DESIGN BID BUILD PROJECT SPECIFICATIONS

PREPARED BY:

Naval Facilities Engineering Command, Southeast
P.O. Box 30, NAS Jacksonville, Florida 32212-0030

CONSTRUCTION ISSUE - 10 June 2016

WHARF BRAVO STRUCTURAL REPAIRS

NAVAL STATION GUANTANAMO BAY, CUBA

E PROJECT #: 1295318

FOR COMMANDER NAVFAC SE – BLTL: Michele Jackson, P.E.

PROJECT MANAGER: Elaine Gallant, P.E.

TECHNICAL BRANCH HEAD: Michael Johnson, R.A.

Discipline	Prepared By:	Reviewed By:
Waterfront:	John McCoy, P.E.	Kurt Wittman, P.E.
Structural:	Vitaly Feygin, P.E.	Kurt Wittman, P.E.
Electrical:	Chris Duguid, P.E	FLORES.RAMON.H.1383332679 Digitally signed by FLORES.RAMON.H.1383332679 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USN, cn=FLORES.RAMON.H.1383332679 Date: 2016.06.09 15:39:09 -04'00' Ramon Flores, P.E.
Civil:	Ricardo Palmo	Jeff Frank, P.E.

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
Wharf Bravo Structural Repairs

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
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		00 73 01.00 25	SD-01 Preconstruction Submittals															
			Entry Approval for Employees	1.3.1.1	G													
		01 14 00.00 25	SD-01 Preconstruction Submittals															
			List of Contact Personnel	1.3.1.1	G													
		01 20 00.00 25	SD-01 Preconstruction Submittals															
			Schedule of Prices	1.3	G													
		01 30 00.00 25	SD-01 Preconstruction Submittals															
			View Location Map	1.3	G													
			Progress and Completion	1.4	G													
			Pictures															
		01 32 17.00 25	SD-01 Preconstruction Submittals															
			Qualifications	1.5	G													
			Baseline Network Analysis	1.3	G													
			Schedule															
			SD-07 Certificates															
			Monthly Network Analysis	1.7.1	G													
			SD-11 Closeout Submittals															
			As-Built Schedule	1.7.2	G													
		01 33 00	SD-01 Preconstruction Submittals															
			Submittal Register		G													
		01 35 26.00 25	SD-01 Preconstruction Submittals															
			Accident Prevention Plan (APP)	1.8	G													
			SD-06 Test Reports															
			Monthly Exposure Reports	1.4														
			Notifications and Reports	1.13														
			Accident Reports	1.13.2	G													

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		01 35 26.00 25	LHE Inspection Reports	1.13.3														
			SD-07 Certificates															
			Contractor Safety Self-Evaluation	1.5														
			Checklist															
			Crane Operators/Riggers	1.7.1.5														
			Standard Lift Plan	1.8.2.2	G													
			Critical Lift Plan	1.8.2.3	G													
			Naval Architecture Analysis	1.8.2.3	G													
			Activity Hazard Analysis (AHA)	1.9														
			Confined Space Entry Permit	1.10.1														
			Hot Work Permit	1.10.1														
			Certificate of Compliance	1.13.4														
			Third Party Certification of	1.13.5														
			Barge-Mounted Mobile Cranes															
			License Certificates	1.15														
			Radiography Operation Planning	1.15.1	G													
			Work Sheet															
		01 45 00.00 25	SD-01 Preconstruction Submittals															
			Construction Quality Control (QC)	1.6.1	G													
			Plan															
			Indoor Air Quality (IAQ)	1.18	G													
			Management Plan															
			Basis of Design and Design	1.10.1														
			Intent															
			SD-07 Certificates															
			CA Resume															

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		01 45 35.00 25	SD-01 Preconstruction Submittals															
			Contractor Statement of	1.3.12	G													
			Responsibility															
			Project Manual		G													
			Written Practices	3.1.2	G													
			SD-06 Test Reports															
			Daily Reports	3.1.2	G													
			Biweekly Reports	3.1.1	G													
			SD-07 Certificates															
			Special Inspector	1.5	G													
			SD-11 Closeout Submittals															
			Comprehensive Final Report	3.1.2	G													
		01 50 00.00 25	SD-01 Preconstruction Submittals															
			Construction site plan	1.3	G													
			Traffic control plan	3.4.1	G													
			SD-03 Product Data															
			Backflow preventers	1.4	G													
			SD-06 Test Reports															
			Backflow Preventer Tests		G													
			SD-07 Certificates															
			Backflow Tester		G													
			Backflow Preventers	1.4														
		01 57 19.00 25	SD-01 Preconstruction Submittals															
			Solid Waste Management Permit	1.9	G													
			Environmental Protection Plan	1.6	G													
			SD-11 Closeout Submittals															

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		01 57 19.00 25	Stormwater Pollution Prevention	3.2.1.2	G													
			Plan Compliance Notebook															
		01 74 19.00 25	SD-01 Preconstruction Submittals															
			Waste Management Plan	1.5	G													
			SD-11 Closeout Submittals															
			Records	1.6														
		01 78 00.00 25	SD-03 Product Data															
			Warranty Management Plan	1.6.1														
			Warranty Tags	1.6.4														
			Spare Parts Data	1.5														
			SD-08 Manufacturer’s Instructions															
			Instructions	1.6.1														
			SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.3	G													
			Manuals															
			SD-11 Closeout Submittals															
			As-Built Drawings	3.1	G													
			Record Drawings	3.2	G													
			Certification of EPA Designated	2.1	G													
			Items															
			Interim DD FORM 1354	3.5	G													
			Checklist for DD FORM 1354	3.5	G													
			NAVFAC Sustainable & Energy	3.6	G													
			Data Record Card															

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		01 78 23.00 25	SD-10 Operation and Maintenance																
			Data																
			O&M Database		G														
			Training Plan		G														
			Training Outline		G														
			Training Content		G														
			SD-11 Closeout Submittals																
			Training Video Recording		G														
			Validation of Training Completion		G														
		02 41 00	SD-01 Preconstruction Submittals																
			Existing Conditions	1.9	G														
			SD-07 Certificates																
			Demolition Plan	1.2.1	G														
			Notification	1.6	G														
			SD-11 Closeout Submittals																
			Receipts																
		03 01 32	SD-01 Preconstruction Submittals																
			Work Plan	1.6.6	G														
			Demolition Plan	1.7.3	G														
			Demolition Plan	3.2.1	G														
			Water Control Plan	1.7.3	G														
			Contractor Qualifications	1.6.1.1															
			Worker Qualifications	1.6.1.2															
			SD-03 Product Data																
			Bond Breaker																
			Fiber Reinforcement																

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		03 01 32	Testing Technicians	1.6.1.3														
			SD-04 Samples															
			Field-Molded Sealants and															
			Primer															
			SD-05 Design Data															
			Repair material mixture	1.6.4														
			proportioning															
			SD-06 Test Reports															
			Compression Seals and															
			Lubricant															
			Cement-Based Concrete	1.6.4														
			Cement-Based Concrete	1.6.5.1														
			Cement-Based Mortar	1.6.4														
			Cement-Based Mortar	1.6.5.1														
			Rapid-Hardening Repair Material															
			Dry-Pack Mortar															
			SD-07 Certificates															
			Grout Fluidifier	2.1.2														
			Aggregate	2.1.3														
			SD-08 Manufacturer’s Instructions															
			Rapid-Hardening Repair Material															
			Manufacturer's Material Safety	1.6														
			Data Sheets															
		03 31 29	SD-01 Preconstruction Submittals															
			Concrete Curing Plan	1.8.2.2	G													
			Concrete Qualification Program	1.7.4	G													

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		03 31 29	Concrete Quality Control		G													
			Program															
			Concrete Placement and	1.8.2.4	G													
			Compaction															
			Concrete Pumping	1.8.2.4														
			Curing concrete elements	1.8.2.1														
			Form Removal Schedule	1.8.2.3														
			Laboratory Qualifications	1.6.2	G													
			Quality Control Personnel	1.6.1	G													
			SD-02 Shop Drawings															
			closure pour detail joints		G													
			Formwork	1.8.1.1														
			Precast elements		G													
			Reinforcing steel	1.6.1.2	G													
			SD-03 Product Data															
			Admixtures	1.8.5.5	G													
			Air Entraining	2.4.1	G													
			Aggregates	1.8.5.4	G													
			Materials for curing concrete	2.8.1	G													
			Material Safety Data Sheets															
			Mechanical Reinforcing Bar		G													
			Connectors															
			Non-shrink grout		G													
			Pore Blocker Admixture		G													
			Preformed joint filler															
			Reinforcing Bars		G													

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		03 31 29	Reinforcement		G														
			Reinforcement supports	3.2.1	G														
			SD-05 Design Data																
			Concrete Mixture Requirements	1.8.5.1	G														
			Mixture designs	1.8.2.6	G														
			Mass Concrete Temperature		G														
			Control Plans																
			SD-06 Test Reports																
			Air Entraining	2.4.1															
			Aggregates	1.8.5.4															
			Admixtures	1.8.5.5															
			As-Built Report																
			Cement	1.8.5.6															
			Concrete mixture proportions																
			Concrete Test Reports	1.8.5															
			Complementary Cementing	1.8.5.2															
			Materials																
			Fresh Concrete Properties	1.7.4.1															
			Hardened Concrete Properties	1.7.4.2															
			Mechanical Reinforcing Bar																
			Connectors																
			Reinforcing Bars																
			Reinforcement and Hot-Dip		G														
			Galvanizing Coating																
			Water	2.3															
			Pore Blocker		G														

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		03 31 29	SD-07 Certificates																
			Admixtures	1.8.5.5															
			Cementitious Materials	2.1															
			Cementitious material mill	1.8.3.1															
			certificates																
			Field testing technician and	1.6.1.2															
			testing agency																
			SD-08 Manufacturer’s Instructions																
			Coatings																
			SD-11 Closeout Submittals																
			Aggregate Moisture Content	1.8.3.1															
			Aggregate Sampling	1.8.3.1															
			As-built report		G														
			Concrete Test Reports	1.8.5	G														
			Quality Control Charts																
			Daily inspection reports	1.8.4.1															
			Quality Team Meetings	1.8.4.3															
			Sampling logs	1.8.4.2															
		05 12 00	SD-02 Shop Drawings																
			Fabrication drawings	1.3.1	G														
			SD-03 Product Data																
			Shop primer	2.6.2															
			Welding electrodes and rods	2.4.1															
			Non-Shrink, Non-Metallic Grout																
			SD-06 Test Reports																
			Bolts, nuts, and washers	2.3															

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		05 12 00	SD-07 Certificates																
			Steel	2.2															
			Bolts, nuts, and washers	2.3															
			Galvanizing	2.5															
			Welding procedures and	1.3.2.1															
			qualifications																
		05 50 13	SD-02 Shop Drawings																
			angles and plates		G														
			Steel railing and handrails		G														
			Mooring bollards and anchor		G														
			bolts																
			SD-03 Product Data																
			Mooring bollards and anchor		G														
			bolts																
			SD-07 Certificates																
			Qualification of Welders and																
			Welding Operators																
			Certified Load Capacity of																
			Bollards and Bits																
		06 71 33	SD-01 Preconstruction Submittals																
			Qualification of Manufacturer	1.4.1															
			Qualification of Engineer of	1.4.2															
			Record																
			SD-02 Shop Drawings																
			Fabrication and Installation	1.4.2	G														
			Drawings and Details																

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		06 71 33	SD-03 Product Data															
			Manufacturer's Catalog Data	1.2.1	G													
			SD-06 Test Reports															
			Ultraviolet Testing	2.1.1														
			Thermal Expansion	2.1.1														
			Flame Spread	2.1.1														
			SD-07 Certificates															
			Manufacturer's Sample Warranty	1.2.1														
			SD-08 Manufacturer’s Instructions															
			Manufacturer's	1.5														
			Recommendations															
			SD-11 Closeout Submittals															
			Manufacturer's Warranty	3.2.1	G													
		09 97 13.26	SD-07 Certificates															
			Coal tar epoxy-polyamide	2.1.1.1														
		22 05 83.63	SD-03 Product Data															
			Installation Equipment	2.1														
			CIPP Lining Tube	2.2.1														
			Epoxy Resin	2.1														
			Liner Materials	2.1														
			SD-08 Manufacturer’s Instructions															
			CIPP Manufacturer's Written	3.2	G													
			Installation Instructions															
			SD-11 Closeout Submittals															
			Report Summarizing The Extent	3.2	G													
			Of Pipe Lining Performed															

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		22 05 83.63	Pre-Lining Inspection	3.2	G														
			Post-Lining Inspection	3.2	G														
			Manufacturer's Warranty	1.4	G														
			Record Drawings	3.2	G														
		26 05 33	SD-02 Shop Drawings																
			600 V Power Connection Station	2.1	G														
			5 kV Power Connection Station	2.2	G														
			Ship Service Emergency Trip	2.3	G														
			Panel																
			SD-03 Product Data																
			600 V Single Pole Connectors	2.1.2	G														
			Industrial Service Auxiliary	2.1.4	G														
			Devices																
			Metering Accessories	2.1.5	G														
			5 kV Cable Couplers	2.2.2	G														
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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2010) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2010) Installation of Ductile-Iron Water Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)

ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D1140	(2000; R 2006) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1883	(2007; E 2009; E 2009) CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D4318	(2010) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D698	(2012) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC. Satisfactory materials for grading comprise stones less than 8 inches, except for fill material for pavements and railroads which comprise stones less than 3 inches in any dimension.

1.2.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.2.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C136, ASTM D422, and ASTM D1140.

1.2.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with AASHTO T 180 and corrected with AASHTO T 224. To maintain the same percentage of coarse material, use the "remove and replace" procedure as described in NOTE 8 of Paragraph 7.2 in AASHTO T 180.

1.2.5 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3 inches in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials

usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.6 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.7 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.2.8 Select Granular Material

1.2.8.1 General Requirements

Select granular material consist of materials classified as GW, GP, SW, SP by ASTM D2487 where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D1140. Provide a minimum coefficient of permeability of 0.002 feet per minute when tested in accordance with ASTM D2434.

1.2.8.2 California Bearing Ratio Values

Bearing Ratio: At 0.1 inch penetration, provide a bearing ratio of 10 percent at 95 percent ASTM D1557 maximum density as determined in accordance with ASTM D1883 for a laboratory soaking period of not less than 4 days. Conform the combined material to the following sieve analysis:

Sieve Size	Percent Passing by Weight
2 1/2 inches	100
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60
No. 200	5 - 25

1.2.9 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 2 inches or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, free the initial backfill material of stones larger than 1 inch in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

1.2.10 Expansive Soils

Expansive soils are defined as soils that have a plasticity index equal to or greater than 15 when tested in accordance with ASTM D4318.

1.3 SYSTEM DESCRIPTION

Subsurface soil boring logs are shown on the drawings. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.3.1 Classification of Excavation

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation.

1.3.2 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring; G
Dewatering Work Plan; G

SD-03 Product Data

Utilization of Excavated Materials; G

SD-06 Test Reports

Testing
Borrow Site Testing

SD-07 Certificates

Testing

PART 2 PRODUCTS

2.1 BURIED WARNING AND IDENTIFICATION TAPE

Provide polyethylene plastic and metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes

Red:	Electric
Yellow:	Gas, Oil; Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air

2.1.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.1.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.2 DETECTION WIRE FOR NON-METALLIC PIPING

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

PART 3 EXECUTION

3.1 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Dispose unsatisfactory excavated material in designated waste or spoil areas. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from other approved areas selected by the Contractor as specified.

3.1.1 Drainage

Provide for the collection and disposal of surface and subsurface water

encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.1.2 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Do not permit French drains, sumps, ditches or trenches within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Take control measures by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, maintain the water level continuously.

3.1.3 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Excavation made with power-driven equipment is not permitted within 2 feet of known Government-owned utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.2 OPENING AND DRAINAGE OF EXCAVATION

Notify the Contracting Officer sufficiently in advance of the opening of any excavation to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, excavation areas providing adequate drainage. Transport overburden and other spoil material to designated spoil areas or otherwise dispose of as directed. Ensure that excavation of any area, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.3 SHORING

3.3.1 General Requirements

Submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as

necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.3.2 Geotechnical Engineer

Hire a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer is responsible for updating the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and submit an updated plan if necessary. Submit a monthly written report, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Contracting Officer is responsible for arranging meetings with the Geotechnical Engineer at any time throughout the contract duration.

3.4 GROUND SURFACE PREPARATION

3.4.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Contracting Officer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 6 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inches, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.5 UTILIZATION OF EXCAVATED MATERIALS

Dispose unsatisfactory materials removing from excavations into designated waste disposal or spoil areas. Submit procedure and location for disposal of unused satisfactory material. Do not waste any satisfactory excavated material without specific written authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed. Clear and grub newly designated waste areas on Government-controlled land before disposal of waste material thereon. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

3.6 BURIED TAPE AND DETECTION WIRE

3.6.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.6.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over it's entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.7 BACKFILLING AND COMPACTION

Place backfill adjacent to any and all types of structures, and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials, to prevent wedging action or eccentric loading upon or against the structure. Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs GROUND SURFACE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.7.1 Trench Backfill

Backfill trenches to the grade shown.

3.7.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.7.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6 inches loose thickness.

3.7.1.3 Bedding and Initial Backfill

Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D698 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

a. Class II: Coarse sands and gravels with maximum particle size of 1.5 inches, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

3.7.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, railroads and airfields, with satisfactory material. Place backfill material and compact as follows:

3.7.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 25 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.8 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.8.1 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.8.2 Pipeline

3.8.2.1 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.8.2.2 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight segmented elastomeric end seals.

3.9 SUBGRADE PREPARATION

3.9.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade with six passes of a 10 ton, pneumatic-tired roller. Operate the roller in a systematic manner to ensure the number of passes over all areas, and at speeds between 2-1/2 to 3-1/2 mph. When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Contracting Officer. Undercut rutting or pumping of material as directed by the Contracting Officer and replace with fill and backfill material.

3.9.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inches below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified.

3.9.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Compact each layer to at least 95 percent of laboratory maximum density.

3.9.3.1 Subgrade for Pavements

Compact subgrade for pavements to at least 95 percentage laboratory maximum density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact the top 12 inches of subgrade.

3.10 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.10.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.10.2 Grading Around Structures

Construct areas within 5 feet outside of each structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.11 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. Submit qualifications of the Corps validated commercial testing laboratory or the Contractor's validated testing facilities. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Contracting Officer.

a. Determine field in-place density in accordance with ASTM D1556.

b. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.11.1 Fill and Backfill Material Gradation

One test per 500 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM D1140.

3.11.2 In-Place Densities

a. One test per 2500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

b. One test per 1000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

3.11.3 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Contracting Officer.

3.11.4 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material to determine the optimum moisture and laboratory maximum density values. One representative test per 500 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

3.11.5 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.12 DISPOSITION OF SURPLUS MATERIAL

Provide surplus material or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber as

waste in an approved location coordinated with Contracting Officer.

