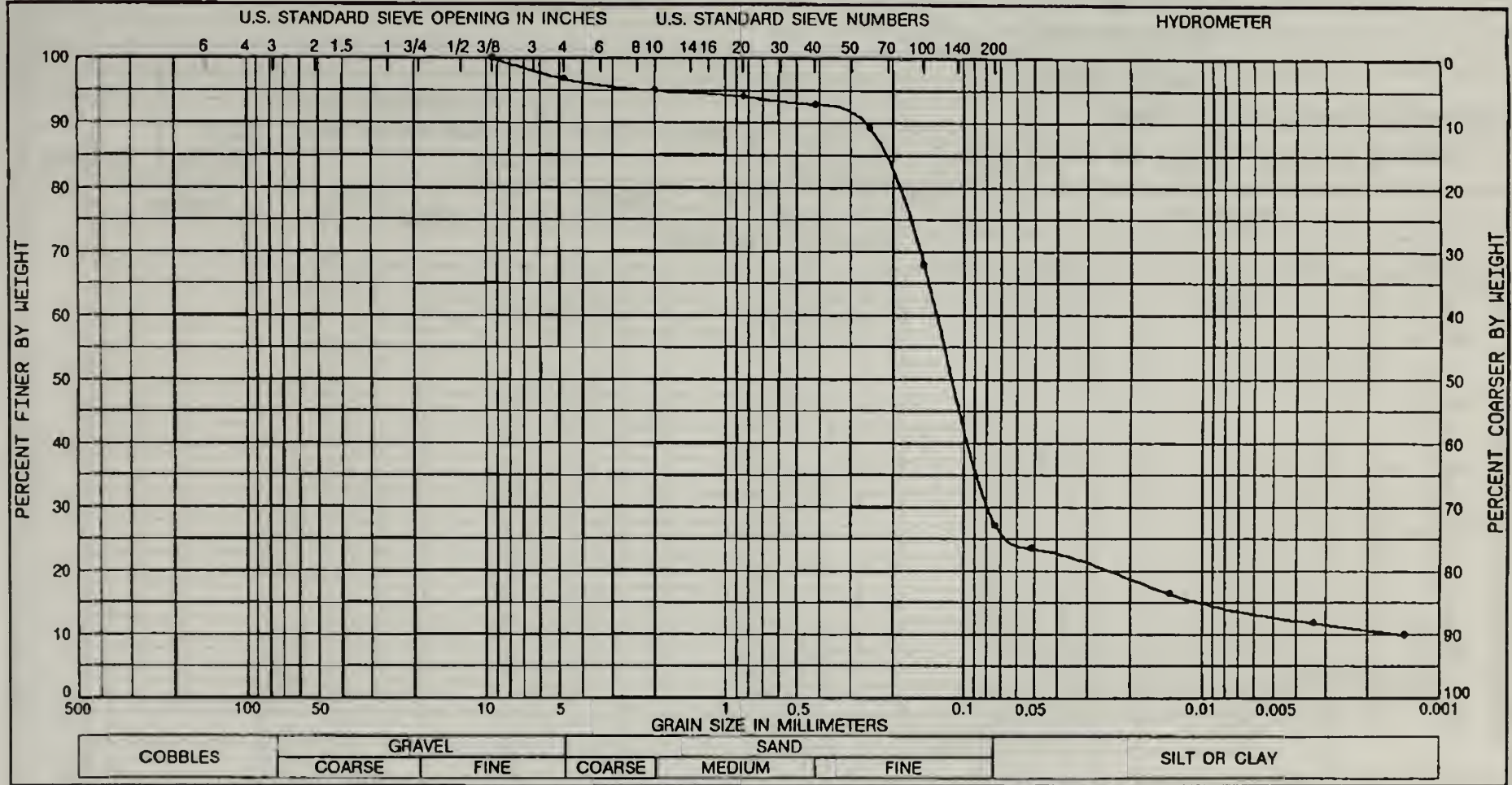
Sample No.	Depth/Elev	Visual Classification	Nat w%	LL	PL	PI
3	8.0-9.3'	Gray poorly graded sand (SP).	1.3	--	--	--

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4004
Boring No. FS-9-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIV. ON LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



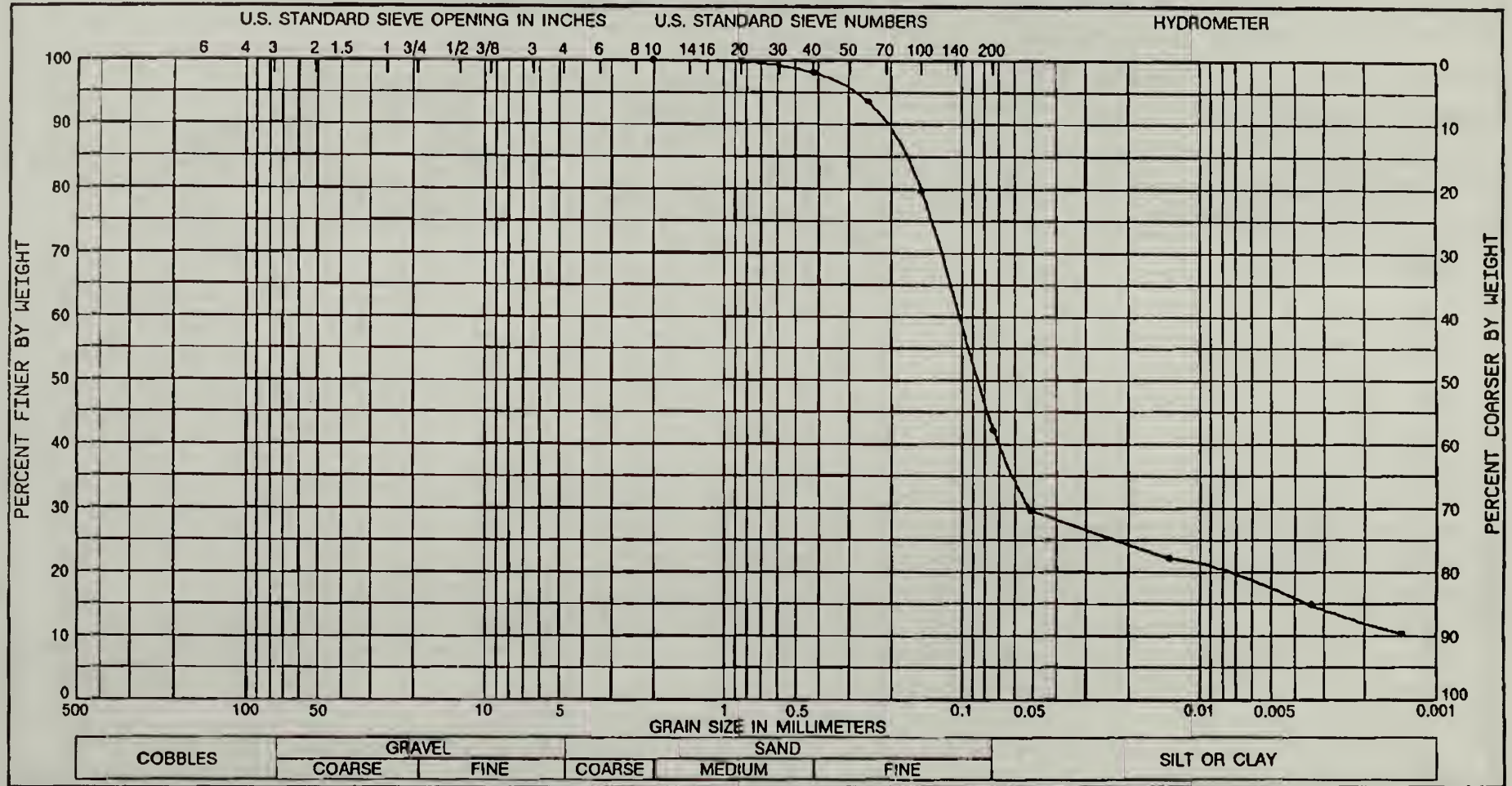
Sample No.	Depth/Elev	Visual Classification	Nat w%	LL	PL	PI
4	13.0-14.5'	Gray clayey sand (SC), with a trace of gravel size weathered rock fragments (calcareous sizes), and with a trace of mica.	42.3	--	--	--

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4005
Boring No. FS-9-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



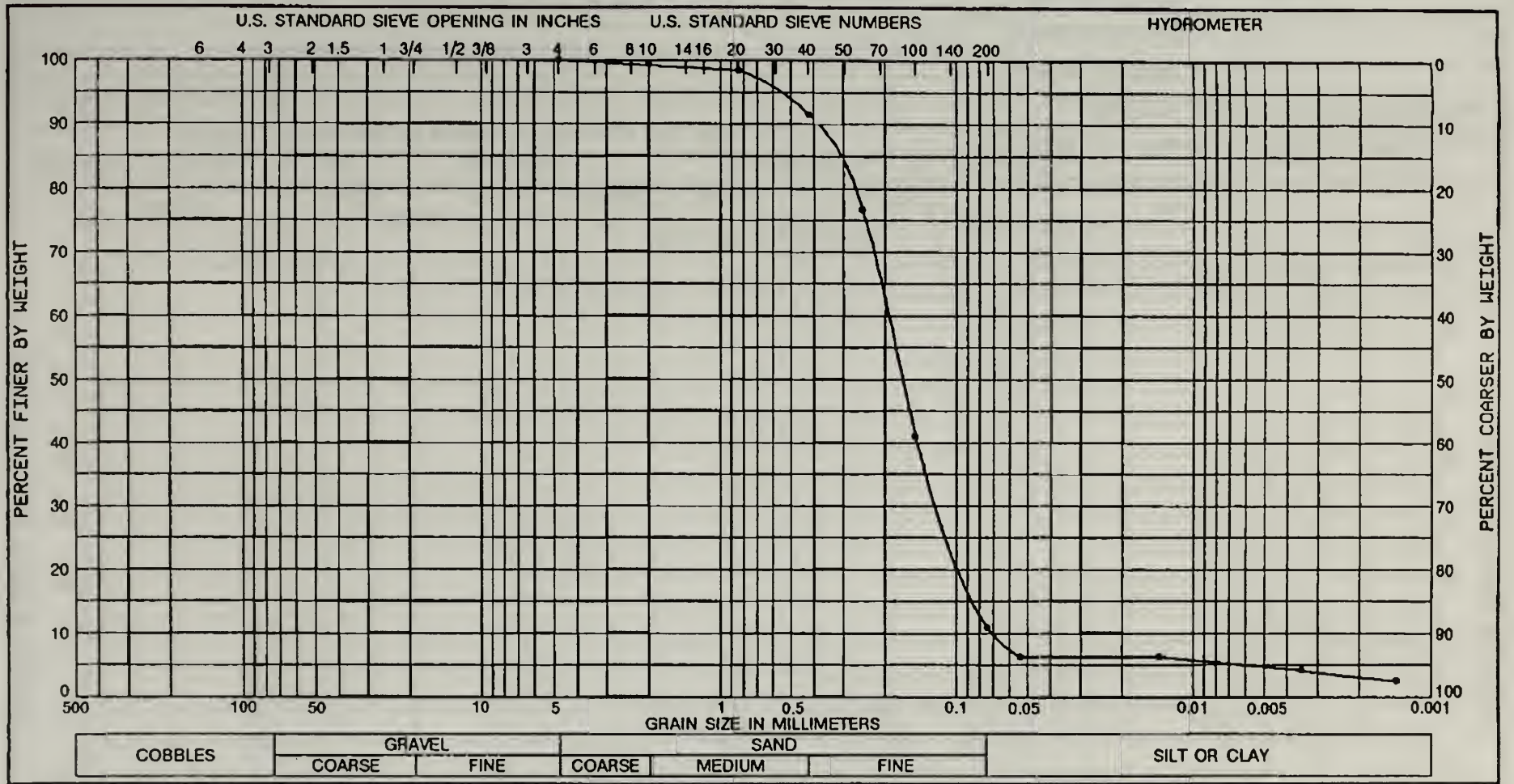
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
5	14.5-16.0'	Gray clayey sand (SC), with a trace of mica and organic matter.	48.8	44	22	22