3.13 GEOTECHNICAL REPORT

The Geotechnical Report is attached below. Earthwork for retaining wall shall be performed in accordance with the criteria established in the Geotechnical Report.

-- End of Section --

GEOTECHNICAL ENGINEERING REPORT

Wharf Bravo Repairs
Naval Base Guantanamo Bay, Cuba
A/E Contract No. N69450-13-D-0010, X-019
Work Order No. 1295318

Schnabel Reference 15619016.00

February 5, 2016

Schnabel ENGINEERING

February 5, 2016

Mr. Chris Ions, AIA
LS3P Collaborative, LLC
227 West Trade Street, Suite 700
Charlotte, NC 28202

Subject: **Geotechnical Engineering Services**
Wharf Bravo Repairs, Naval Base Guantanamo Bay, Cuba
A/E Contract No. N69450-13-D-0010, X-019, Work Order No. 1295318
Schnabel Reference 15619016.00

Dear Mr. Ions:

SCHNABEL ENGINEERING CONSULTANTS, INC. (Schnabel) is pleased to submit our geotechnical engineering report for this project. This study was performed in accordance with our proposal dated June 12, 2015.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

Sincerely,

SCHNABEL ENGINEERING CONSULTANTS, INC.

Mahalingam Bahiradhan, PE
Senior Engineer

Richard H. Wargo, PE
Principal

SOUTH CAROLINA
REGISTERED PROFESSIONAL ENGINEER
No. 18108
RICHARD H. WARGO

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GEOTECHNICAL ENGINEERING REPORT
WHARF BRAVO REPAIRS
NAVAL BASE GUANTANAMO BAY, CUBA

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APPENDICES

Appendix A: Subsurface Exploration Data
Figure A-1: Test Boring Location Plan
Figures A-2 & A-3: Subsurface Cross Sections
Appendix B: Soil Laboratory Test Data
Appendix C: Liquefaction Analyses Results
Appendix D: Engineering Calculations
Appendix E: Previous Test Boring Data

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1.0 1.0 SCOPE OF SERVICES

Per the Statement of Work provided by NAVFAC Southeast dated March 30, 2015, with subsequent discussions and scope revisions, our scope of work consisted of the following:

- Subsurface exploration, consisting of:
  - Three (3) soil test borings to depths of 100 feet, and three (3) soil test borings to depths of 75 feet.

- Field engineering services, including:
  - Site reconnaissance.
  - Contacting public utility locating service and/or base locating service.
  - Field supervision by engineer

- Soil laboratory testing, including:
  - Each soil type encountered shall be classified in accordance with the Unified Soil Classification System (ASTM D 2487).
  - One moisture content test performed for each soil stratum encountered in each boring for full depth in accordance with ASTM D 2216.
  - The moist and dry unit weights shall be determined for each soil profile encountered. The unconfined compressive strength of cohesive soils shall be determined with pocket penetrometer and/or unconfined compression tests (ASTM D 2166).
  - The Atterberg Limits (ASTM D 4318) shall be determined for all cohesive soils encountered.
  - A particle size analysis (ASTM C 136 or ASTM D 422) shall be performed for each soil type encountered.

- Geotechnical Engineering Report, including:
  - A dimensioned plot plan showing the locations of test borings.
  - Boring logs
  - Seismic site classification, in accordance with requirements and procedures of IBC-2012 Section 1613.3.2 and ASCE7-10 Chapter 20, with discussion of evaluation.
  - Liquefaction analyses results
  - Earth pressure diagrams for the proposed retaining wall under static and seismic conditions
  - Estimation of allowable bond stress for the bonded portion of anchors.

Urban Engineers will provide a report of the following under a separate agreement with LS3P:

Analysis and conceptual design recommendations of a new anchored sheet pile wall with a distance from top of cap to design mudline of 52 ft (i.e. to EL-46). Provide a seismic analysis based on the requirements found in UFC 4-152-01 Design: Piers and Wharves. The site is located in a high seismic area, therefore, the firm shall indicate at time of proposal the planned analysis method of analysis of the new wall. Indicate

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analysis and assumptions in final report. The report shall provide the following: toe depth of the new wall with applicable factors of safety for all load conditions (dead load, 300 psf uniform live load, crane loading (Grove RT880E), seismic analysis) and required combinations; moment, shear, and deflection diagrams for each analysis; anchor reactions; required minimal free length of soil anchors; required deflections for seismic; recommended steel sheet pile material and minimal section properties. Provide all calculations and analysis to support conceptual design recommendations.

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2.0 EXISTING CONDITIONS AND PROPOSED CONSTRUCTION

The wharf is approximately 1,100 feet in length. In the 1990's, a new wall was designed and constructed in front of approximately 500 feet of the wharf resulting in an uneven berthing face along the wall. Since the design of this new wall, there have been significant changes and improvements in the seismic analysis of anchored sheet pile walls and NAVFAC Southeast has determined that the project requires an updated seismic analysis of the wall be performed to support the extension of the existing wall face. Additionally, there are concerns that additional soil borings should be performed to determine elevation of stiff and/or rock as well as support the analysis.

According to the 1990 drawings provided by NAVFAC Southeast, the existing sheet pile wall was to be driven to tip grades of EL-62 feet. The wall was to be supported by earth anchors installed at 45 degree angle with a design load of 220 kips.

The project involves construction of a new bulkhead outboard of an existing sheet pile wall at a distance of about seven (7) feet. The new bulkhead will have a distance from top of cap to design mudline of 52 feet (i.e. to EL-46 feet), same as the existing wall. We understand that the space between the new and existing wall will likely be filled with flowable fills.

Considering the anticipated high lateral earth pressures developed during a seismic event, a deep soil mixing of a potential liquefiable zones based on the subsurface conditions is proposed behind the existing wall. The width of the deep soil mixing zone will be determined based on the slope stability results of model proposed by NAVFAC to ensure stability at static and seismic conditions. The slope stability results are presented in Appendix D. The required factor of safety values for these analyses were prescribed by the NAVFAC. We also understand that the top of the new wall will be tied by a horizontal anchor behind the improved soil mass by deep soil mixing. The improved soil mass behind the existing wall near the borings B-101, B-102 and B-103 considered in this study are presented in the table below.

Boring	Bottom Elevation of Improved Soil Mass (feet)	Width of Improved Soil Mass (feet)
B-101	-53	50
B-102	-45	46
B-103	-25	24

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3.0 SUBSURFACE EXPLORATION PROGRAM

We performed a subsurface exploration to identify the subsurface stratigraphy underlying the site and to evaluate the geotechnical properties of the materials encountered. Exploration methods used are discussed below. The appendices to this report contain the results of our exploration.

3.1 Subsurface Exploration

Our subcontractor, F&R, Chesapeake, Virginia drilled six (6) test borings under our observation between July 9 and 15, 2015. The Standard Penetration Test (SPT) was performed at selected depths in the borings. Appendix A includes specific observations, remarks, and logs for the borings, classification criteria, drilling methods, and sampling protocols. Figure A-1, included in Appendix A, indicates the approximate test boring locations. Estimated subsurface cross-sections are also included as Figures A-2 and A-3. We will retain soil samples up to 45 days beyond the issuance of this report, unless you request other disposition.

We obtained ground surface grades and additional site information from the topographic site plan provided by NAVFAC Southeast, as well as our site visit.

3.2 Previous Explorations by Others

Several test borings were previously performed in the vicinity to the project site by others in 1995 under NAVFAC Contract N62470-91-B-1269. Logs for these borings are included in Appendix E for reference.

These data were developed by others and we were not present during collection of this information. We have reviewed the data for reasonableness, but we assume no responsibility for the completeness and accuracy of this information.

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4.0 LABORATORY TESTING

Our laboratory performed tests on selected samples obtained during the subsurface exploration. The testing aided in the classification of materials encountered in the subsurface exploration and provided data for use in the development of recommendations for design. Moisture contents and classification tests results are shown on the boring logs in Appendix A. The remainder of the test results are included in Appendix B.

We performed natural moisture content (ASTM D-2216), Atterberg Limit (ASTM D-4318), gradation (ASTM D-422) and natural density (ASTM D-7263) tests on samples of soil representing the strata present. Additionally, we performed pocket penetrometer testing of the relatively cohesive soils to determine relative unconfined compressive strengths.

This information was used to provide soil classifications and parameters for use with published correlations with soil properties. The results are presented in the Summary of Laboratory Tests in Appendix B and are summarized (for each stratum) in Section 5.0.

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5.0 SUBSURFACE CONDITIONS

5.1 Generalized Subsurface Stratigraphy

The surface at the boring locations consisted of concrete pavement varying from 7.5 to 10 inches in thickness.

We characterized the following generalized subsurface stratigraphy based on the exploration and laboratory test data included in the appendices.

Table 5-1: Soil Stratigraphy

Type	Test Depth (feet)	Description
STRATUM A (FILL)	At the ground surface to depths of 15 to 39 feet.	Sandy Lean Clay, Sandy Silt to Silty Sand (FILL) with varying amounts of gravel, coral and shell fragments; generally very soft to medium consistency/loose to firm density (N-value = WOH to 22 bpf)
STRATUM A1 (PROBABLE FILL)	Below Stratum A, to depths of 30 to 49 feet.	Sandy Lean Clay, Sandy Silt to Silty Sand (PROBABLE FILL) with varying amounts of gravel, coral and shell fragments; generally soft consistency/loose to firm density (N-value = 3 to 9 bpf)
STRATUM B (ALLUVIAL)	Below Stratum B, to depths of 50 to 79 feet.	Sandy Lean Clay (CL), Clayey Sand (SC) to Silty Sand (SM) with varying amounts of gravel, coral and shell fragments; generally loose to compact density (N-value = 3 to 60 bpf)
STRATUM C (RESIDUAL)	Below Stratum C, to depth of 74.5 to 100 feet.	Fat Clay (CH) Sandy Lean Clay (CL), Clayey Sand (SC) to Silty Sand (SM); generally firm to compact density (N-value = 16 to +60 bpf)
STRATUM D (DISINTEGRATED ROCK)	Below Stratum D, to boring termination depth of 100 feet.	Disintegrated Rock; generally very dense (N-value = +60 bpf)

The above “N” values indicate the Standard Penetration Test resistances encountered in a particular layer as determined from the number of blows required to drive a two (2)- inch O.D., 1-3/8 inch I.D. sampling spoon one foot using a 140 pound hammer falling 30 inches. This test is conducted after seating the sampler six inches in the bottom of the hole according to ASTM D1586. Note that some of the variation in blow counts can be attributed to varying amounts of gravel, coral and shell fragments within the soil matrices.

Soil samples have been classified in accordance with ASTM D2488 and D2487 where laboratory tests were performed. The ASTM D2487 and D2488 group symbols (e.g. SM), indicated above and on the boring logs, are based on visual observations and limited soil laboratory testing of recovered soil

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samples. Criteria for soil classification are given in Appendix A. Some variation is likely to occur between the visual and laboratory classification.

Disintegrated rock is defined as residual material with SPT N values between 60 blows per foot and refusal. Refusal is defined as an N value of 50 blows for a penetration of one inch or less.

5.2 Groundwater

We observed groundwater level at depths varying from about 3.2 to 5 feet below existing surface grades after drilling. The test boring logs in Appendix A include groundwater observations obtained during our subsurface exploration.

The groundwater levels on the logs indicate our estimate of the hydrostatic water table at the time of our subsurface exploration. The final design should anticipate the fluctuation of the hydrostatic water table depending on variations in precipitation, surface runoff, tidal action, leaking utilities and similar factors.

5.3 Seismic Site Design Parameters

We evaluated the Seismic Site Class for this project according to the International Building Code (IBC) Section 1613.3.2 (2012) and ASCE 7-10, Chapter 20. Our analysis indicates Seismic Site Class for the project site is “E”.

Based on phone conversations with NAVFAC, the design Peak Ground Acceleration (PGA) for the project site is 0.29g. It appears that this value is based on the design seismic event that has 10% exceedance in 50 years (475 year return period). Since there is no detailed USGS mapping of Cuba available, the magnitude of the design seismic event for the project was estimated using the USGS web site application for Southern Florida and Puerto Rico for the same return period. The design magnitude was adjusted towards the value of Puerto Rico by considering the proximity of the project site to Haiti and Puerto Rico. The design earth quake magnitude of 6.5 was used in our liquefaction analysis.

5.4 Liquefaction Analyses

Liquefaction potential of the subsoils of the project site was evaluated using a program “Liquefy”. Liquefaction is a phenomenon where loose, granular soils below the water table experience a sudden reduction in shear strength due to the increased pore pressure in response to strong earthquake shaking over successive cycles of ground motion. Liquefaction of granular soil layers typically results in settlements in the form of depressions filled with water.

The ‘Liquefy” program is based on NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022, SP117, Southern California Earthquake Center.

The proposed wall is considered as a Critical Risk Category Structure and therefore a Factor of Safety of 1.1 was used in our liquefaction analyses. Our liquefaction analyses considered Fines Corrections during liquefaction using Idriss and Seed Method and settlement analysis of all zones using Ishihara and Yoshimine Method.

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Liquefaction analyses results for the subsurface conditions encountered in borings B-101, B-102 and B-103 showed the presence of potentially liquefiable soils down to elevations -66 feet,-45 feet and -20 feet, respectively,

Based on the current available data on sites where liquefaction was observed throughout the world, it appears that the depth of liquefiable soils is limited to about 60 feet below the grade regardless of the presence of potentially liquefiable soils below those depths. Therefore, we have limited to the liquefiable depth to Elevation -58 feet.

Based on the liquefaction analyses, the liquefaction settlement of about 7 to 22 inches is anticipated throughout the site. The liquefaction analyses are presented in Appendix D

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6.0 RETAINING WALL RECOMMENDATIONS

Based on discussions with Urban Engineers and NAVFAC Southeast, the proposed new bulkhead will system will consist of improved soil mass using deep soil mixing to avoid liquefaction behind the existing wall and to increase stability will be used. As requested by the NAVFAC, an undrained cohesion value of 150 psi for the improved soil and flowable fills was used in our analyses. We understand that this value includes the necessary factor of safety values based on the intended field quality assurance program and environmental factors such as contractors experience etc. The top of the new wall will be tied by a horizontal anchor above the water level directly behind the improved soil mass. In addition, the improved soil mass will help reduce the lateral earth pressure on the new and existing wall substantially, which will help to minimize the required sheet pile embedment. The space between the new and existing wall will be filled with flowable fills. Further, the flowable fill are in the vicinity of boring B-101 will be supported by pin piles.

6.1 Design Earth Pressure Recommendations

Design earth pressure diagrams are developed for the full height of the wall with one anchor that is installed at Elevation 3 feet. The developed design pressure diagrams are applicable for the walls that are built to their full heights in this project. The design earth pressure diagrams are developed for the portions of the wall near borings B-101, B-102 and B-103. Following assumptions are made during the development of the earth pressures:

- Design water level is same on both sides of the new and existing wall at Elevation 3 feet.
- Design seismic event is assumed to have 10% exceedance in 5 years (a 475 year return period).
- The retaining wall will likely deflect at least 2 inches during the design seismic event.
- The applicable live load should be applied in addition to these earth pressure loads.

The pressure diagram for the one anchor wall was based on the AASHTO LRDG Bridge Design Specifications (2012). Since the depth of improved soil mass extends the whole retained depth on the wall near borings B-101 and B-102, the higher cohesion values will help stand the improved soil mass itself without exerting any pressure on the wall. However, the ability of the improved soil mass resisting the earth pressure, water pressures and inertia forces under static and seismic conditions was evaluated using simple stability check calculations. The improved soil mass near boring locations B-101 and B-102 were stable under static and seismic conditions and therefore, no earth pressure on the retained portion of the walls will be present near these borings. However, the improved soil mass near boring B-103 is not stable under static and seismic conditions and therefore the earth pressures, water pressures and inertia forces need to be considered when designing the sheet pile wall for static and seismic conditions. The slope stability calculations, stability calculations and earth pressure diagrams are presented in Appendix D. A Factor of Safety value of 1.5 was used on the passive pressure of the embedded portion of the wall.

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7.0 GENERAL SPECIFICATION RECOMMENDATIONS

This report may be made available to prospective bidders for informational purposes. We recommend that the project specifications contain the following statement:

> *Schnabel Engineering Consultants, Inc., has prepared this geotechnical engineering report for this project. This report is for informational purposes only and is not part of the contract documents. The opinions expressed represent the Geotechnical Engineer's interpretation of the subsurface conditions, tests, and the results of analyses performed. Should the data contained in this report not be adequate for the Contractor's purposes, the Contractor may make, before bidding, independent exploration, tests and analyses. This report may be examined by bidders at the office of the Owner, or copies may be obtained from the Owner at nominal charge.*

Additional data and reports prepared by others that could have an impact upon the Contractor's bid should also be made available to prospective bidders for informational purposes.

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8.0 LIMITATIONS

We based the analyses and recommendations submitted in this report on the information obtained from our exploration. We attempted to provide for normal contingencies, but the possibility remains that unexpected conditions may be encountered during construction.

This report has been prepared to aid in the evaluation of this site and to assist in the design of the project. It is intended for use concerning this specific project. We based our recommendations on information on the site and proposed construction as described in this report. Substantial changes in loads, locations, or grades should be brought to our attention so we can modify our recommendations as needed. We would appreciate an opportunity to review the plans and specifications as they pertain to the recommendations contained in this report, and to submit our comments to you based on this review.

We have endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or other instrument of service.

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APPENDIX A

SUBSURFACE EXPLORATION DATA

Subsurface Exploration Procedures
General Notes for Subsurface Exploration Logs
Identification of Soil
Boring Logs, B-101 through B-106
Figure A-1: Test Boring Location Plan
Figures A-2 & 3: Subsurface Cross Sections

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SUBSURFACE EXPLORATION PROCEDURES

Test Borings – Hollow Stem Augers

The borings are advanced by turning an auger with a center opening of 2¼ or 3¼ inches. A plug device blocks off the center opening while augers are advanced. Cuttings are brought to the surface by the auger flights. Sampling is performed through the center opening in the hollow stem auger by standard methods after removal of the plug. Usually, no water is introduced into the boring using this procedure.

Standard Penetration Test Results

The Standard Penetration Test (SPT) is performed in the borings at regular depth intervals to collect soil samples. The numbers in the Sampling Data column of the boring logs represent SPT results. Each number represents the blows needed to drive a 2-inch O.D., 1⅜-inch I.D. split-spoon sampler 6 inches, using a 140-pound hammer falling 30 inches. The sampler is typically driven a total of 18 or 24 inches. The first 6 inches are considered a seating interval. The total of the number of blows for the second and third 6-inch intervals is the SPT "N value." The Standard Penetration Test is performed according to ASTM D1586.

The SPT samples were obtained using a hydraulically driven automatic trip hammer (ATH). Most correlations with SPT data are based on N-values collected with a safety hammer. The energy applied to the split-spoon sampler using the ATH is about 33 percent greater than that applied using the safety hammer, resulting in lower N-values. The hammer blows shown on the boring logs are uncorrected for the higher energy. However, we correct SPT N values for the higher energy when using N values in our analyses.

Soil Classification Criteria

The group symbols on the logs represent the Unified Soil Classification System Group Symbols (ASTM D2487) based on visual observation and limited laboratory testing of the samples. Criteria for visual identification of soil samples are included in this appendix. Some variation can be expected between samples visually classified and samples classified in the laboratory.

Disintegrated rock is defined as residual material with SPT N values between 60 blows per foot and refusal. Refusal is defined as an N value of 50 blows for a penetration of one inch or less.

Partially weathered rock (PWR) is defined as residual material with SPT N values between 100 blows per foot and refusal. Refusal is defined as an N value of 50 blows for a penetration of one inch or less.

Pocket Penetrometer Results

The values following "PP=" in the sampling data column of the logs represent pocket penetrometer readings. Pocket penetrometer readings provide an estimate of the unconfined compressive strength of fine-grained soils.

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GENERAL NOTES FOR SUBSURFACE EXPLORATION LOGS

1. Numbers in sampling data column next to Standard Penetration Test (SPT) symbols indicate blows required to drive a 2-inch O.D., 1⅜-inch I.D. sampling spoon 6 inches using a 140 pound hammer falling 30 inches. The Standard Penetration Test (SPT) N value is the number of blows required to drive the sampler 12 inches, after a 6 inch seating interval. The Standard Penetration Test is performed in general accordance with ASTM D1586.
2. Visual classification of soil is in accordance with terminology set forth in “Identification of Soil.” The ASTM D2487 group symbols (e.g., CL) shown in the classification column are based on visual observations.
3. Estimated water levels indicated on the logs are only estimates from available data and may vary with precipitation, porosity of the soil, site topography, and other factors.
4. Refusal at the surface of rock, boulder, or other obstruction is defined as an SPT resistance of 50 blows for 1 inch or less of penetration.
5. The logs and related information depict subsurface conditions only at the specific locations and at the particular time when drilled or excavated. Soil conditions at other locations may differ from conditions occurring at these locations. Also, the passage of time may result in a change in the subsurface soil and water level conditions at the subsurface exploration location.
6. The stratification lines represent the approximate boundary between soil and rock types as obtained from the subsurface exploration. Some variation may also be expected vertically between samples taken. The soil profile, water level observations and penetration resistances presented on these logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.
7. Key to symbols and abbreviations:

	S-1, SPT 5+10+1	Sample No., Standard Penetration Test Number of blows in each 6-inch increment
	UD-1, UNDIST Rec=24", 100%	Sample No., 2" or 3" Undisturbed Tube Sample Recovery in inches, Percent Recovery
	Run #1, CORE Run = 5.0 ft REC = 60", 100% RQD = 60", 100%	Core No., Rock Core Run length in feet Recovery in inches, Percent Recovery RQD in inches, Percent RQD

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IDENTIFICATION OF SOIL

I. DEFINITION OF SOIL GROUP NAMES (ASTM D2487)

			SYMBOL	GROUP NAME
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels – More than 50% of coarse fraction retained on No. 4 sieve Coarse, ¾" to 3" Fine, No. 4 to ¾"	Clean Gravels Less than 5% fines	GW	WELL GRADED GRAVEL
			GP	POORLY GRADED GRAVEL
		Gravels with fines More than 12% fines	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	Sands – 50% or more of coarse Fraction passes No. 4 sieve Coarse, No. 10 to No. 4 Medium, No. 40 to No. 10 Fine, No. 200 to No. 40	Clean Sands Less than 5% fines	SW	WELL GRADED SAND
			SP	POORLY GRADED SAND
		Sands with fines More than 12% fines	SM	SILTY SAND
			SC	CLAYEY SAND
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays – Liquid Limit less than 50 Low to medium plasticity	Inorganic	CL	LEAN CLAY
			ML	SILT
		Organic	OL	ORGANIC CLAY
				ORGANIC SILT
	Silts and Clays – Liquid Limit 50 or more Medium to high plasticity	Inorganic	CH	FAT CLAY
			MH	ELASTIC SILT
		Organic	OH	ORGANIC CLAY
				ORGANIC SILT
Highly Organic Soils	Primarily organic matter, dark in color and organic odor		PT	PEAT

II. DEFINITION OF SOIL COMPONENT PROPORTIONS (ASTM D2487)

			Examples
Adjective Form	GRAVELLY SANDY	>30% to <50% coarse grained component in a fine-grained soil	GRAVELLY LEAN CLAY
	CLAYEY SILTY	>12% to <50% fine grained component in a coarse-grained soil	SILTY SAND
"With"	WITH GRAVEL WITH SAND	>15% to <30% coarse grained component in a fine-grained soil	FAT CLAY WITH GRAVEL
	WITH GRAVEL WITH SAND	>15% to <50% coarse grained component in a coarse-grained soil	POORLY GRADED GRAVEL WITH SAND
	WITH SILT WITH CLAY	>5% to <12% fine grained component in a coarse-grained soil	POORLY GRADED SAND WITH SILT

III. GLOSSARY OF MISCELLANEOUS TERMS

SYMBOLS ..... Unified Soil Classification Symbols are shown above as group symbols. A dual symbol "-" indicates the soil belongs to two groups. A borderline symbol "/" indicates the soil belongs to two possible groups.

FILL ..... Man-made deposit containing soil, rock and often foreign matter.

PROBABLE FILL ..... Soils which contain no visually detected foreign matter but which are suspect with regard to origin.

DISINTEGRATED ROCK (DR) ..... Residual materials with a standard penetration resistance (SPT) between 60 blows per foot and refusal. Refusal is defined as an SPT of 100 blows for 2" or less penetration.

PARTIALLY WEATHERED ROCK (PWR)..... Residual materials with a standard penetration resistance (SPT) between 100 blows per foot and refusal. Refusal is defined as an SPT of 100 blows for 2" or less penetration.

BOULDERS & COBBLES..... Boulders are considered rounded pieces of rock larger than 12 inches, while cobbles range from 3 to 12-inch size.

LENSES..... 0 to ½-inch seam within a material in a test pit.

LAYERS ..... ½ to 12-inch seam within a material in a test pit.

POCKET ..... Discontinuous body within a material in a test pit.

MOISTURE CONDITIONS..... Wet, moist or dry to indicate visual appearance of specimen.

COLOR..... Overall color, with modifiers such as light to dark or variation in coloration.

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Schnabel ENGINEERING — **TEST BORING LOG**

Project: Wharf Bravo
Guantanamo Bay, Cuba

Boring Nunber: **B101**
Contract Number: 15619016.00
Sheet: 1 of 3

Contractor: F&R Inc.
Chesapeake, Virginia
Contractor Foreman: Kenny Abbott
Schnabel Representative: Richard Wargo
Equipment: CME-55 (Truck)
Method: 2-1/4" ID Hollow Stem Auger
Hammer Type: Auto Hammer (140 lb)
Dates Started: 7/8/15 **Finished:** 7/9/15
Latitude: 19.91628 **Longitude:** -75.15191
Plunge: -90 **Bearing:**
Ground Surface Elevation: 4± (ft) **Total Depth:** 99.1 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
After Drilling ▽	7/10	10:00 AM	3.3'	---	75.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	10" concrete core							
0.8	FILL clayey sand, fine to medium grained sand; moist, light brown, contains coral fragments	FILL	3.3			SPT 5+3+2+3	MC = 20.0%	
3.0	FILL sandy silt; moist, dark gray, contains fine to medium sand, diesel odor ▽	FILL	1.1			SPT 2+4+4+4	MC = 22.5%	
5.0	FILL sandy lean clay; wet, dark gray, contains fine to medium sand	FILL	-0.9		5	SPT 1+1+1+2		
7.0	FILL silty sand, fine to medium grained sand; wet, dark gray, contains gravel	FILL	-2.9			SPT 1/12+1"	MC = 26.7%	
9.0	FILL sandy silt; wet, dark gray, contains fine to medium sand, contains gravel	FILL	-4.9		10	SPT 1+1+1+1	MC = 32.4%	
				A	15	SPT 1+1+2+2		
	Change: grayish brown				20	SPT 1+2+2		
24.0	FILL silty sand, fine to coarse grained sand; moist, grayish brown, contains gravel	FILL	-19.9		25	SPT 1+1+2	MC = 40.5%	
	Change: contains coral fragments					SPT 2+3+2		

(continued)

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 9/3/15

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B101** Contract Number: 15619016.00 Sheet: 2 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	FILL silty sand, fine to coarse grained sand; moist, grayish brown, contains gravel *(continued)*	FILL		A				
34.0			-29.9					
	POORLY GRADED SAND WITH SILT, fine to coarse grained sand; wet, brown	SP-SM			35	SPT 2+3+6	MC = 31.6%	
35.0			-30.9					
	SILTY SAND, fine to coarse grained sand; moist, grayish brown, contains gravel coral & shell fragments	SM						
39.0			-34.9	A1				
	SILTY SAND WITH GRAVEL, fine to coarse grained sand; wet, gray	SM			40	SPT 3+3+4	MC = 28.8%	
44.0			-39.9					
	CLAYEY SAND, fine to coarse grained sand; wet, gray, contains coral & shell fragments	SC			45	SPT 1+2+3	MC = 42.4%	
49.0			-44.9					
	Coral fragments, contains fine grained sandy lean clay; wet, gray	GP			50	SPT 2+3+4		
54.0			-49.9					
	SANDY LEAN CLAY; wet, gray, contains fine to coarse, contains coral & rock fragments	CL		B	55	SPT 4+4+4	MC = 47.0%	
59.0			-54.9					
	SILTY SAND, fine to medium grained sand; wet, gray, contains shell fragments	SM			60	SPT 2+3+2	MC = 27.3%	
64.0			-59.9					
	SILTY SAND, fine to coarse grained sand; wet, gray, contains gravel & coral fragments	SM			65	SPT 8+6+10		
69.0			-64.9					
		SP-SM		C	70	SPT 6+7+11		

(continued)

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B101** Contract Number: 15619016.00 Sheet: 3 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
70.5	POORLY GRADED SAND, fine to medium grained sand; wet, gray with speckles of black, contains shell fragments *(continued)*		-66.4					
	LEAN CLAY WITH SAND, fine to medium grained sand; moist, light brown, contains fine grained sand	CL			75	SPT 8+12+18	MC = 23.6% LL = 43 PL = 22 MC = 23.6% % Passing #200 = 81.3	
79.5	CLAYEY SAND, fine grained sand; moist, light brown	SC	-75.4	C	80	SPT 8+12+16	MC = 23.1%	
84.5	LEAN CLAY WITH SAND; moist, light brown, contains fine grained sand	CL	-80.4		85	SPT 8+11+15	MC = 24.1%	
89.0	CLAYEY SAND, fine grained sand; moist, light brown, contains gravel	SC	-84.9		90	SPT 50/2.5"		
94.0	POORLY GRADED SAND WITH SILT, fine to medium grained sand; wet, brown with speckles of black	SP-SM	-89.9		95	SPT 22+40+10/1"	MC = 26.3%	
95.0	DISINTEGRATED ROCK; dry, gray	DR	-90.9	D				
99.1			-95.0			SPT 50/1"		

Bottom of Boring at 99.1 ft.
Boring terminated at selected depth.
Boring backfilled with cement upon completion.

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B102** Contract Number: 15619016.00 Sheet: 1 of 3

Contractor: F&R Inc.
Chesapeake, Virginia

Contractor Foreman: Kenny Abbott

Schnabel Representative: Richard Wargo

Equipment: CME-55 (Truck)

Method: 2-1/4" ID Hollow Stem Auger

Hammer Type: Auto Hammer (140 lb)

Dates Started: 7/10/15 **Finished:** 7/10/15

Latitude: 19.91566 **Longitude:** -75.15183

Plunge: -90 **Bearing:**

Ground Surface Elevation: 6± (ft) **Total Depth:** 100.5 ft

Groundwater Observations

Date	Time	Depth	Casing	Caved

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.8	9.8" concrete core		5.0			SPT 5+3+7+7		
3.0	FILL clayey sand, fine to coarse grained sand; moist, light brown, contains gravel Change: dark brown Change: dark gray, contains gravel	FILL	2.8	A	5	SPT 3+3+5+3 SPT 2+2+3+3 SPT 1+2+2+2	MC = 18.4%	
					10	SPT 1+2+1+1		
15.0	Change: wet, gray CLAYEY SAND, fine to coarse grained sand; wet, gray, contains shell & gravel fragments	SC	-9.2	A1	15	SPT 2+1+2	LL = 42 PL = 23 MC = 39.1% % Passing #200 = 40.8	
	Change: contains coral fragments				20	SPT 2+1+2		
					25	SPT 2+2+2		
						SPT 2+2+2		

(continued)

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 9/3/15

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B102** Contract Number: 15619016.00 Sheet: 2 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	CLAYEY SAND, fine to coarse grained sand; wet, gray, contains shell & gravel fragments *(continued)*	SC		A1	35	SPT 3+2+3		
39.0	SILTY SAND, fine to coarse grained sand; wet, gray, contains coral & shell fragments	SM	-33.2		40	SPT 3+2+5	MC = 28.3%	
					45	SPT 2+2+4		
					50	SPT 7+14+11	MC = 22.4%	
	Change: contains clayey sand pockets			B	55	SPT 6+14+27	MC = 26.8%	
59.0	SANDY LEAN CLAY, fine to coarse grained sand; moist, brown, trace gravel	CL	-53.2		60	SPT 9+20+22	LL = 39 PL = 24 MC = 31.6% % Passing #200 = 60.1	
64.0	CLAYEY SAND WITH GRAVEL, fine to coarse grained sand; moist, dark brown	SC	-58.2		65	SPT 8+19+49	MC = 25.8%	
69.0		SP	-63.2		70	SPT 10+17+21	MC = 17.9%	

(continued)

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B102** Contract Number: 15619016.00 Sheet: 3 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	POORLY GRADED SAND, fine to coarse grained sand; wet, dark brown, contains gravel *(continued)*	SP		B				
74.5	SILTY SAND, fine to medium grained sand; moist, dark brown		-68.7		75	SPT 5+16+20	MC = 21.2%	
	Change: contains gravel	SM			80	SPT 17+33+50		
84.0	CLAYEY SAND, fine to coarse grained sand; moist, gray		-78.2		85	SPT 8+12+16	MC = 21.5%	
		SC		C	90	SPT 4+10+14	LL = 32 PL = 20 MC = 24.8% % Passing #200 = 63.9	
90.5	SILTY SAND; moist, brown		-84.7					
		SM			95	SPT 21+50/3"	MC = 15.2%	
	Change: fine to medium grained sand; contains rock fragments				100	SPT 30+22+35	MC = 13.3%	
100.5			-94.7					

Bottom of Boring at 100.5 ft.
Boring terminated at selected depth.
Boring backfilled with cement upon completion.

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 9/3/15

Schnabel ENGINEERING — **TEST BORING LOG**

Project: Wharf Bravo
Guantanamo Bay, Cuba

Boring Nunber: **B103**
Contract Number: 15619016.00
Sheet: 1 of 3

Contractor: F&R Inc.
Chesapeake, Virginia
Contractor Foreman: Kenny Abbott
Schnabel Representative: Richard Wargo
Equipment: CME-55 (Truck)
Method: 2-1/4" ID Hollow Stem Auger
Hammer Type: Auto Hammer (140 lb)
Dates Started: 7/10/15 **Finished:** 7/13/15
Latitude: 19.91515 **Longitude:** -75.15177
Plunge: -90 **Bearing:**
Ground Surface Elevation: 6± (ft) **Total Depth:** 99.3 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Completion	7/14	8:40 AM	5.0'	---	78.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.6	7" concrete core		5.2					
	FILL silty sand, fine to coarse grained sand; moist, brown, contains gravel Change: dark brown	FILL				SPT 7+5+5+8	MC = 18.9%	
3.0	FILL lean clay with sand; moist, dark gray, contains fine grained sand	FILL	2.8			SPT 5+7+8+7		
4.0	FILL silty sand with gravel, fine to coarse grained sand; moist, dark brown Change: wet, dark gray, fuel odor	FILL	1.8		5	SPT 4+6+4+3		
						SPT 4+3+1+2		
	Change: no odor	FILL		A	10	SPT 3+3+3+2		
					15	SPT 1+1+2	MC = 42.9%	
19.0	CLAYEY SAND, fine to coarse grained sand; wet, gray, contains coral fragments	SC	-13.2		20	SPT 2+2+3	MC = 27.9%	
24.0	LEAN CLAY WITH SAND; wet, brown, contains fine grained sand, contains coral fragments	CL	-18.2	A1	25	SPT 1+2+2	MC = 40.7%	
						SPT 2+2+30		

(continued)

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 9/3/15

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B103** Contract Number: 15619016.00 Sheet: 2 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	LEAN CLAY WITH SAND; wet, brown, contains fine grained sand, contains coral fragments *(continued)*	CL		A1				
34.0	SILTY SAND, fine to coarse grained sand; moist, dark brown, contains gravel	SM	-28.2		35	SPT 10+30+35	MC = 17.1%	
					40	SPT 17+23+27		
					45	SPT 10+17+21		
49.0	SILTY SAND, fine to medium grained sand; moist, brown, contains gravel	SM	-43.2	B	50	SPT 22+20+23		
55.0	CLAYEY SAND, fine grained sand; moist, brown	SC	-49.2		55	SPT 11+14+19	MC = 24.9%	
					60	SPT 5+7+11	MC = 30.9%	
					65	SPT 9+11+15	MC = 25.3%	
					70	SPT 4+8+12	MC = 24.2%	

(continued)

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B103** Contract Number: 15619016.00 Sheet: 3 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	CLAYEY SAND, fine grained sand; moist, brown *(continued)*	SC		B				
74.0	SILTY SAND, fine to coarse grained sand; moist, brown, contains gravel	SM	-68.2		75	SPT 7+13+19	MC = 21.1%	
80.0	SAND WITH SILT, fine to coarse grained sand; wet, dark brown, contains rock fragments	SP-SM	-74.2		80	SPT 12+26+25	MC = 25.5%	
84.0	LEAN CLAY WITH SAND; moist, brown, contains fine to medium sand, contains rock fragments	CL	-78.2	C	85	SPT 19+14+19	MC = 20.3%	
89.0	CLAYEY SAND; moist, light brown, contains gravel	SC	-83.2		90	SPT 6+10+12	MC = 33.8%	
94.0	POORLY GRADED SAND WITH SILT, fine to coarse grained sand; wet, brown with speckles of black, contains gravel Change: contains rock fragments	SP-SM	-88.2		95	SPT 7+7+24	MC = 21.2%	
99.0	Change: DISINTEGRATED ROCK; dry, brown	DR	-93.2	D		SPT 50/4"		

Bottom of Boring at 99.3 ft.
Boring terminated at selected depth.
Boring backfilled with cement upon completion.