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4006
Boring No. FS-9-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



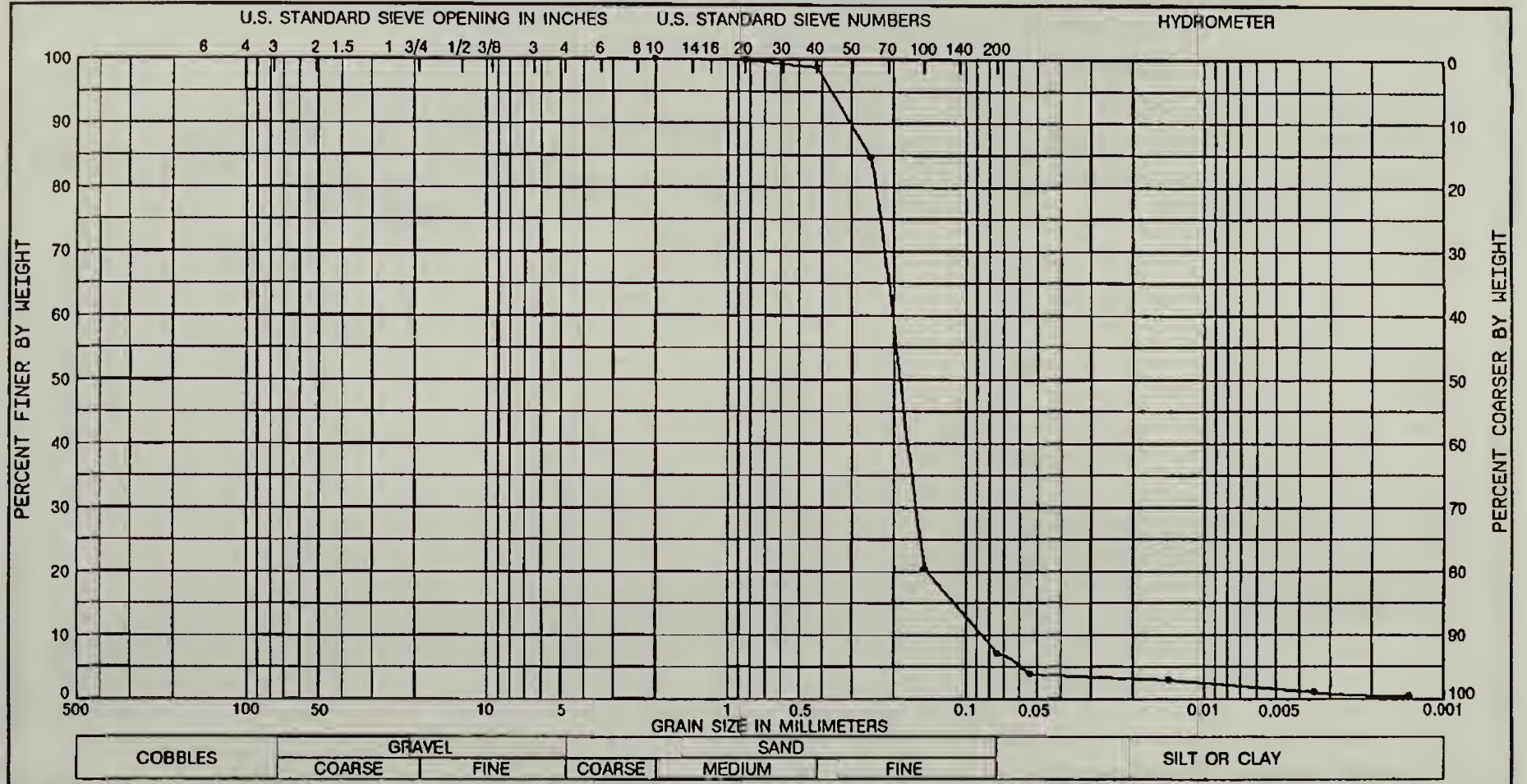
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
7	17.5-19.0'	Gray poorly graded silty sand (SP-SM), with a trace of mica.	25.8	NP	NP	NP

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4007
Boring No. FS-9-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



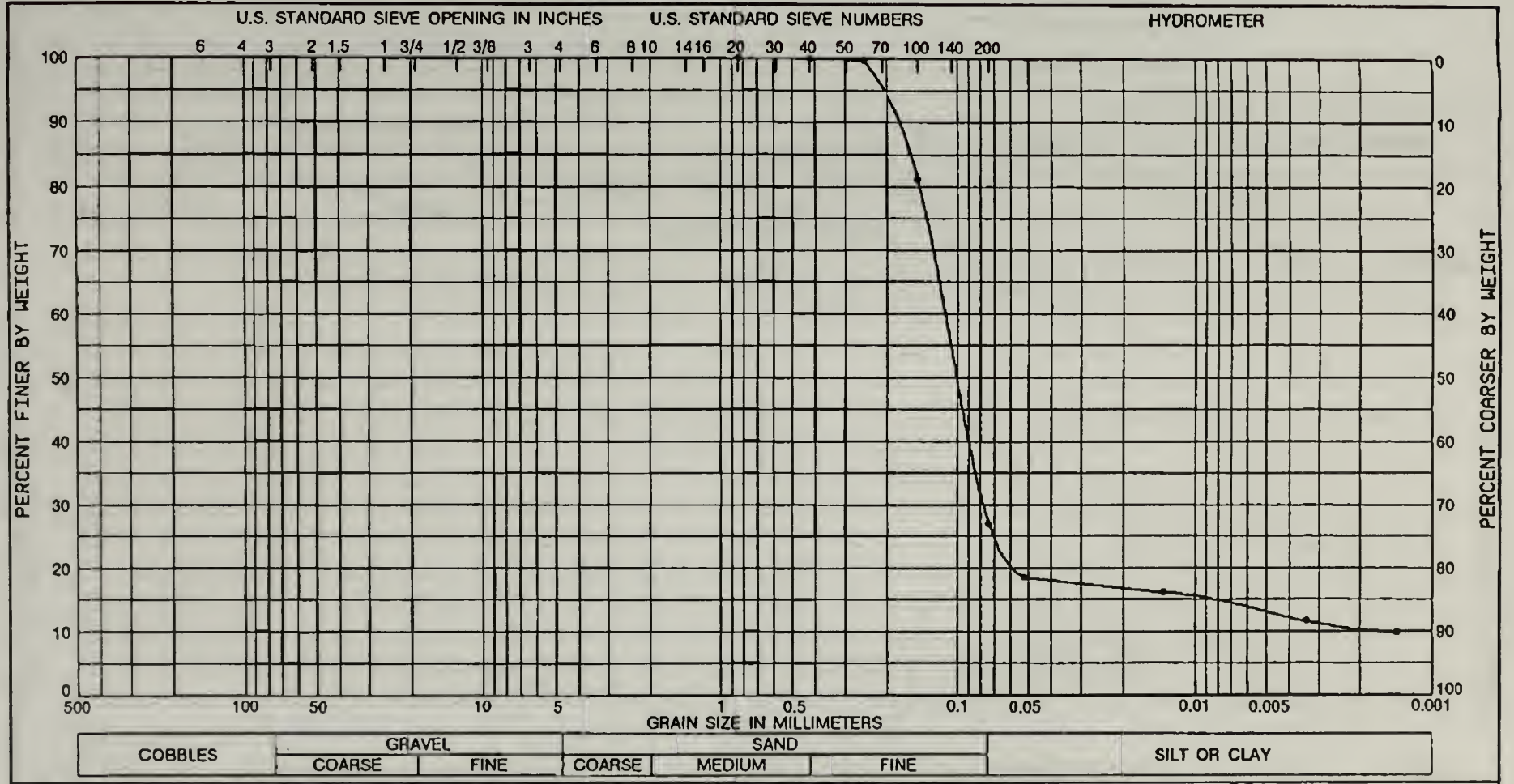
Sample No.	Depth/Elev	Visual Classification	Nat w%	LL	PL	PI
12	25.0-26.5'	Gray poorly graded silty sand (SP-SM).	20.2	--	--	--

GRADATION CURVES

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4008
Boring No. FS-9-92
Date 07/15/92