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 9/3/15

Schnabel ENGINEERING — **TEST BORING LOG**

Project: Wharf Bravo
Guantanamo Bay, Cuba

Boring Nunber: **B104**
Contract Number: 15619016.00
Sheet: 1 of 3

Contractor: F&R Inc.
Chesapeake, Virginia
Contractor Foreman: Kenny Abbott
Schnabel Representative: Richard Wargo
Equipment: CME-55 (Truck)
Method: 2-1/4" ID Hollow Stem Auger
Hammer Type: Auto Hammer (140 lb)
Dates Started: 7/8/15 **Finished:** 7/8/15
Latitude: 19.91633 **Longitude:** -75.15180
Plunge: -90 **Bearing:**
Ground Surface Elevation: 4± (ft) **Total Depth:** 75.5 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Completion	7/9	10:00 AM	3.2'	---	55.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	10" concrete core							
0.8	FILL sandy silt; moist, grayish brown, contains fine to medium sand, contains fine gravel	FILL	2.8			SPT 4+3+2+2	MC = 20.7%	
3.0	FILL sandy lean clay; wet, grayish brown, contains fine to coarse		0.6			SPT 2+1+3+4	MC = 27.1%	
	Change: contains gravel				5	SPT 2+5+7+3		
						SPT 2+3+3+2		
	Change: brownish gray, contains coral fragments	FILL			10	SPT 1+1+2+2	MC = 28.2%	
14.0	FILL clayey sand, fine to medium grained sand; wet, brownish gray, trace coral fragments	FILL	-10.4	A	15	SPT 1+2+2+2	LL = 42 PL = 22 MC = 27.0% % Passing #200 = 43.4	
19.0	FILL silty sand, fine to coarse grained sand; wet, gray, contains coral and shell fragments	FILL	-15.4		20	SPT 7+2+3	MC = 40.6%	
24.0	FILL sandy lean clay; wet, gray, contains fine grained sand	FILL	-20.4		25	SPT 1/12+1"	MC = 42.4%	
	Change: contains shell fragments,					SPT 2+2+3		

(continued)

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B104** Contract Number: 15619016.00 Sheet: 2 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	diesel odor FILL sandy lean clay; wet, gray, contains fine grained sand *(continued)*	FILL		A				
34.0	wet, gray, coral fragments, contains fine sandy lean clay	GP	-30.4		35	SPT 6+5+2		
39.0	SANDY LEAN CLAY; wet, gray, contains fine to coarse, contains coral fragments	CL	-35.4	A1	40 45	SPT 2+2+2 SPT 2+2+2		
49.0	CLAYEY SAND, fine to medium grained sand; gray, contains shell fragments	SC	-45.4		50 55	SPT 2+2+2 SPT 2+3+2	MC = 31.6%	
59.0	CLAYEY SAND, fine to medium grained sand; moist, dark gray, contains peat	SC	-55.4	B	60	SPT 1+1+2		
64.0	SANDY LEAN CLAY; wet, gray, contains fine to medium sand, contains coral fragments	CL	-60.4		65	SPT 3+2+1	MC = 36.2%	
69.0		SP-SM	-65.4		70	SPT 13+19+17	MC = 23.3%	

(continued)

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B104** Contract Number: 15619016.00 Sheet: 3 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	POORLY GRADED SAND WITH SILT, fine to medium grained sand; wet, gray with speckles of black, contains shell and rock fragments *(continued)*	SP-SM		B				
74.0	POORLY GRADED SAND, fine to coarse grained sand; wet, contains shell and rock fragments	SP	-70.4		75	SPT 17+28+26	MC = 13.7%	
75.3	LEAN CLAY WITH SAND; moist, light brown, contains fine grained sand	CL	-71.7	C				
75.5			-71.9					

Bottom of Boring at 75.5 ft.
Boring terminated at selected depth.
Boring backfilled with cement upon completion.

Schnabel ENGINEERING **TEST BORING LOG**

Project: Wharf Bravo
Guantanamo Bay, Cuba

Boring Nunber: **B105**
Contract Number: 15619016.00
Sheet: 1 of 3

Contractor: F&R Inc.
Chesapeake, Virginia
Contractor Foreman: Kenny Abbott
Schnabel Representative: Richard Wargo
Equipment: CME-55 (Truck)
Method: 2-1/4" ID Hollow Stem Auger
Hammer Type: Auto Hammer (140 lb)
Dates Started: 7/9/15 **Finished:** 7/9/15
Latitude: 19.91597 **Longitude:** -75.15174
Plunge: -90 **Bearing:**
Ground Surface Elevation: 5± (ft) **Total Depth:** 74.8 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Completion	7/10	2:00 PM	4.5'	---	59.5'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.7	7.5-inch concrete core		4.4					
	FILL silty sand, fine to coarse grained sand; dry, light brown and dark brown, contains coral fragments Change: wet	FILL				SPT 5+4+6+3 SPT 2+2+2+1	MC = 30.0%	
5.0	FILL poorly graded sand with silt, fine to coarse grained sand; wet, brown, contains gravel Change: gray	FILL	0.1		5	SPT 2+1+1+1 SPT 1+1/12+1"		
9.0	FILL clayey sand, fine to coarse grained sand; wet, gray, with coral & rock fragments		-3.9		10	SPT 1+1+1+1	LL = 49 PL = 25 MC = 50.8% % Passing #200 = 30.8	
				A	15	SPT 1+1+1		
	Change: contains coral gravel & shell fragments	FILL			20	SPT 1+1+1	MC = 42.6%	
					25	SPT 4+1+3		
						SPT 4+10+6	MC = 31.9%	

(continued)

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 9/3/15

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B105** Contract Number: 15619016.00 Sheet: 2 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	FILL clayey sand, fine to coarse grained sand; wet, gray, with coral & rock fragments *(continued)*	FILL		A	35	SPT 5+8+14		
39.0	SILTY SAND, fine to medium grained sand; moist, brown	SM	-33.9		40	SPT 14+27+34		
44.0	POORLY GRADED SAND, fine to coarse grained sand; wet, brown with speckles of black, trace silt	SP	-38.9	B	45	SPT 7+13+13		
49.0	POORLY GRADED SAND WITH GRAVEL, fine to coarse grained sand; wet, brown, trace silt	SP	-43.9		50	SPT 5+18+16	MC = 37.6%	
50.0	CLAYEY SAND, fine grained sand; moist, brown	SC	-44.9					
54.0	FAT CLAY; moist, brown, contains fine grained sand	CH	-48.9		55	SPT 8+14+21	LL = 59 PL = 27 MC = 26.5% % Passing #200 = 90.6	
59.0	SILTY SAND, fine grained sand; moist, brown	SM	-53.9	C	60	SPT 8+12+18	MC = 24.6%	
64.0	FAT CLAY; moist, brown and gray, contains fine grained sand	CH	-58.9		65	SPT 4+10+15	LL = 66 PL = 28 MC = 24.6% % Passing #200 = 92.2	
70.0		SM	-64.9		70	SPT 5+12+16	MC = 25.0%	

(continued)

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B105** Contract Number: 15619016.00 Sheet: 3 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	SILTY SAND, fine grained sand; moist, brown *(continued)*	SM		C				
74.0 74.5 74.8	SANDY LEAN CLAY; moist, dark brown, contains fine to coarse brown, probable DISINTEGRATED RK material	CL	-68.9 -69.4 -69.7	D		SPT 18+50/3"	MC = 12.0%	

Bottom of Boring at 74.8 ft.
Boring terminated at selected depth.
Boring backfilled with cement upon completion.

Schnabel ENGINEERING — **TEST BORING LOG**

Project: Wharf Bravo
Guantanamo Bay, Cuba

Boring Nunber: **B106**
Contract Number: 15619016.00
Sheet: 1 of 3

Contractor: F&R Inc.
Chesapeake, Virginia
Contractor Foreman: Kenny Abbott
Schnabel Representative: Richard Wargo
Equipment: CME-55 (Truck)
Method: 2-1/4" ID Hollow Stem Auger
Hammer Type: Auto Hammer (140 lb)
Dates Started: 7/13/15 **Finished:** 7/13/15
Latitude: 19.91534 **Longitude:** -75.15169
Plunge: -90 **Bearing:**
Ground Surface Elevation: 5± (ft) **Total Depth:** 75.5 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Completion	7/14	8:30 AM	5.0'	---	63.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	10-inch concrete core							
0.9	FILL clayey sand, fine to coarse grained sand; moist, brown and gray, contains gravel	FILL	4.4	A		SPT 6+9+9+5		
	Change: brown					SPT 3+3+2+3	MC = 15.2%	
	Change: dark gray, contains coral fragments				5	SPT 2+1+2+2	MC = 26.5%	
	Change: no coral fragments, contains rock fragments					SPT 1+3+4+5		
	Change: wet, gray, organic odor				10	SPT 6+3+2+3		
	Change: contains shell fragments, organic odor				15	SPT WOH/18"	MC = 46.6%	
19.0	POORLY GRADED SAND, fine to coarse grained sand; wet, gray, contains coral fragments	SP	-13.7		20	SPT 6+7+8		
24.0	SANDY LEAN CLAY; wet, light brown, contains fine grained sand, contains coral fragments	CL	-18.7	A1	25	SPT 1+1+1	MC = 39.6%	
						SPT 2+2+6	MC = 43.0%	

(continued)

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B106** Contract Number: 15619016.00 Sheet: 2 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
30.0	SANDY SILT; moist, dark brown, contains fine to medium sand, contains gravel	ML	-24.7					
34.5	POORLY GRADED SAND WITH SILT, fine to coarse grained sand; moist, brown, contains gravel	SP-SM	-29.2	B	35	SPT 15+28+40		
					40	SPT 15+20+31	LL = 40 PL = 30 MC = 16.5% % Passing #200 = 10.3	
44.0	POORLY GRADED SAND, fine to coarse grained sand; wet, dark brown, contains gravel	SP	-38.7		45	SPT 34+26+35	MC = 16.3%	
45.0	SILTY SAND, fine to coarse grained sand; moist, dark brown, contains gravel	SM	-39.7					
49.0	POORLY GRADED SAND WITH SILT, fine to coarse grained sand; wet, dark brown	SP	-43.7		50	SPT 12+20+21		
54.0	FAT CLAY WITH SAND, fine to medium grained sand; moist, brown, contains fine grained sand	CH	-48.7		55	SPT 8+14+24	LL = 53 PL = 27 MC = 26.0% % Passing #200 = 88.8	
60.0	SANDY SILT; moist, brown, contains fine grained sand	ML	-54.7	C	60	SPT 12+17+28	MC = 21.7%	
64.0	FAT CLAY WITH SAND, fine to medium grained sand; moist, brown, contains fine grained sand	CH	-58.7		65	SPT 9+14+20	LL = 51 PL = 27 MC = 25.2% % Passing #200 = 82.8	
					70	SPT 5+11+18	MC = 19.6%	

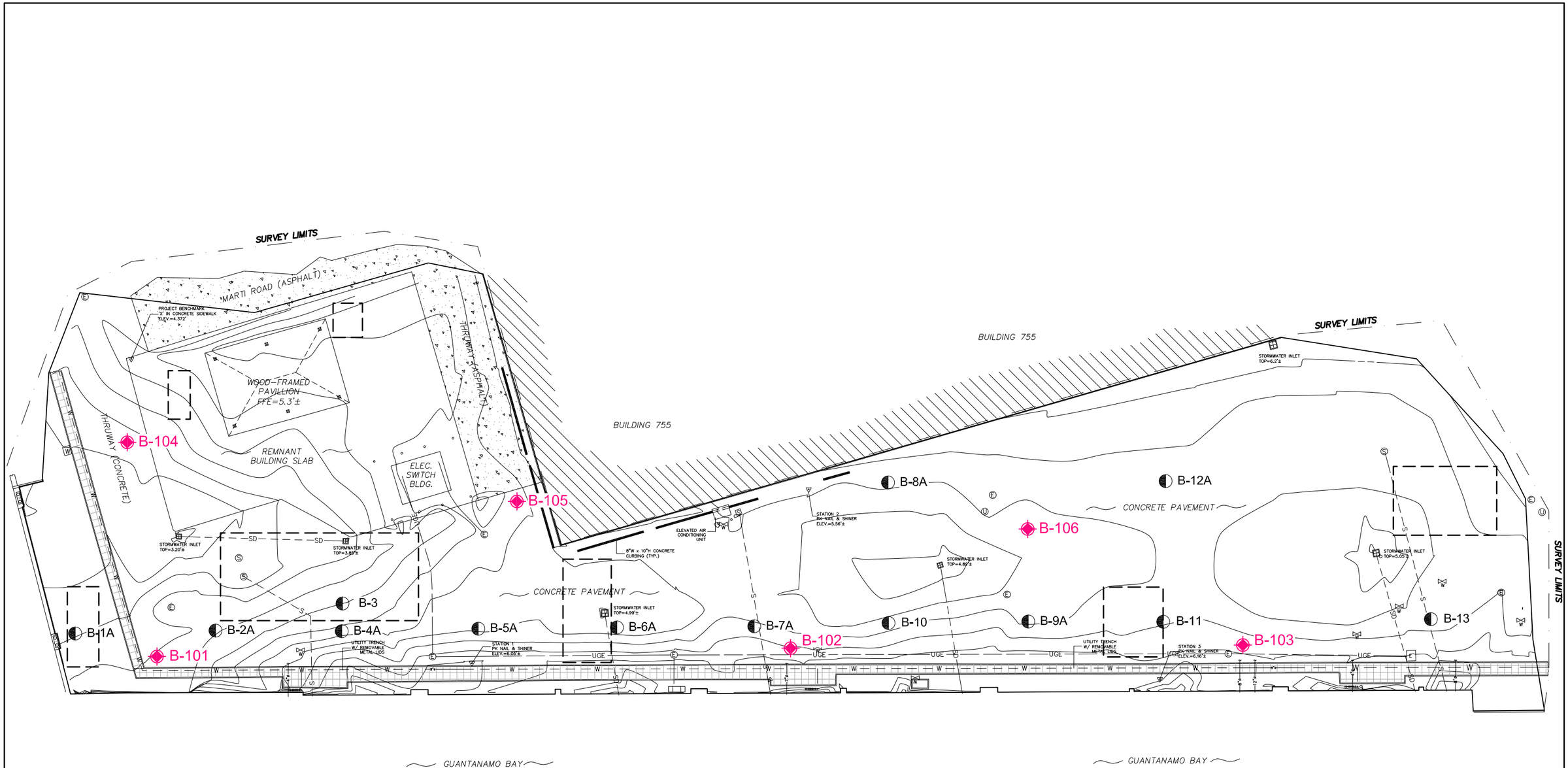
(continued)

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 9/3/15

Schnabel ENGINEERING TEST BORING LOG	Project: Wharf Bravo Guantanamo Bay, Cuba	Boring Nunber: **B106** Contract Number: 15619016.00 Sheet: 3 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	FAT CLAY WITH SAND, fine to medium grained sand; moist, brown, contains fine grained sand *(continued)*	CH		C				
					75	SPT 15+32+20	MC = 14.1%	
75.5	Change: contains rock fragments		-70.2					

Bottom of Boring at 75.5 ft.
Boring terminated at selected depth.
Boring backfilled with cement upon completion.



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SCALE: 1"=40'

0 40' 80'

B-101 THRU B-106
AS-DRILLED BORING LOCATIONS

PREVIOUS (1995) BORING
LOCATIONS

Schnabel ENGINEERING	WHARF BRAVO GUANTANAMO BAY, CUBA	DRAWN BY: CAB	DATE: 09/03/2015	TEST BORING LOCATION PLAN
		CHECKED BY: RHW	SCALE: 1" = 40'	PROJECT NO. 15619016.00 FIGURE A-1

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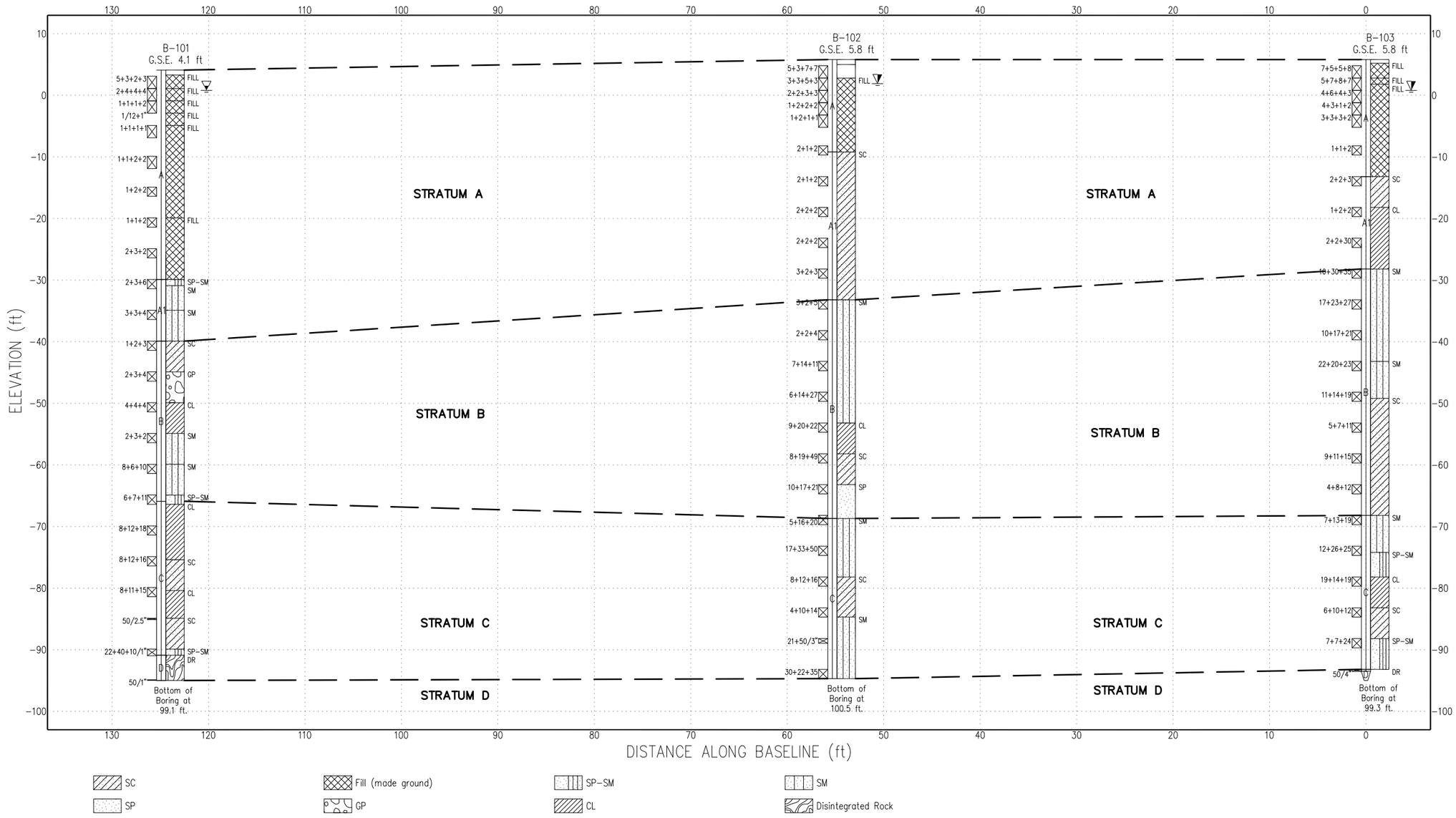