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



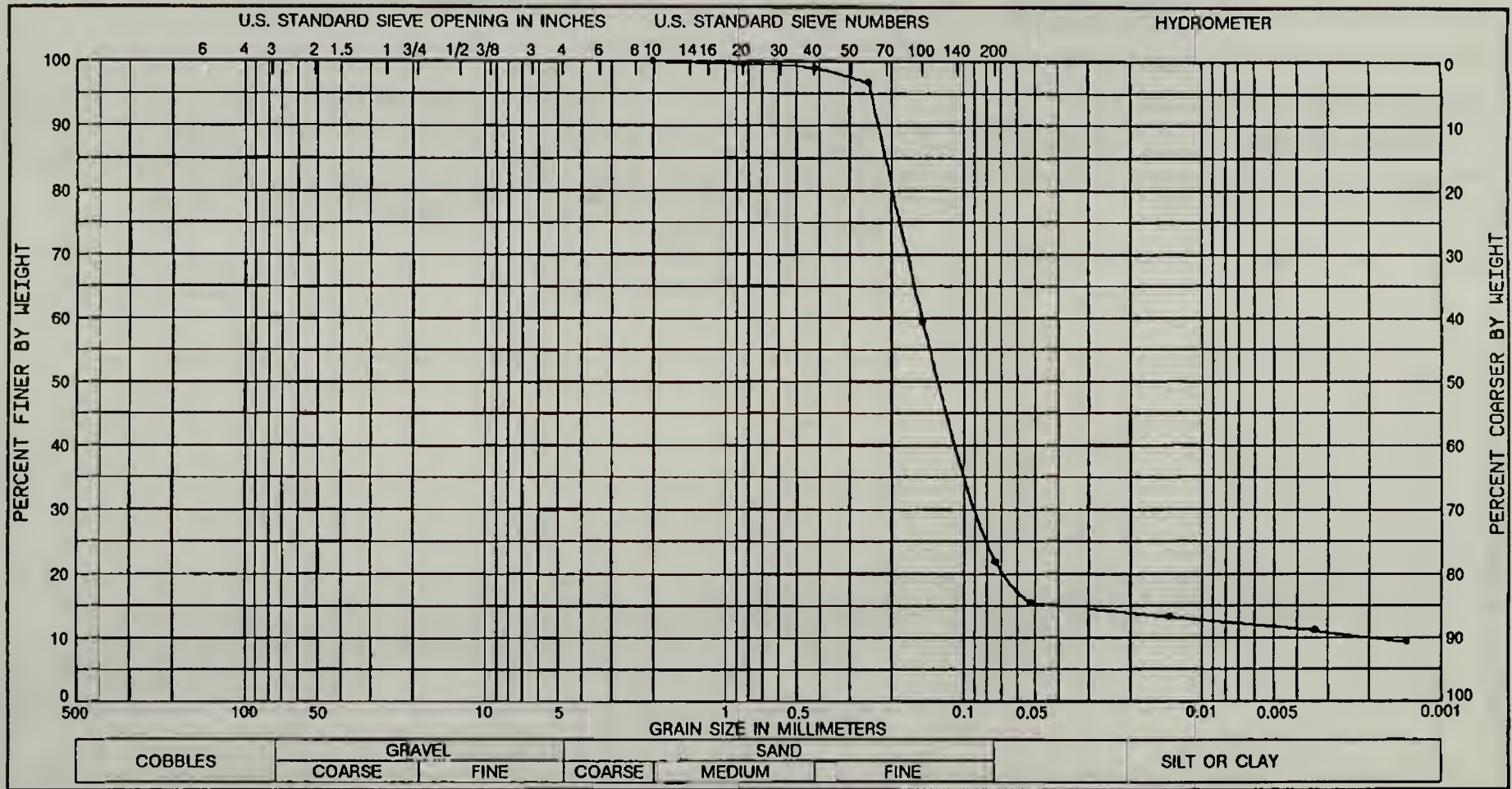
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
18	34.0-35.6'	Gray clayey sand (SC), with a trace of mica and organic matter.	39.5	33	20	13

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4009
Boring No. FS-9-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