Schnabel ENGINEERING	WHARF BRAVO GUANTANAMO BAY, CUBA	DRAWN BY: CAB	DATE: 09/03/2015	SUBSURFACE CROSS SECTION
		CHECKED BY: RHW	SCALE: AS SHOWN	PROJECT NO. 15619016.00 FIGURE A-2

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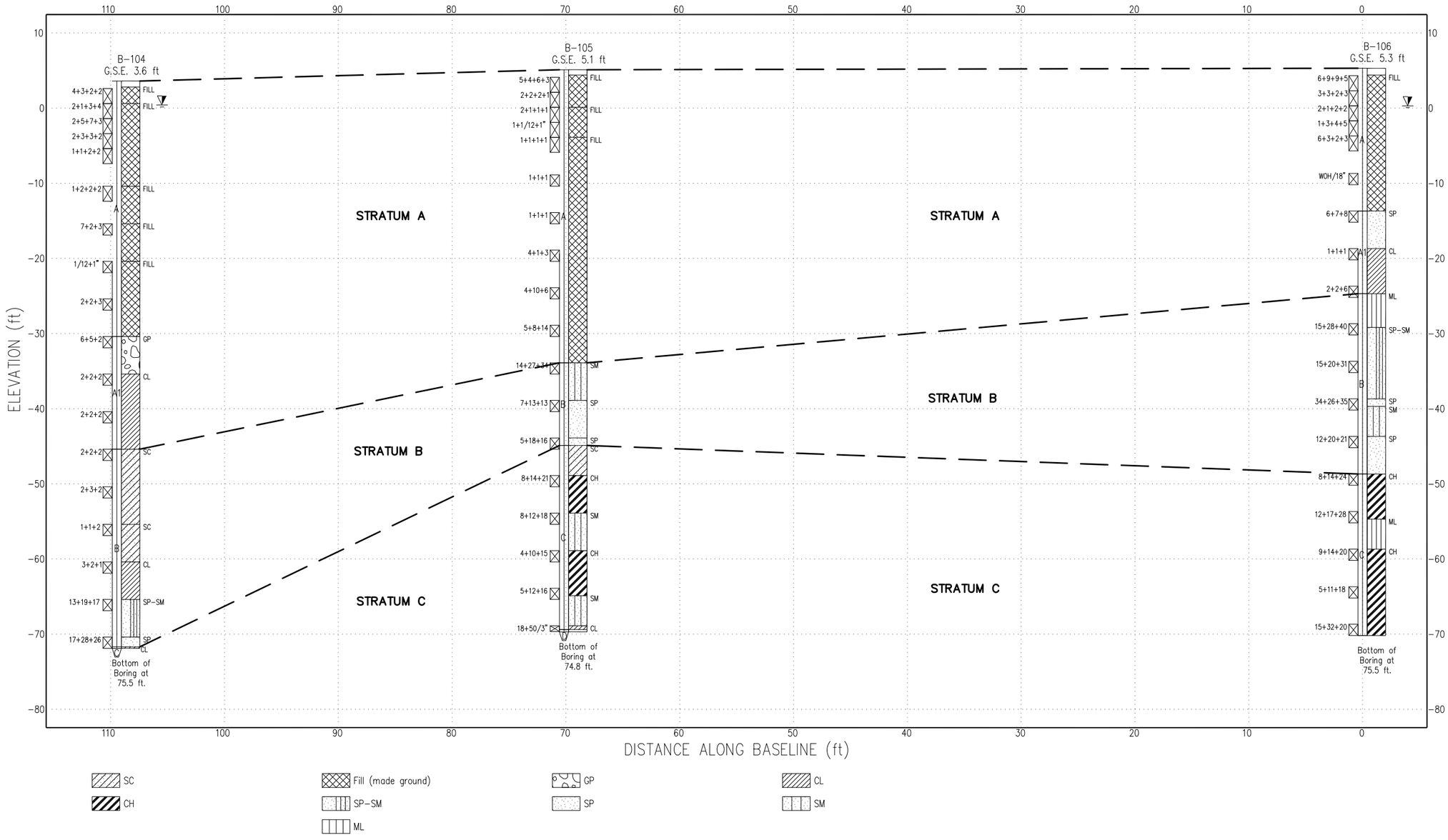

Schnabel ENGINEERING	WHARF BRAVO GUANTANAMO BAY, CUBA	DRAWN BY: CAB	DATE: 09/03/2015	SUBSURFACE CROSS SECTION
		CHECKED BY: RHW	SCALE: AS SHOWN	PROJECT NO. 15619016.00 FIGURE A-3

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APPENDIX B

SOIL LABORATORY TEST DATA

Summary of Laboratory Tests
Gradation Curves

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Summary Of Laboratory Tests

Project Number: 15619016.00

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B101	0.8 / 3.3	Bag		A	--	--	--	20.0	--	--
B101	3.0 / 1.1	Bag		A	--	--	--	22.5	--	--
B101	7.0 / -2.9	Bag		A	--	--	--	26.7	--	--
B101	9.0 / -4.9	Bag		A	--	--	--	32.4	--	--
B101	24.0 / -19.9	Bag		A	--	--	--	40.5	--	--
B101	34.0 / -29.9	Bag		A1	--	--	--	31.6	--	--
B101	39.0 / -34.9	Bag		A1	--	--	--	28.8	--	--

Notes:
1. Soil tests in general accordance with ASTM standards.
2. Soil classifications are in general accordance with ASTM D2487(as applicable), based on testing indicated and visual classification.
3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed

Schnabel ENGINEERING

Project: Wharf Bravo
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B101	44.0 / -39.9	Bag		B	--	--	--	42.4	--	--
B101	54.0 / -49.9	Bag		B	--	--	--	47.0	--	--
B101	59.0 / -54.9	Bag		B	--	--	--	27.3	--	--
B101	73.5 / -69.4	Bag		C	--	--	--	23.6	--	--
B101	74.0 - 75.5 / -69.9 - -71.4	Bag	LEAN CLAY with fine to medium sand (CL), gray	C	43	22	21	23.6	81.3	0.0
B101	79.0 / -74.9	Bag		C	--	--	--	23.1	--	--
B101	83.5 / -79.4	Bag		C	--	--	--	24.1	--	--

Notes:
1. Soil tests in general accordance with ASTM standards.
2. Soil classifications are in general accordance with ASTM D2487(as applicable), based on testing indicated and visual classification.
3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed

Schnabel ENGINEERING

Project: Wharf Bravo
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B101	93.5 / -89.4	Bag		C	--	--	--	26.3	--	--
B102	3.0 / 2.8	Bag		A	--	--	--	18.4	--	--
B102	14.0 - 15.5 / -8.2 - -9.7	Bag	CLAYEY fine to coarse SAND with coral and rock fragments (SC), gray	A	42	23	19	39.1	40.8	26.7
B102	39.0 / -33.2	Bag		B	--	--	--	28.3	--	--
B102	49.0 / -43.2	Bag		B	--	--	--	22.4	--	--
B102	53.5 / -47.7	Bag		B	--	--	--	26.8	--	--
B102	59.0 - 60.5 / -53.2 - -54.7	Bag	Fine to coarse SANDY LEAN CLAY (CL), trace gravel, brown	B	39	24	15	31.6	60.1	6.2

Notes:
1. Soil tests in general accordance with ASTM standards.
2. Soil classifications are in general accordance with ASTM D2487(as applicable), based on testing indicated and visual classification.
3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed

Schnabel ENGINEERING

Project: Wharf Bravo
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B102	64.0 / -58.2	Bag		B	--	--	--	25.8	--	--
B102	69.0 / -63.2	Bag		B	--	--	--	17.9	--	--
B102	74.0 / -68.2	Bag		C	--	--	--	21.2	--	--
B102	84.0 / -78.2	Bag		C	--	--	--	21.5	--	--
B102	89.0 - 90.5 / -83.2 - -84.7	Bag	CLAYEY fine to coarse SAND (SC), gray	C	32	20	12	24.8	63.9	0.0
B102	93.5 / -87.7	Bag		C	--	--	--	15.2	--	--
B102	98.5 / -92.7	Bag		C	--	--	--	13.3	--	--

Notes:
1. Soil tests in general accordance with ASTM standards.
2. Soil classifications are in general accordance with ASTM D2487(as applicable), based on testing indicated and visual classification.
3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed

Schnabel ENGINEERING

Project: Wharf Bravo
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B103	1.0 / 4.8	Bag		A	--	--	--	18.9	--	--
B103	13.5 / -7.7	Bag		A	--	--	--	42.9	--	--
B103	19.0 / -13.2	Bag		A1	--	--	--	27.9	--	--
B103	24.0 / -18.2	Bag		A1	--	--	--	40.7	--	--
B103	34.0 / -28.2	Bag		B	--	--	--	17.1	--	--
B103	53.5 / -47.7	Bag		B	--	--	--	24.9	--	--
B103	59.0 / -53.2	Bag		B	--	--	--	30.9	--	--

Notes:
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Schnabel ENGINEERING

Project: Wharf Bravo
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B103	64.0 / -58.2	Bag		B	--	--	--	25.3	--	--
B103	69.0 / -63.2	Bag		B	--	--	--	24.2	--	--
B103	74.0 / -68.2	Bag		C	--	--	--	21.1	--	--
B103	79.0 / -73.2	Bag		C	--	--	--	25.5	--	--
B103	84.0 / -78.2	Bag		C	--	--	--	20.3	--	--
B103	89.0 / -83.2	Bag		C	--	--	--	33.8	--	--
B103	94.0 / -88.2	Bag		C	--	--	--	21.2	--	--

Notes:
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3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed

Schnabel ENGINEERING

Project: Wharf Bravo
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B104	1.0 - 2.5 / 2.6 - 1.1	Bag		A	--	--	--	20.7	--	--
B104	3.0 - 4.5 / 0.6 - -0.9	Bag		A	--	--	--	27.1	--	--
B104	8.5 - 10.0 / -4.9 - -6.4	Bag		A	--	--	--	28.2	--	--
B104	14.0 - 16.0 / -10.4 - -12.4	Bag	CLAYEY fine to coarse SAND (SC), trace gravel, gray	A	42	22	20	27.0	43.4	10.1
B104	19.0 - 20.5 / -15.4 - -16.9	Bag		A	--	--	--	40.6	--	--
B104	24.0 - 25.5 / -20.4 - -21.9	Bag		A	--	--	--	42.4	--	--
B104	49.0 - 50.5 / -45.4 - -46.9	Bag		B	--	--	--	31.6	--	--

Notes:
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Project: Wharf Bravo
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B104	64.0 - 65.5 / -60.4 - -61.9	Bag		C	--	--	--	36.2	--	--
B104	69.0 - 70.5 / -65.4 - -66.9	Bag		C	--	--	--	23.3	--	--
B104	74.0 - 75.5 / -70.4 - -71.9	Bag		C	--	--	--	13.7	--	--
B105	3.5 / 1.6	Bag		A	--	--	--	30.0	--	--
B105	9.0 - 11.0 / -3.9 - -5.9	Bag	CLAYEY fine to medium SAND with coral fragments (SC), brown	A	49	25	24	50.8	30.8	38.4
B105	19.0 / -13.9	Bag		A	--	--	--	42.6	--	--
B105	29.0 / -23.9	Bag		A	--	--	--	31.9	--	--

Notes:
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Project: Wharf Bravo
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B105	49.0 / -43.9	Bag		B	--	--	--	37.6	--	--
B105	54.0 - 55.5 / -48.9 - -50.4	Bag	FAT CLAY (CH), brown	B	59	27	32	26.5	90.6	0.0
B105	59.0 / -53.9	Bag		B	--	--	--	24.6	--	--
B105	64.0 - 65.5 / -58.9 - -60.4	Bag	FAT CLAY (CH), grayish brown	C	66	28	38	24.6	92.2	0.0
B105	69.0 / -63.9	Bag		C	--	--	--	25.0	--	--
B105	74.0 / -68.9	Bag		C	--	--	--	12.0	--	--
B106	3.5 / 1.8	Bag		A	--	--	--	15.2	--	--

Notes:
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Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15

Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B106	5.0 / 0.3	Bag		A	--	--	--	26.5	--	--
B106	14.0 / -8.7	Bag		A	--	--	--	46.6	--	--
B106	24.0 / -18.7	Bag		A1	--	--	--	39.6	--	--
B106	29.0 / -23.7	Bag		A1	--	--	--	43.0	--	--
B106	39.0 - 40.5 / -33.7 - -35.2	Bag	POORLY GRADED fine to coarse SAND with silt and gravel (SP-SM), brown	B	40	30	10	16.5	10.3	35.6
B106	44.0 / -38.7	Bag		B	--	--	--	16.3	--	--
B106	54.0 - 55.5 / -48.7 - -50.2	Bag	FAT CLAY with fine to medium sand (CH), brown	C	53	27	26	26.0	88.8	0.0

Notes:
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Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Stratum	Liquid Limit	Plastic Limit	Plasticity Index	Natural Moisture (%)	% Passing No. 200 Sieve	% Retained No. 4 Sieve
B106	59.0 / -53.7	Bag		C	--	--	--	21.7	--	--
B106	64.0 - 65.5 / -58.7 - -60.2	Bag	FAT CLAY with fine to medium sand (CH), brown	C	51	27	24	25.2	82.8	0.0
B106	69.0 / -63.7	Bag		C	--	--	--	19.6	--	--
B106	74.0 / -68.7	Bag		C	--	--	--	14.1	--	--

Notes:
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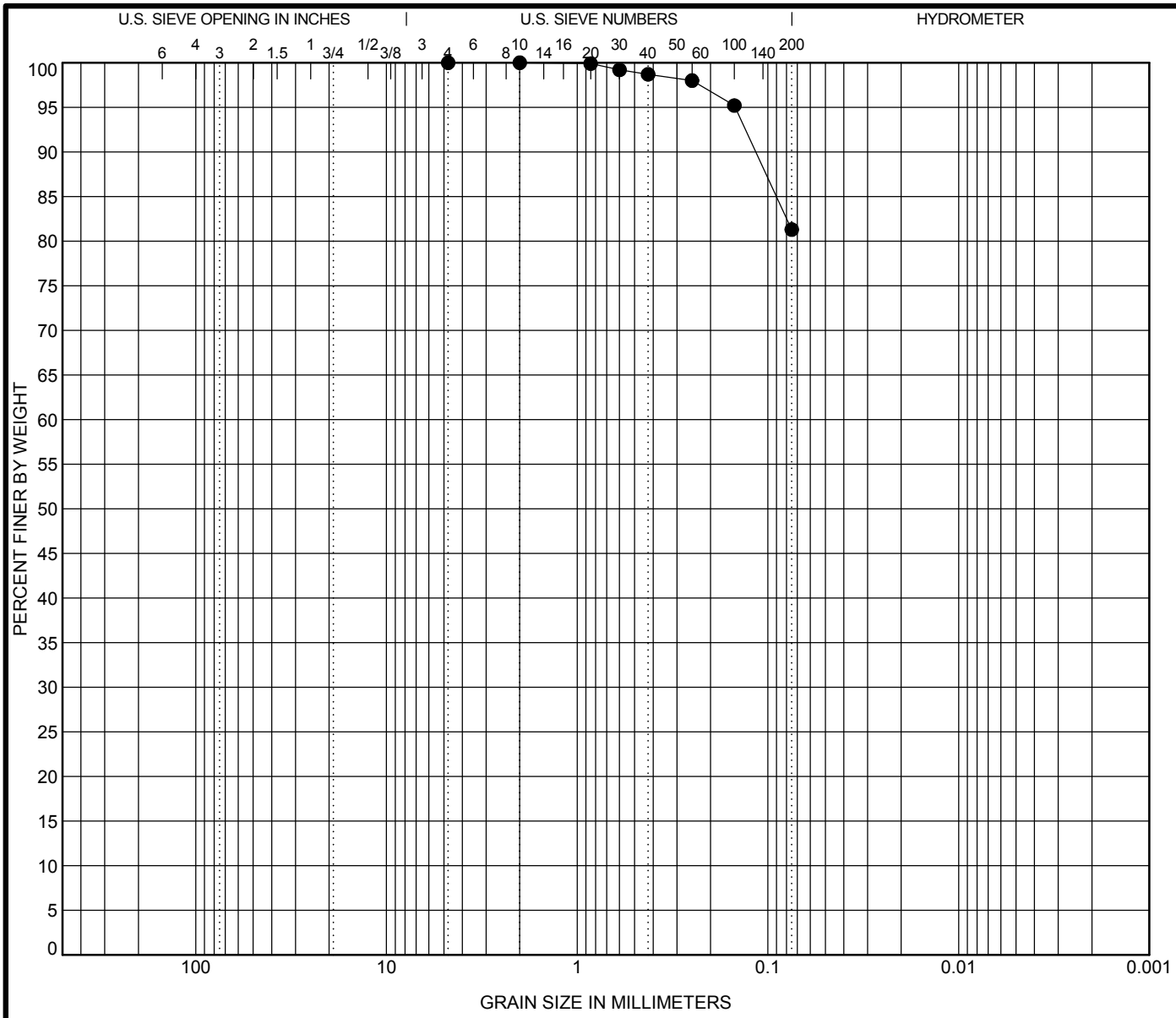
Guantanamo Bay, Cuba

DYNAMIC LAB SUMMARY BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008 04 22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B101	74.0 ft	**LEAN CLAY with fine to medium sand (CL), gray**	**43**	**22**	**21**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**2**				**0.0**	**18.7**	**81.3**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4
% Finer	81.3	95.2	98.0	98.7	99.2	99.9	100.0	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

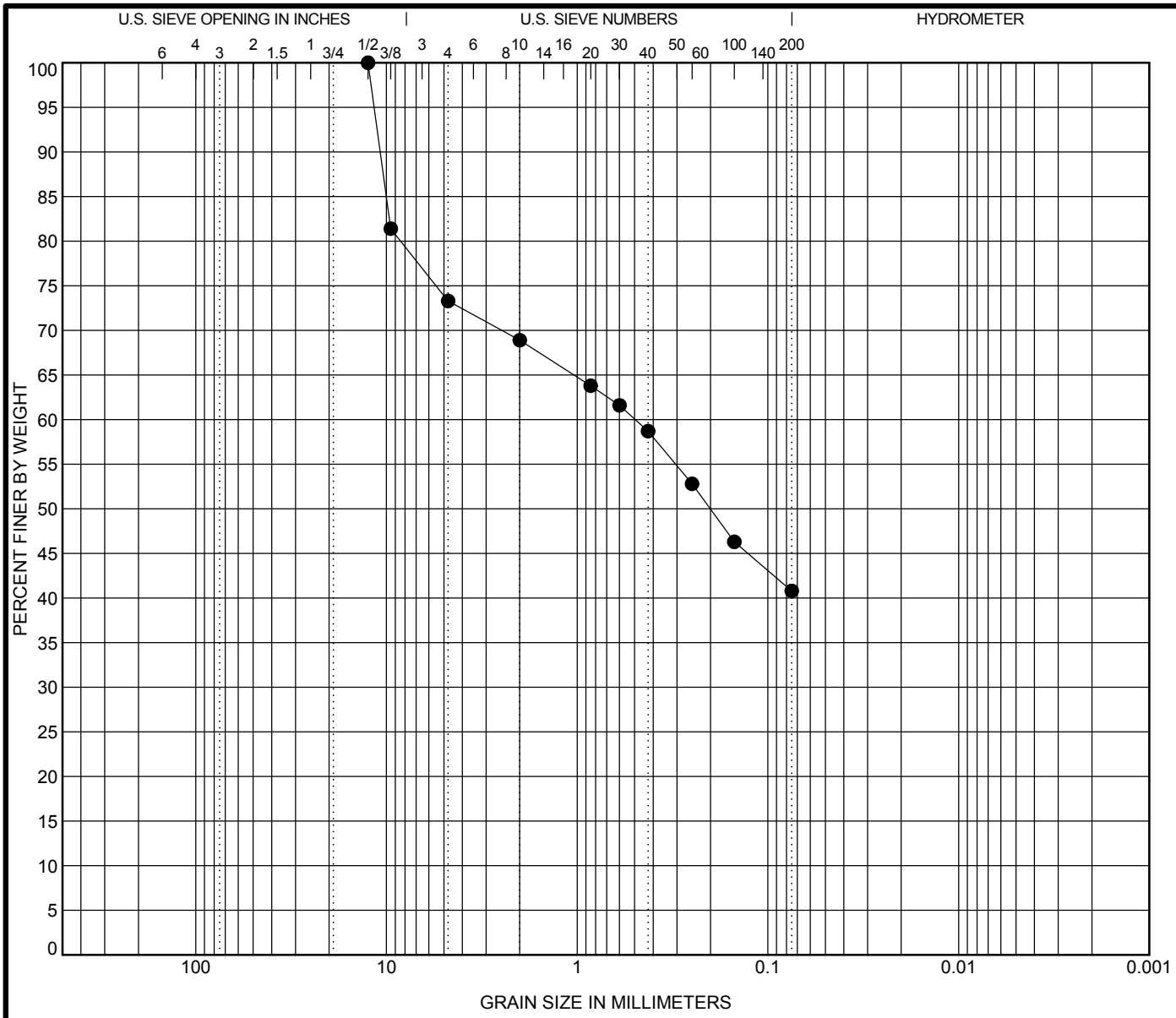
Schnabel ENGINEERING

GRADATION CURVE

Project: Wharf Bravo
Guantanamo Bay, Cuba

Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B102	14.0 ft	**CLAYEY fine to coarse SAND with coral and rock fragments (SC), gray**	**42**	**23**	**19**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**12.5**	**0.496**			**26.7**	**32.5**	**40.8**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4	3/8	1/2
% Finer	40.8	46.3	52.8	58.7	61.6	63.8	68.9	73.3	81.4	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

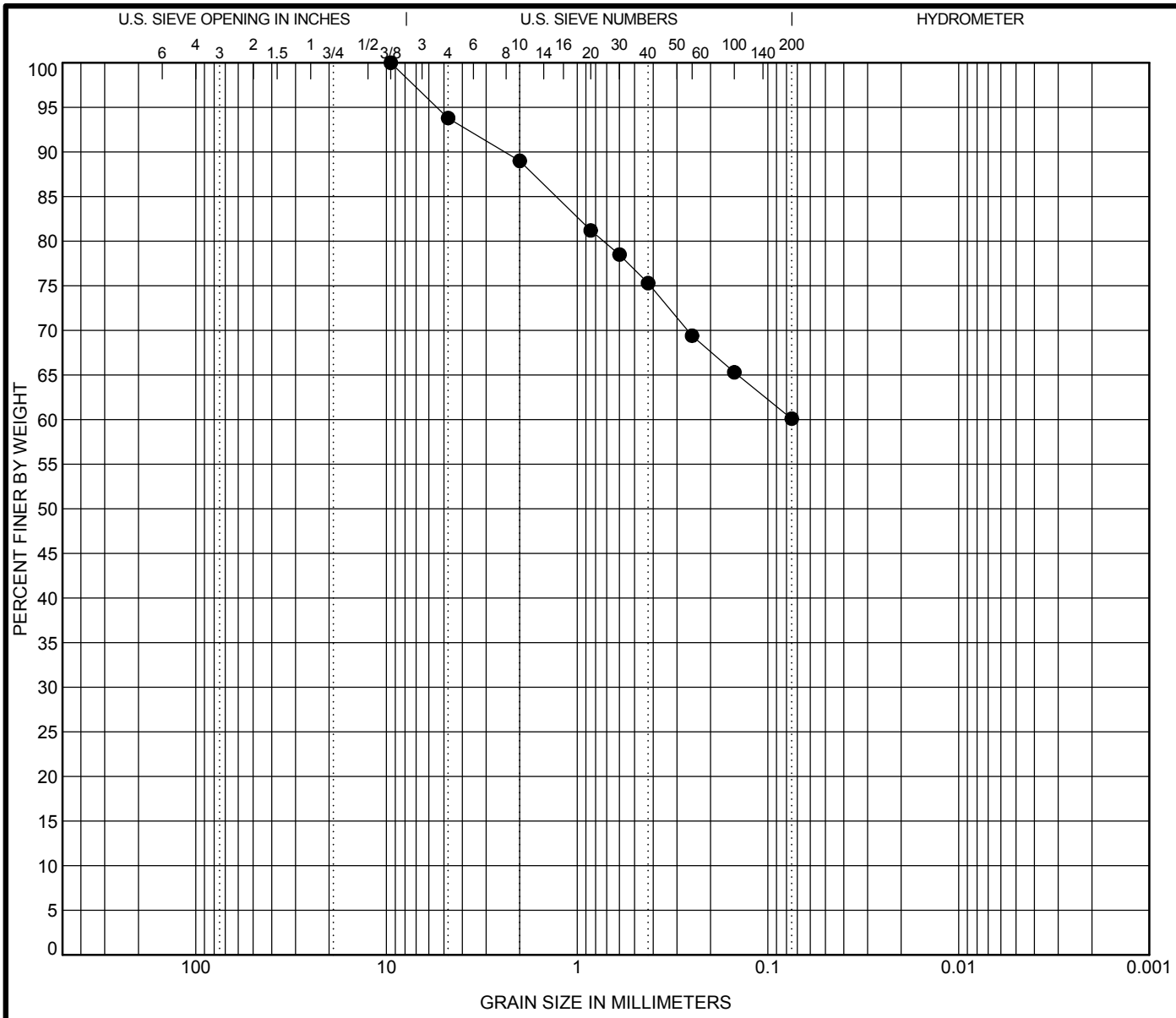
Schnabel ENGINEERING

GRADATION CURVE

Project: Wharf Bravo
Guantanamo Bay, Cuba

Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B102	59.0 ft	**Fine to coarse SANDY LEAN CLAY (CL), trace gravel, brown**	**39**	**24**	**15**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**9.5**				**6.2**	**33.7**	**60.1**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4	3/8
% Finer	60.1	65.3	69.4	75.3	78.5	81.2	89.0	93.8	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

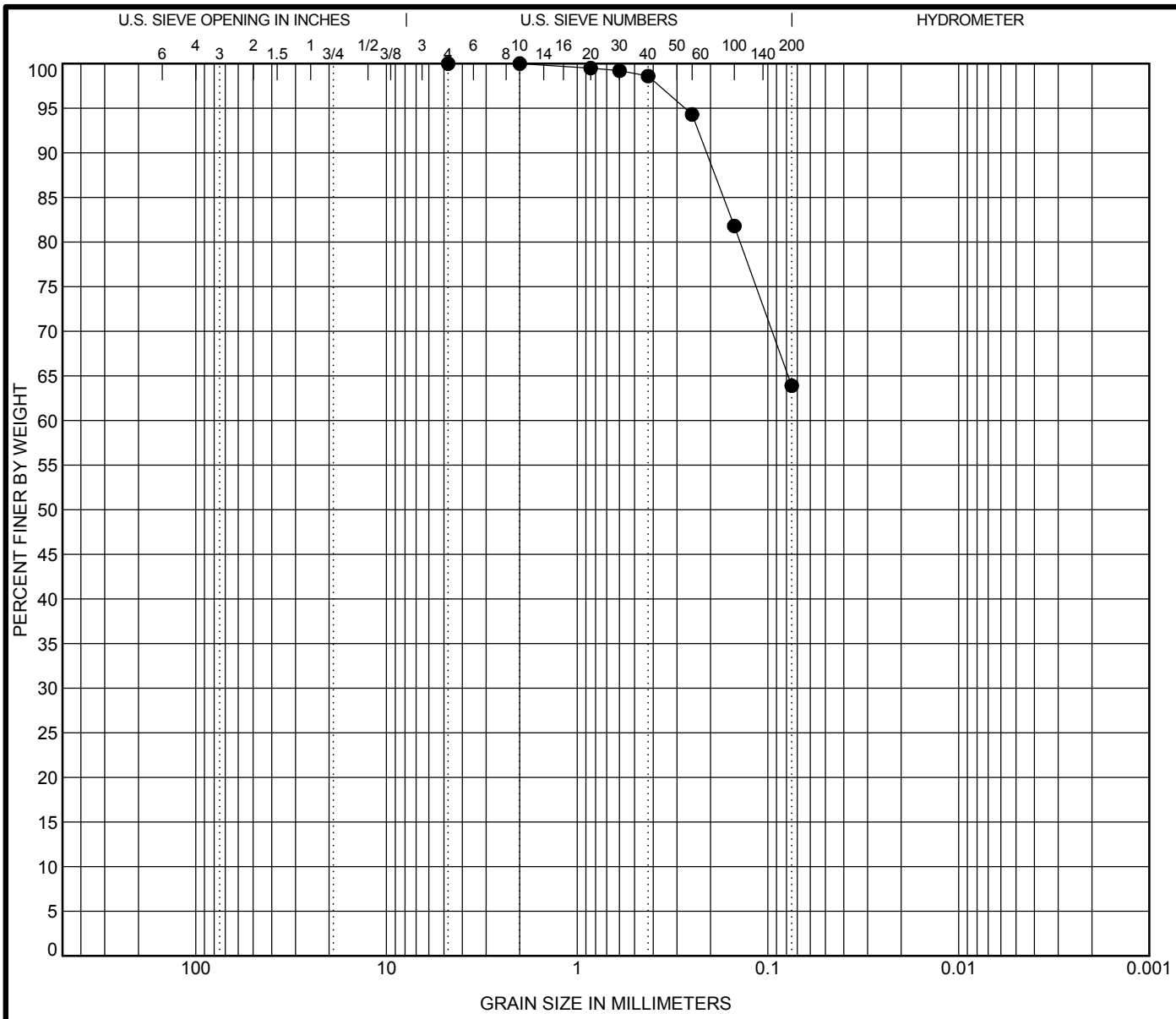
Schnabel ENGINEERING

GRADATION CURVE

Project: Wharf Bravo
Guantanamo Bay, Cuba

Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B102	89.0 ft	**CLAYEY fine to coarse SAND (SC), gray**	**32**	**20**	**12**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**2**				**0.0**	**36.1**	**63.9**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4
% Finer	63.9	81.8	94.3	98.6	99.2	99.5	100.0	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

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GRADATION CURVE

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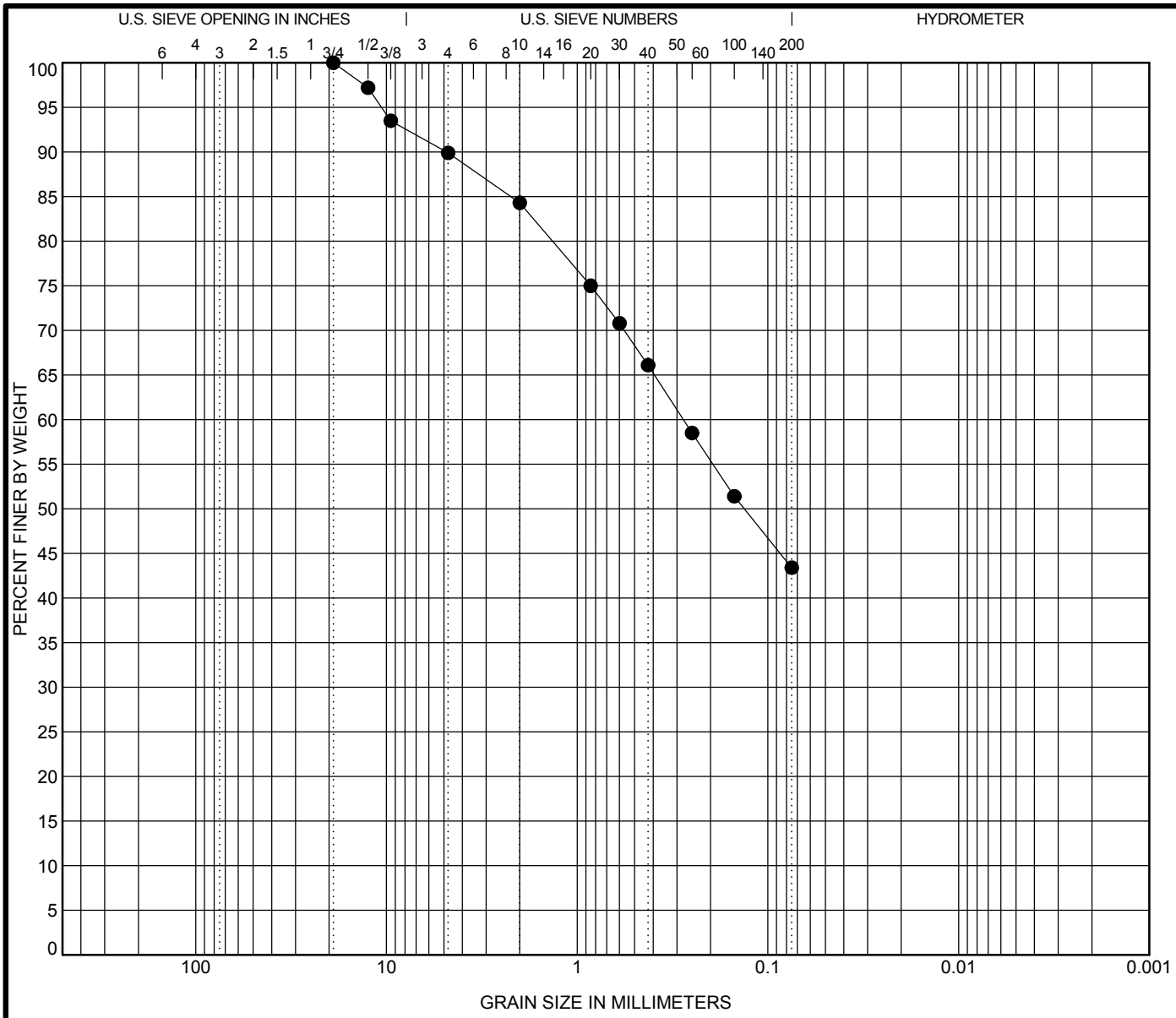
Guantanamo Bay, Cuba

Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B104	14.0 ft	**CLAYEY fine to coarse SAND (SC), trace gravel, gray**	**42**	**22**	**20**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**19**	**0.278**			**10.1**	**46.5**	**43.4**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4	3/8	1/2	3/4
% Finer	43.4	51.4	58.5	66.1	70.8	75.0	84.3	89.9	93.5	97.2	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

Schnabel ENGINEERING

GRADATION CURVE

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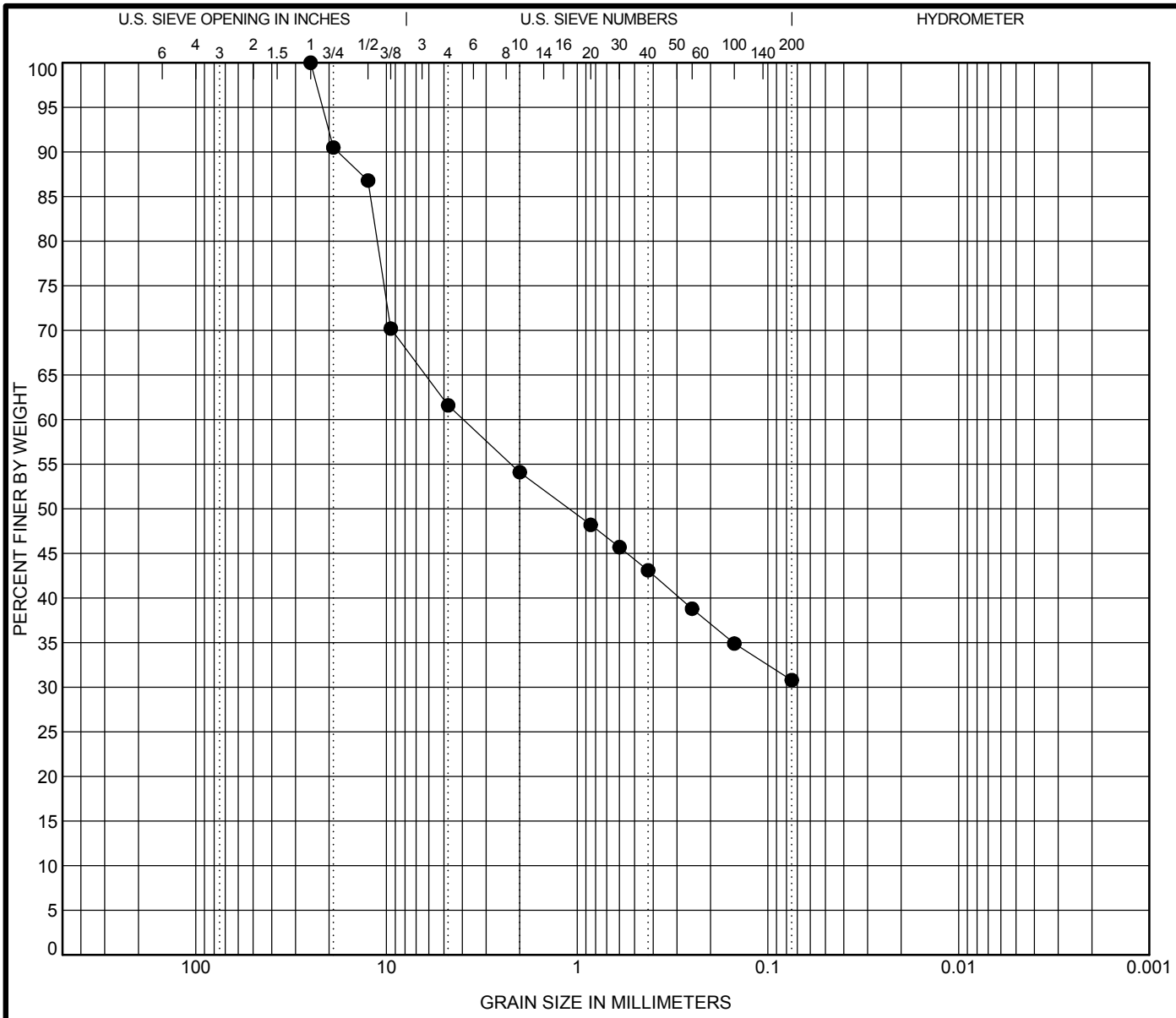
Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B105	9.0 ft	**CLAYEY fine to medium SAND with coral fragments (SC), brown**	**49**	**25**	**24**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**25**	**3.95**			**38.4**	**30.8**	**30.8**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4	3/8	1/2	3/4	1
% Finer	30.8	34.9	38.8	43.1	45.7	48.2	54.1	61.6	70.2	86.8	90.5	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