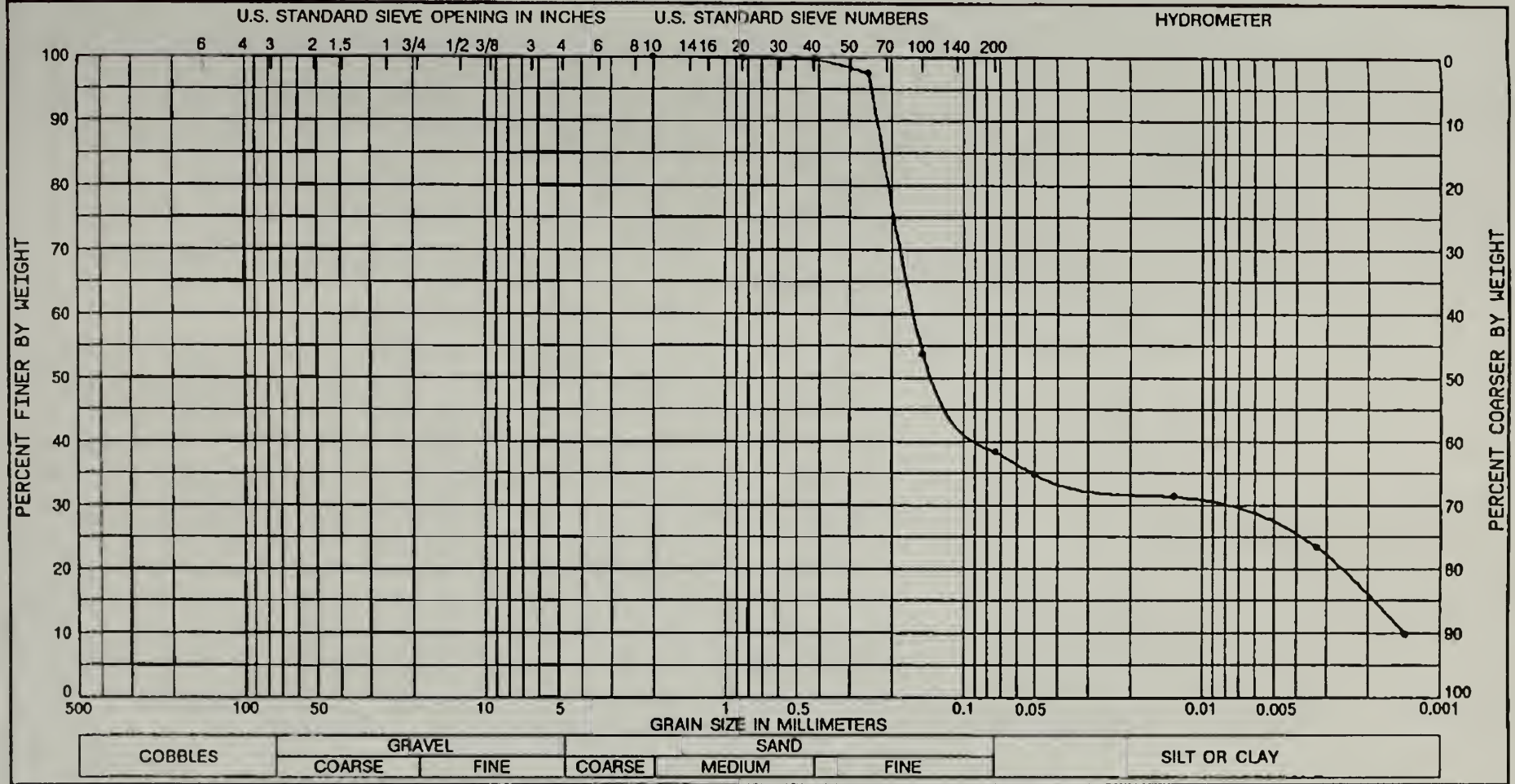
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
21	38.5-40.0'	Gray clayey sand (SC).	34.2	30	20	10

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4010
Boring No. FS-9-92
Date 07/15/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



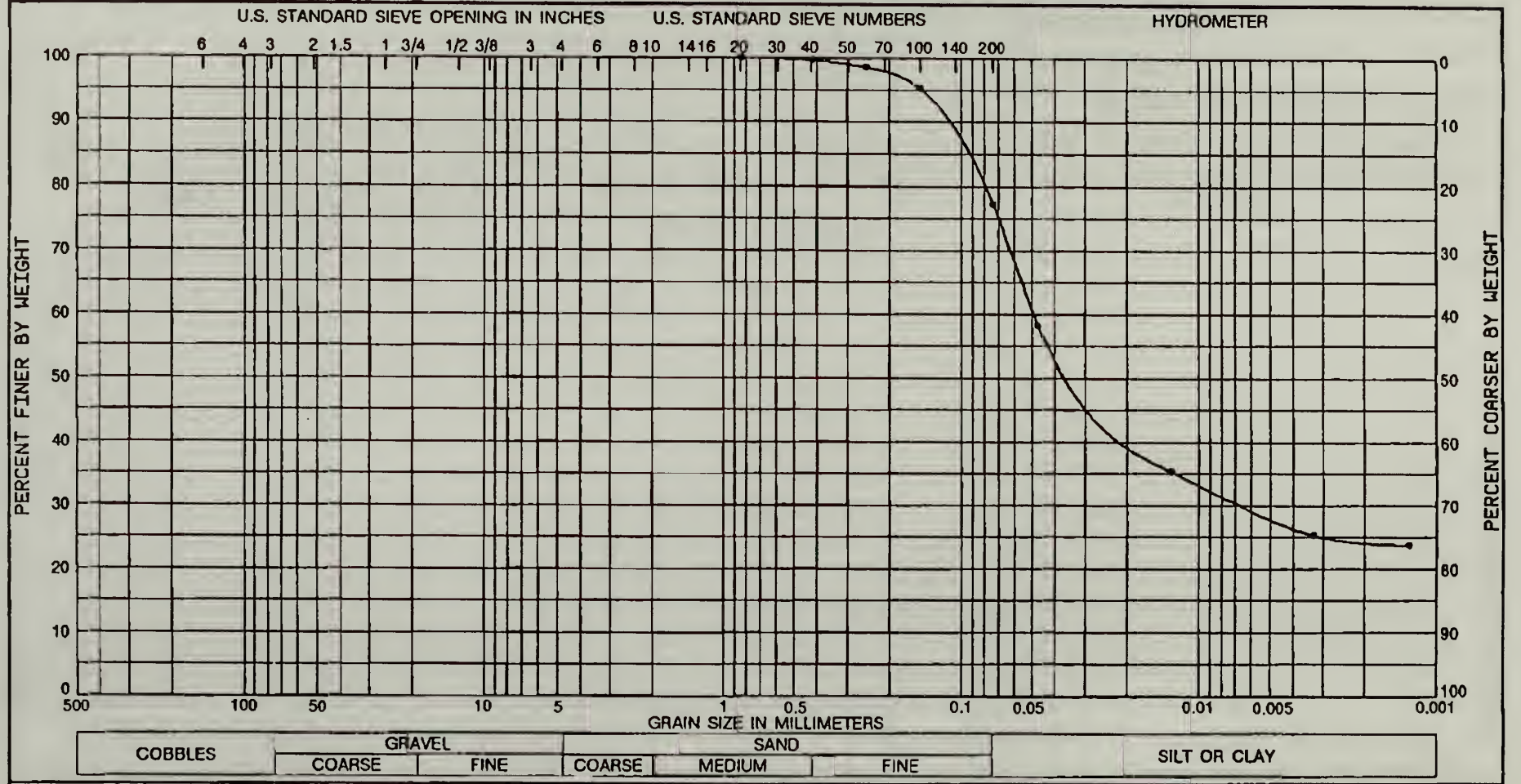
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
26	55.0-56.5'	Gray clayey sand high LL (SC-H).	40.3	51	21	30

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4012
Boring No. FS-9-92
Date 07/16/92

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 6636
REQUISITION: SACRM-92-84



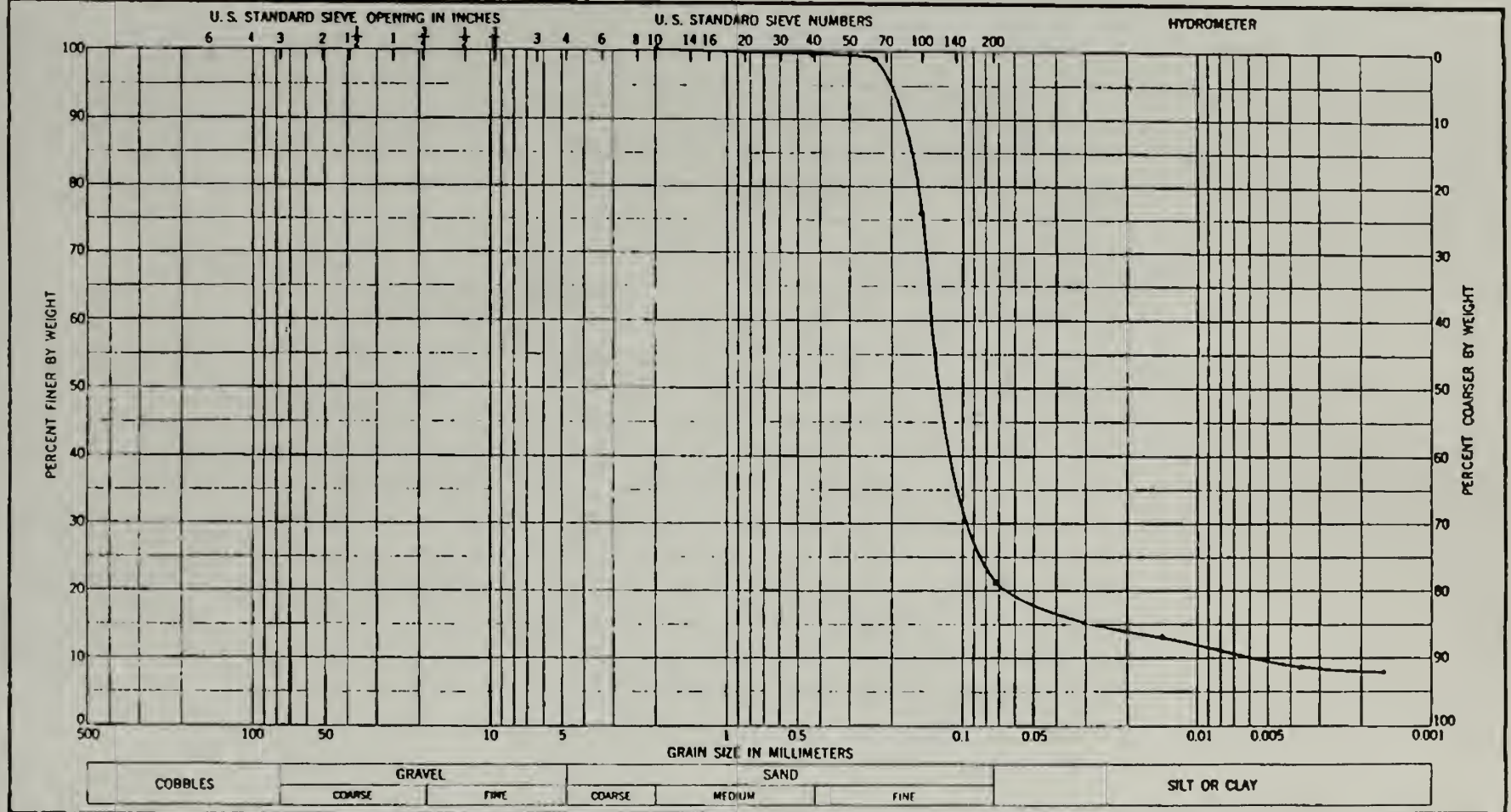
Sample No.	Depth/Elev	Classification	Nat w%	LL	PL	PI
32	75.0-76.5'	Greenish brown fat clay (CH), with some sand.	53.4	80	35	45