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GRADATION CURVE

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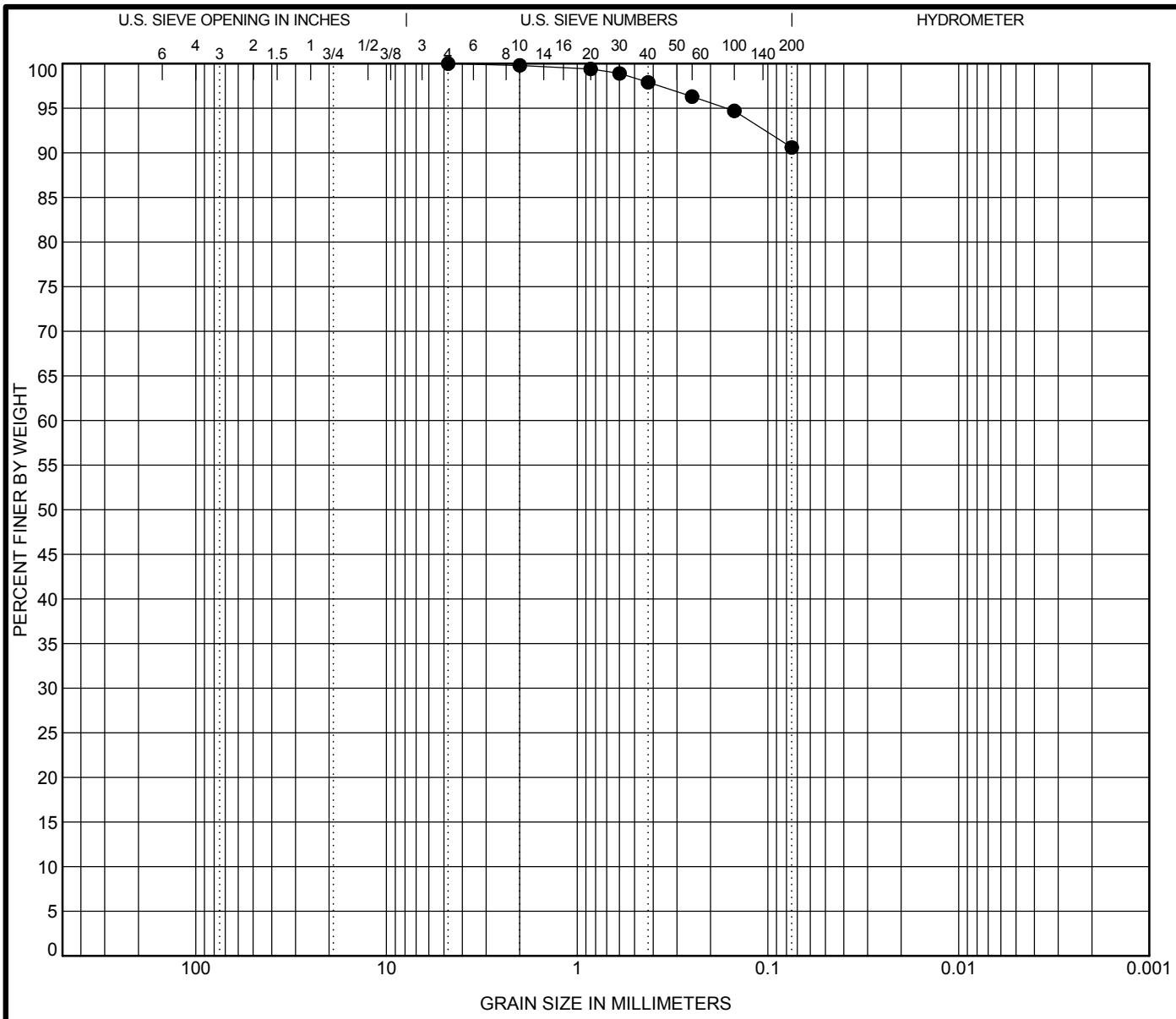
SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B105	54.0 ft	**FAT CLAY (CH), brown**	**59**	**27**	**32**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**4.75**				**0.0**	**9.4**	**90.6**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4
% Finer	90.6	94.7	96.3	97.9	98.9	99.4	99.8	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

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GRADATION CURVE

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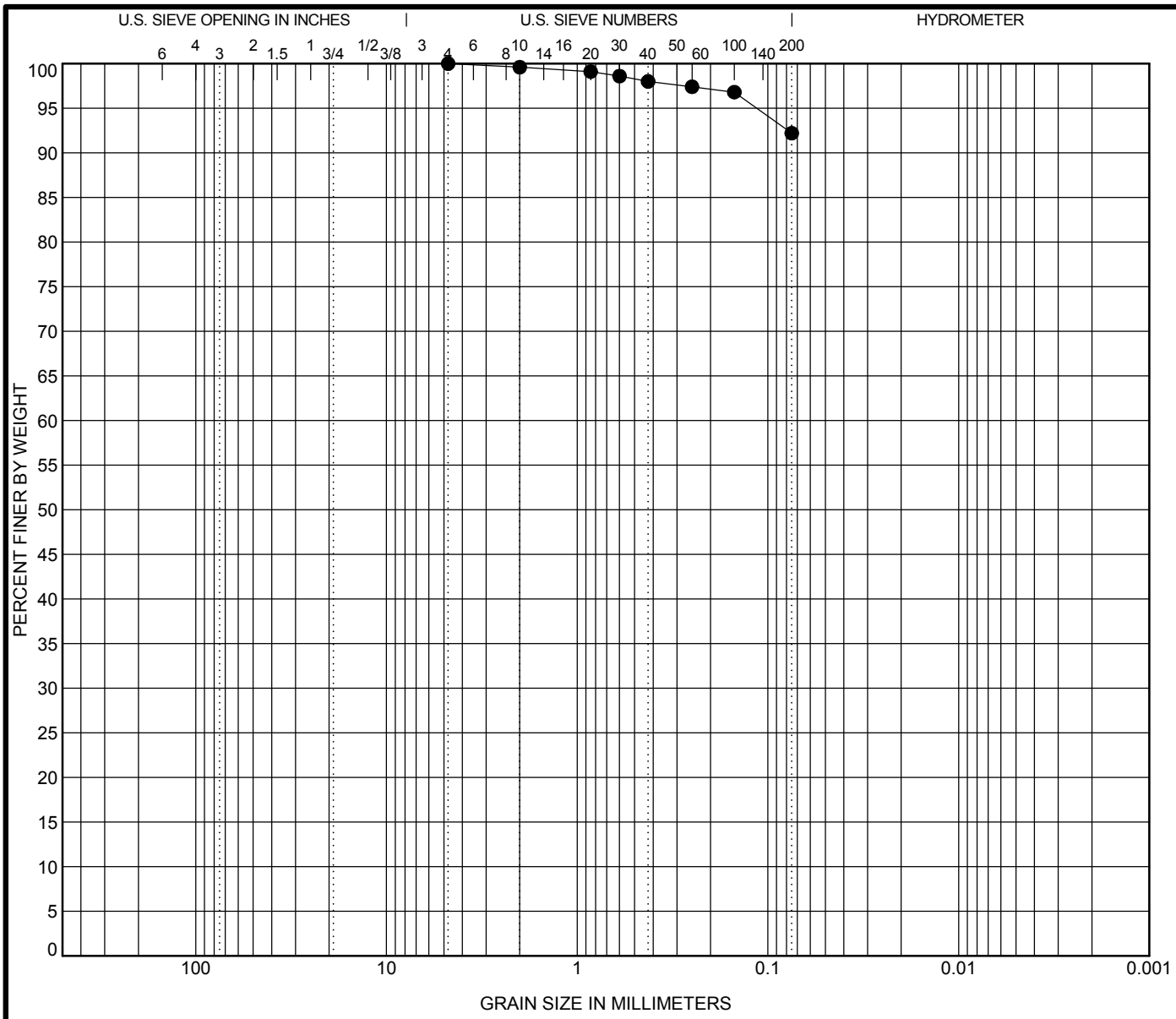
Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B105	64.0 ft	**FAT CLAY (CH), grayish brown**	**66**	**28**	**38**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**4.75**				**0.0**	**7.8**	**92.2**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4
% Finer	92.2	96.8	97.4	98.0	98.6	99.1	99.6	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

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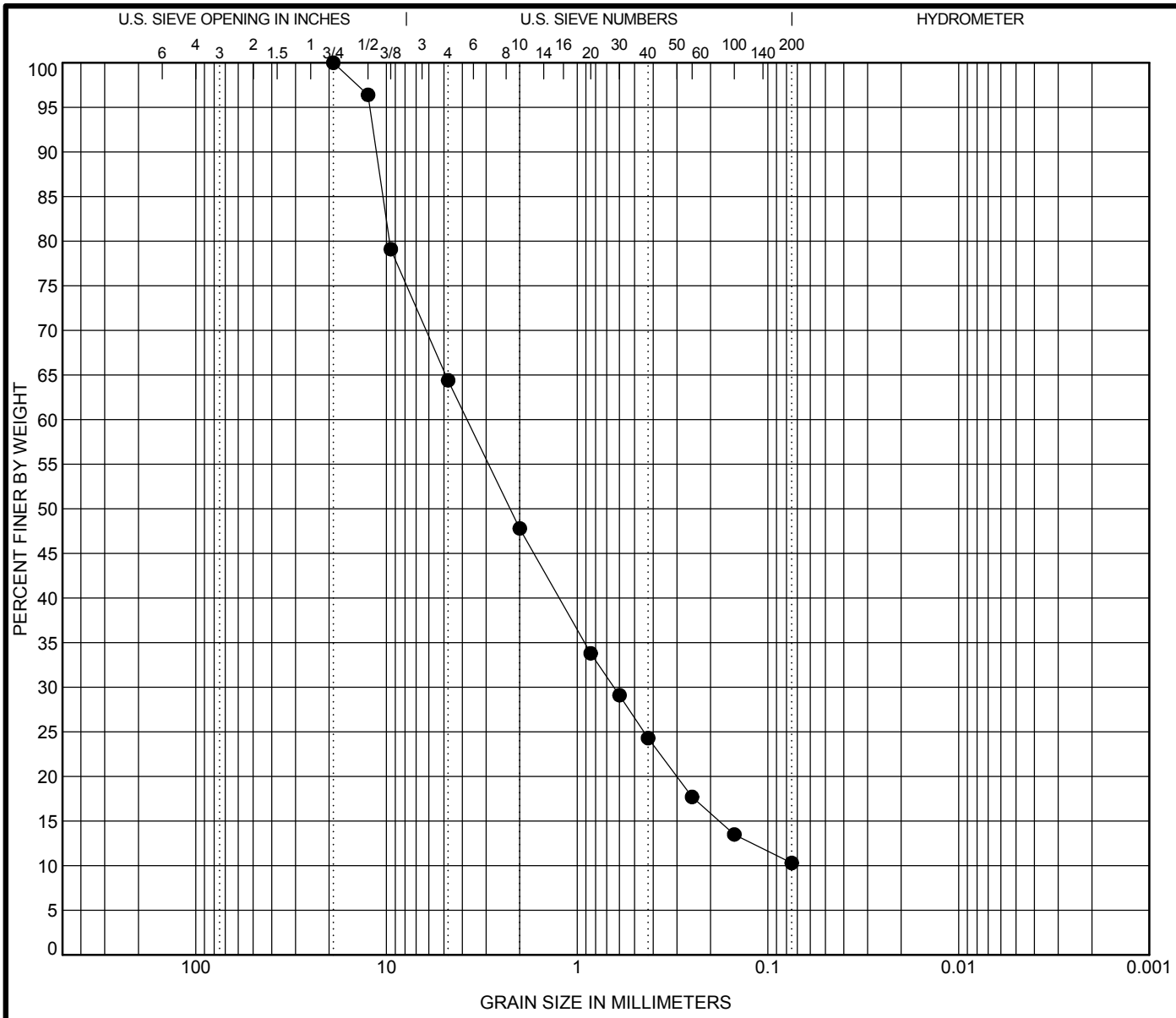
Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B106	39.0 ft	**POORLY GRADED fine to coarse SAND with silt and gravel (SP-SM), brown**	**40**	**30**	**10**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**19**	**3.777**	**0.641**		**35.6**	**54.1**	**10.3**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4	3/8	1/2	3/4
% Finer	10.3	13.5	17.7	24.3	29.1	33.8	47.8	64.4	79.1	96.4	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

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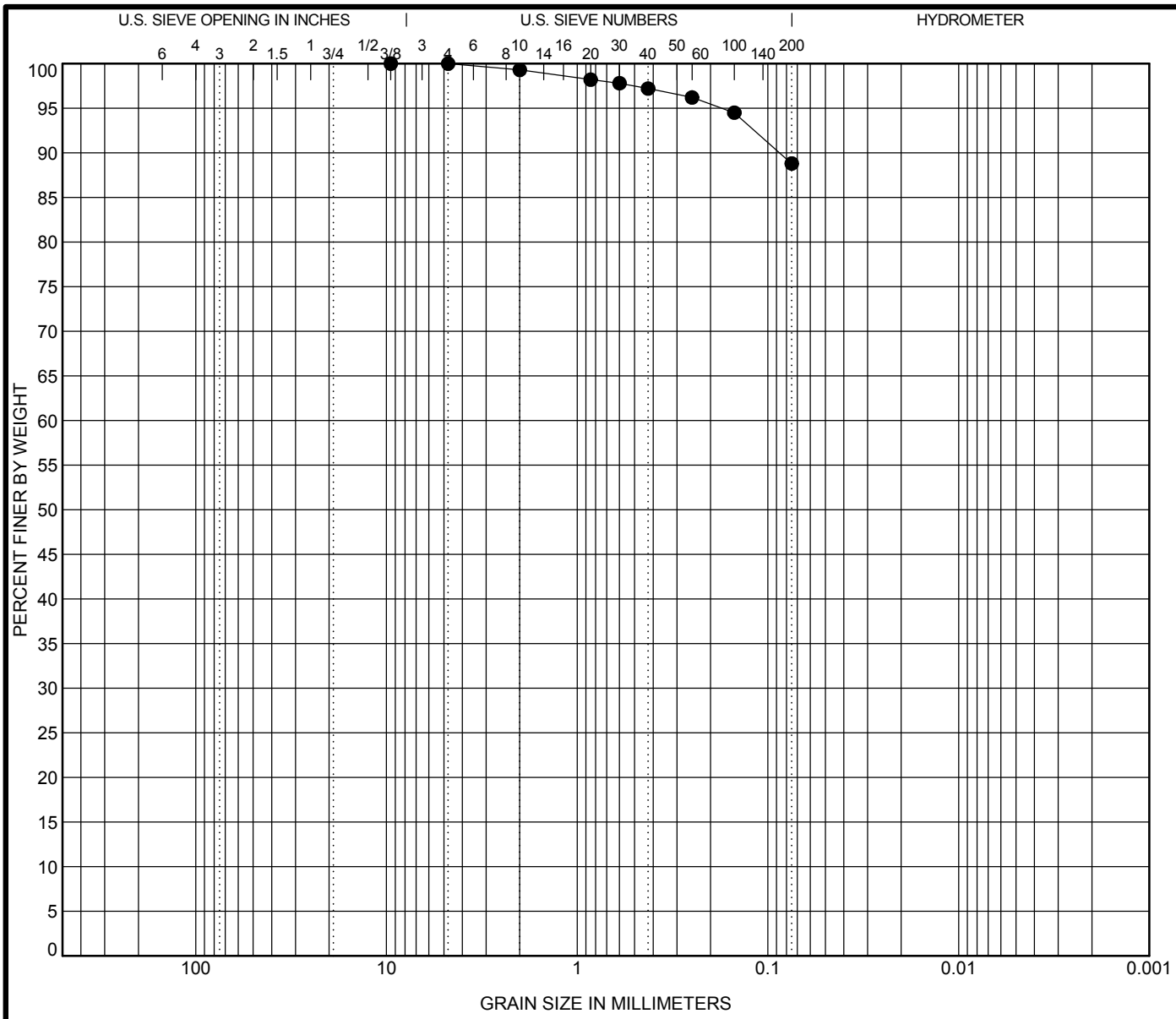


COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B106	54.0 ft	**FAT CLAY with fine to medium sand (CH), brown**	**53**	**27**	**26**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**4.75**				**0.0**	**11.2**	**88.8**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4	3/8
% Finer	88.8	94.5	96.2	97.2	97.8	98.2	99.3	100.0	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