Project Ft. Sumter National Monument
Battery Huger Foundation Invest.
Lab No. 74/4014
Boring No. FS-9-92
Date 07/15/92

GRADATION CURVES

SOUTH ATLANTIC DIVISION LABORATORY
US ARMY CORPS OF ENGINEERS
611 SOUTH COBB DR.
MARIETTA, GA 30060-3112

W.O. NO. 6636
REQ. NO. SACRM-92-84



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
6A	36.5-38.5'	Gray, clayey sand (SC), w/ a trace of mica.	38.3	29	22	7

GRADATION CURVES

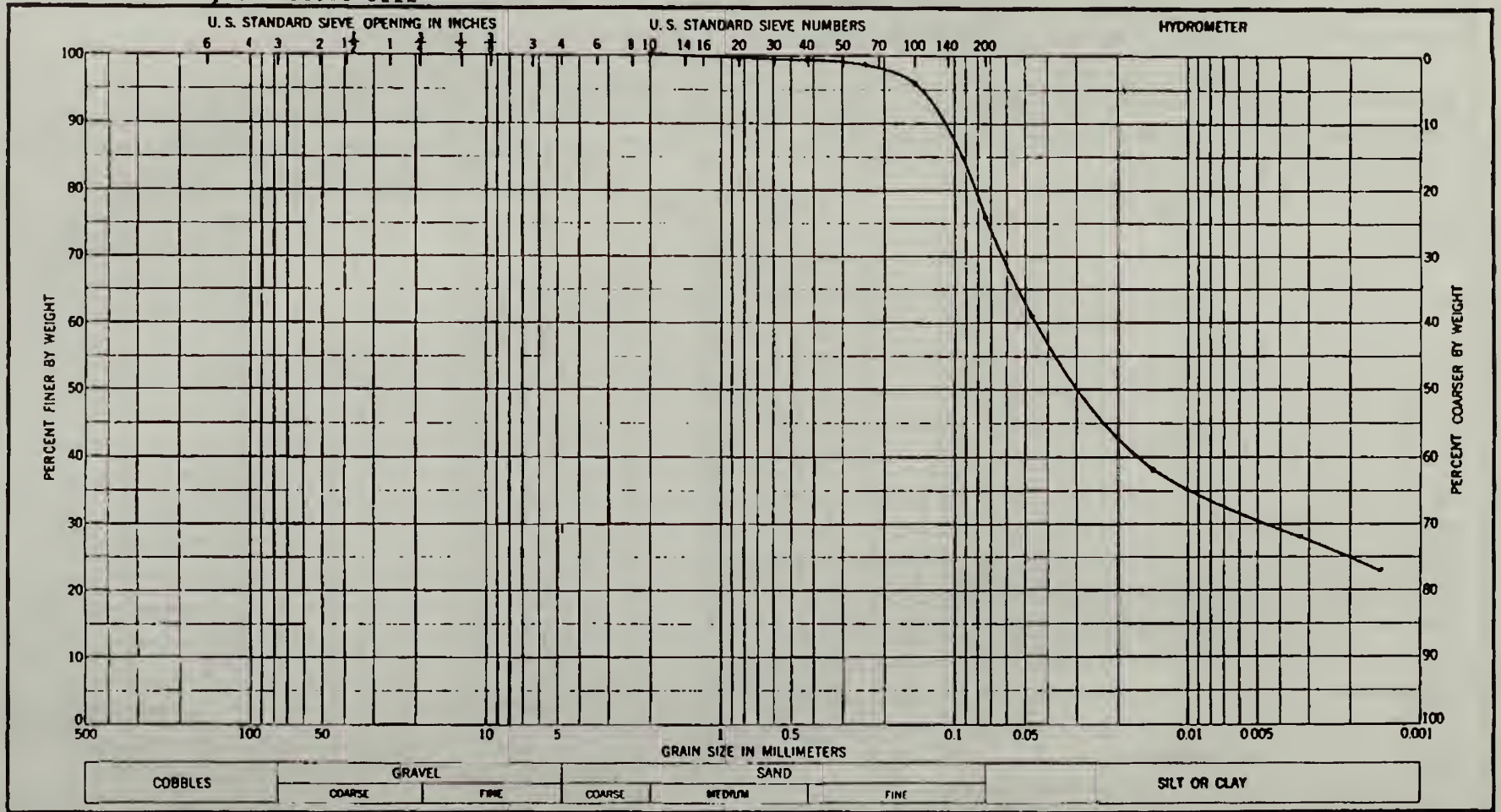
Project: Ft. Sumter National Monument
Lab. No. 96/635*
Area: Battery Huger Investigation
Boring No.: FS-10-92, sample no. 6A
Date: 14 May 92

ENG FORM 1 MAY 63 2087

*Consolidation test

South Atlantic Division Laboratory
US Army Corps of Engineers
611 South Cobb Dr.
Marietta, GA 30060-3112

W.O. NO. 6636
REQ. NO. SACRM-92-84



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
13	75.0-77.0'	Tan, fat clay (CH), w/ some sand sizes.	52.5	88	37	51

GRADATION CURVES

Project: Ft. Sumter National Monument
Lab. No. 96/639*
Area: Battery Huger Investigation
Boring No.: FS-10-92, sample no. 13
Date: 14 May 92

ENG FORM 1 MAY 83 2087

*Consolidation test