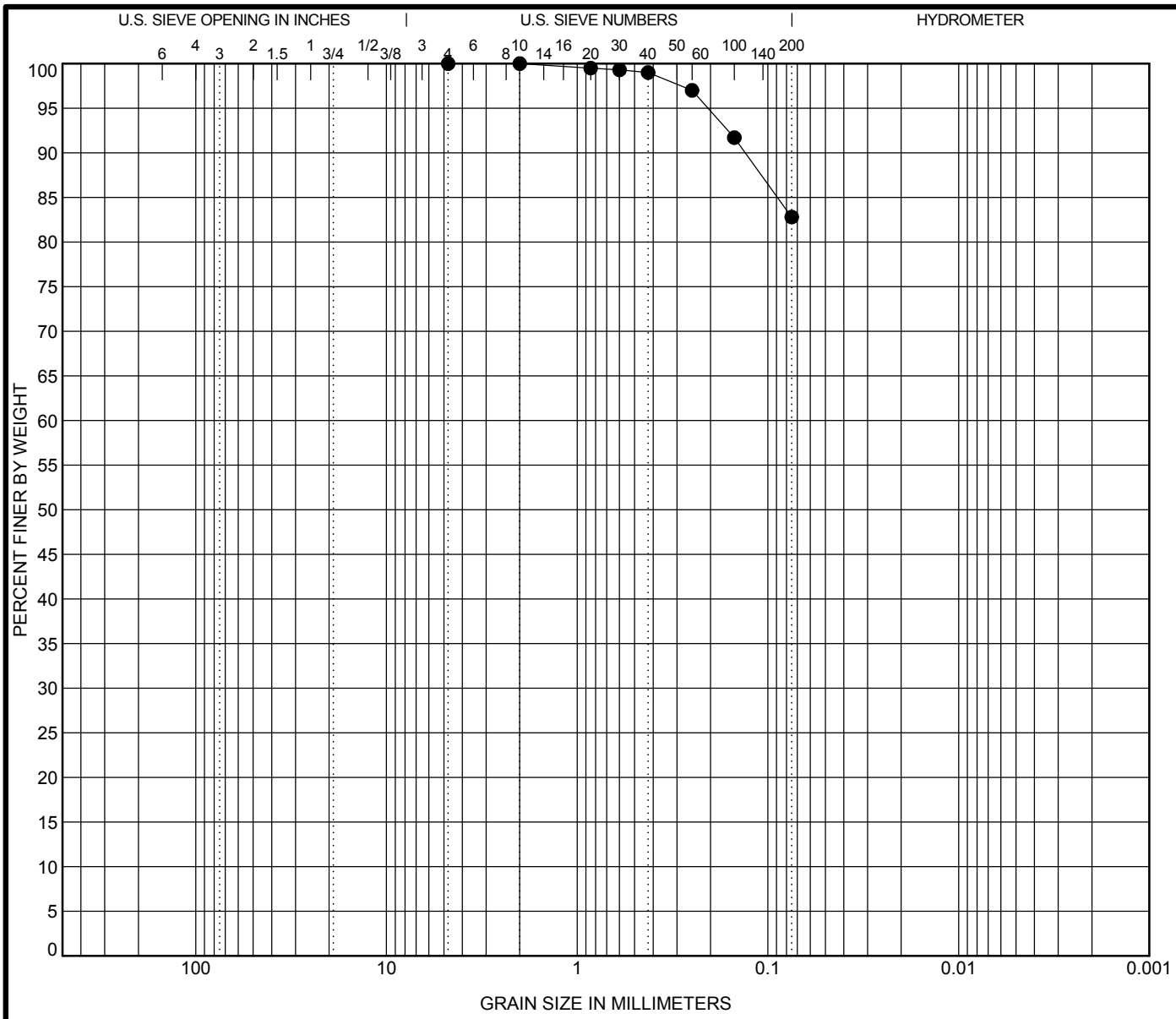
Schnabel ENGINEERING

GRADATION CURVE

Project: Wharf Bravo
Guantanamo Bay, Cuba

Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen		Sample Description	LL	PL	PI		
● B106	64.0 ft	**FAT CLAY with fine to medium sand (CH), brown**	**51**	**27**	**24**		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM C136	**2**				**0.0**	**17.2**	**82.8**	

Percent Finer

Sieve Size	200	100	60	40	30	20	10	4
% Finer	82.8	91.7	97.0	99.0	99.3	99.5	100.0	100.0

Tested By	Tested Date	Reviewed By	Calc By
MDE	7/20/15	SRH	MDE

Schnabel ENGINEERING

GRADATION CURVE

Project: Wharf Bravo
Guantanamo Bay, Cuba

Contract: 15619016.00

SIEVE 1/SHEET BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 9/2/15

APPENDIX C

LIQUEFACTION ANALYSES RESULTS

Results for Borings B-101 through B-106

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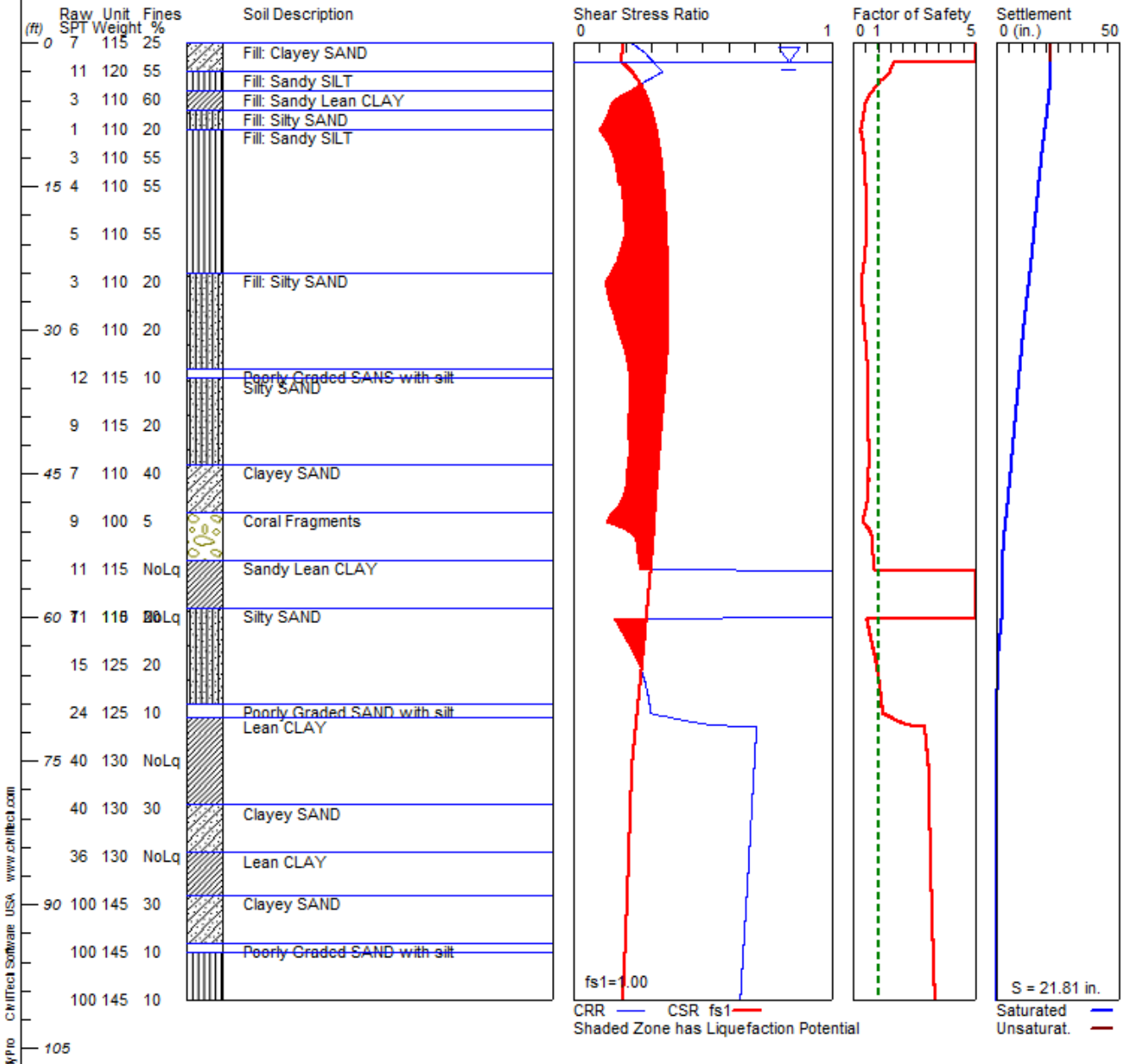
LIQUEFACTION ANALYSIS

Wharf Bravo-Guantanamo Bay

Hole No.=B101 Water Depth=2 ft Surface Elev.=4

Magnitude=6.5
Acceleration=0.29g

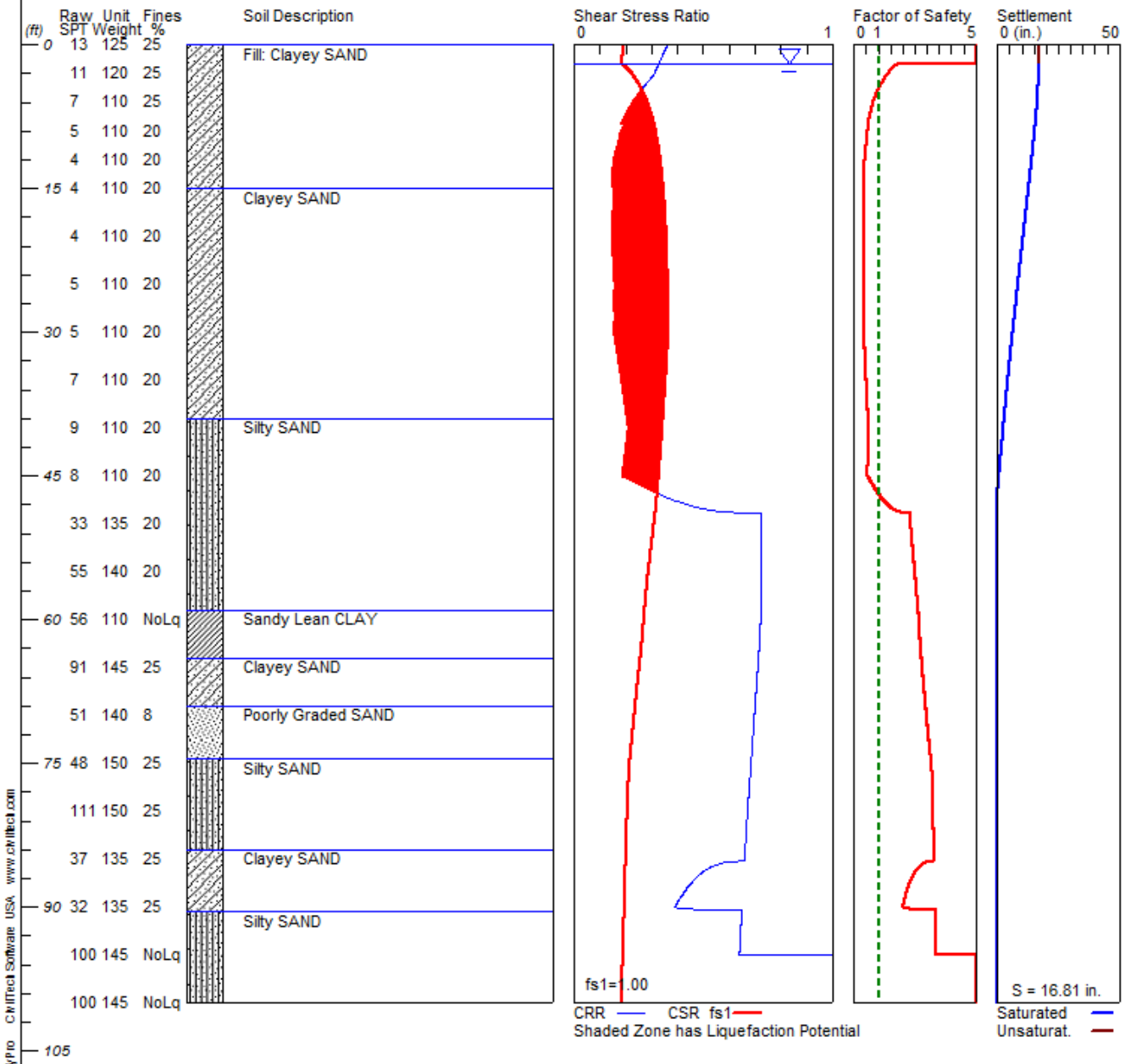


LIQUEFACTION ANALYSIS

Wharf Bravo-Guantanamo Bay

Hole No.=B102 Water Depth=2 ft Surface Elev.=4

Magnitude=6.5
Acceleration=0.29g

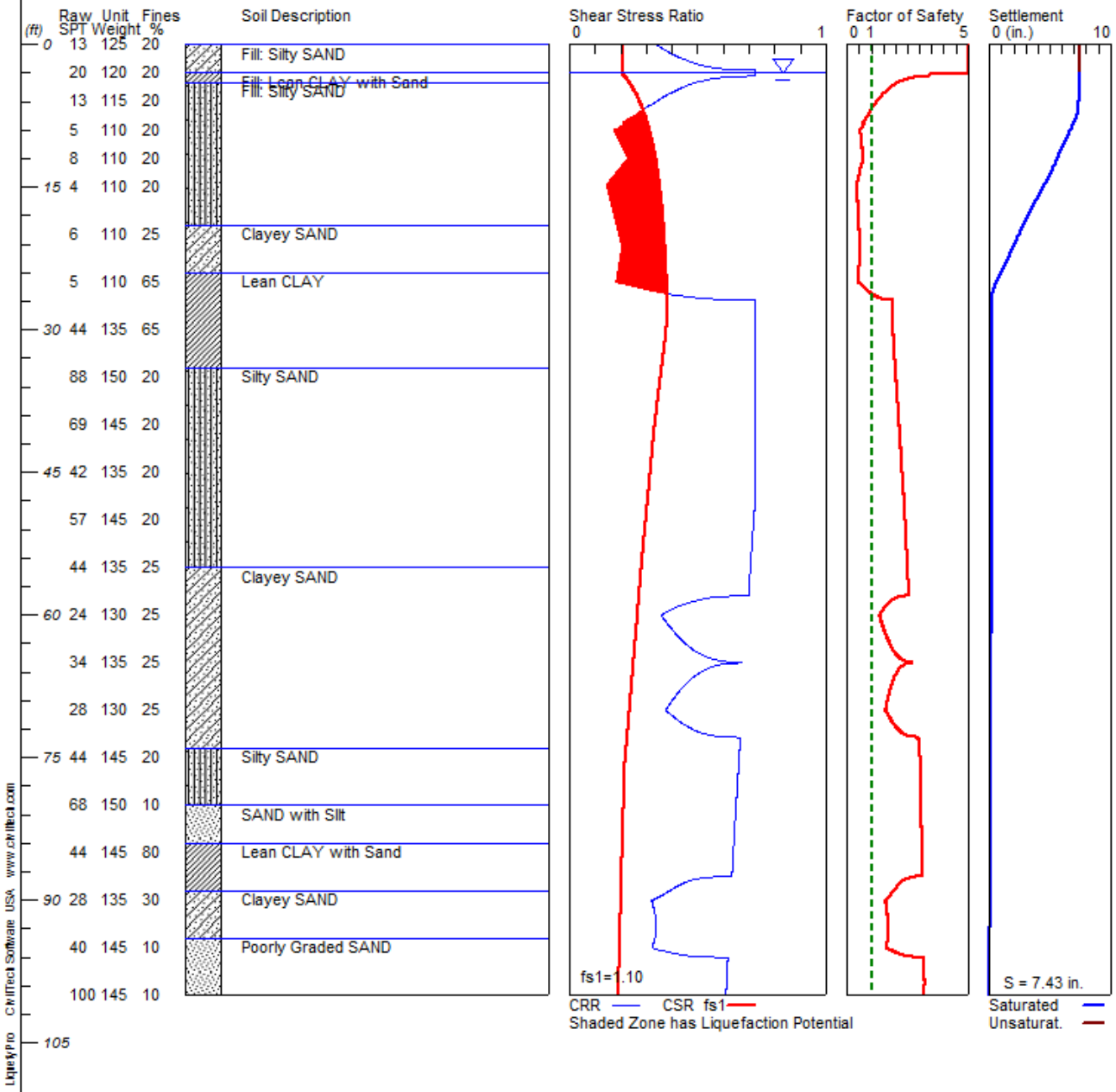


LIQUEFACTION ANALYSIS

Wharf Bravo-Guantanamo Bay

Hole No.=B103 Water Depth=3 ft Surface Elev.=6

Magnitude=6.5
Acceleration=0.29g

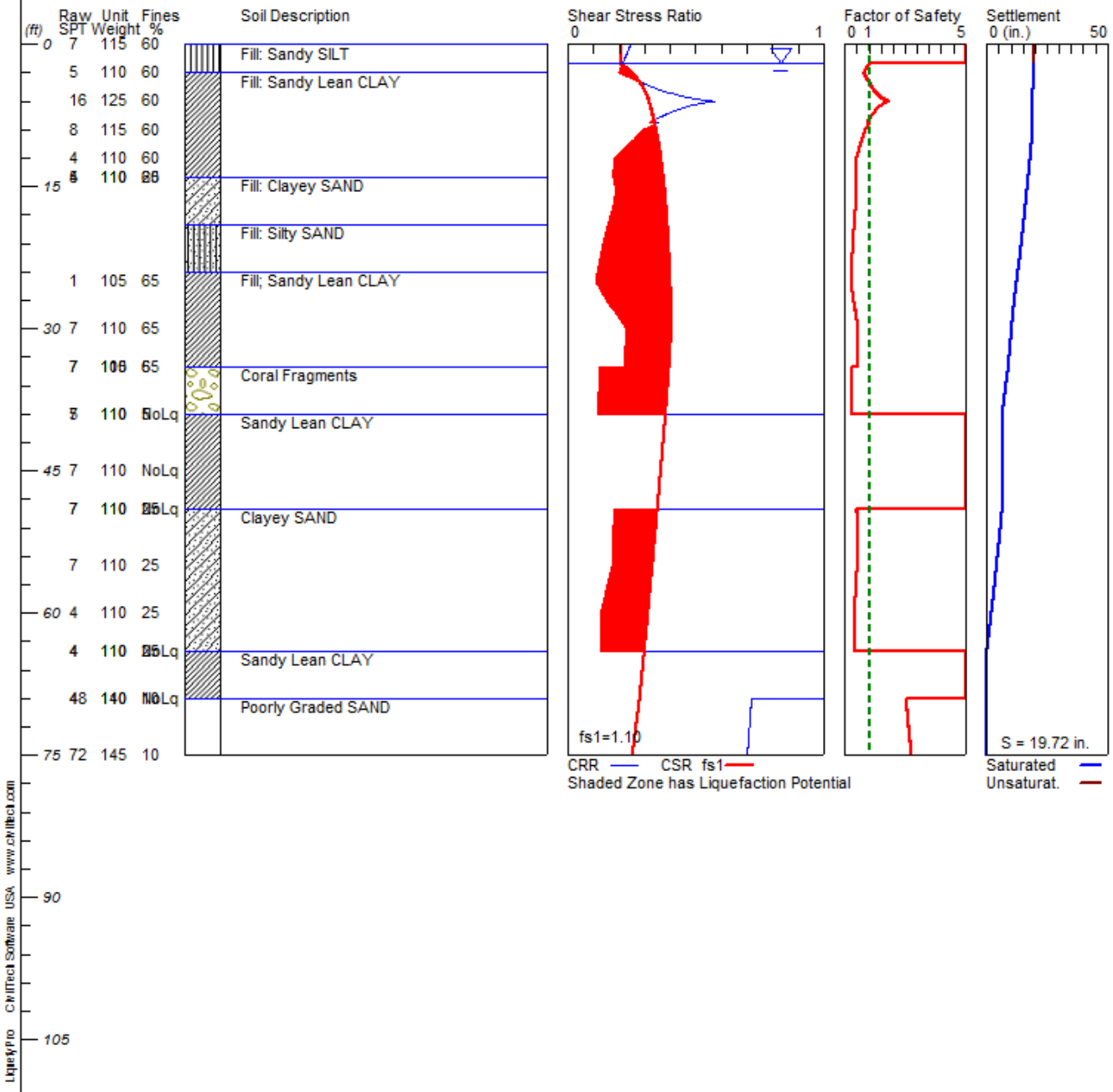


LIQUEFACTION ANALYSIS

Wharf Bravo-Guantanamo Bay

Hole No.=B104 Water Depth=2 ft Surface Elev.=4

Magnitude=6.5
Acceleration=0.29g

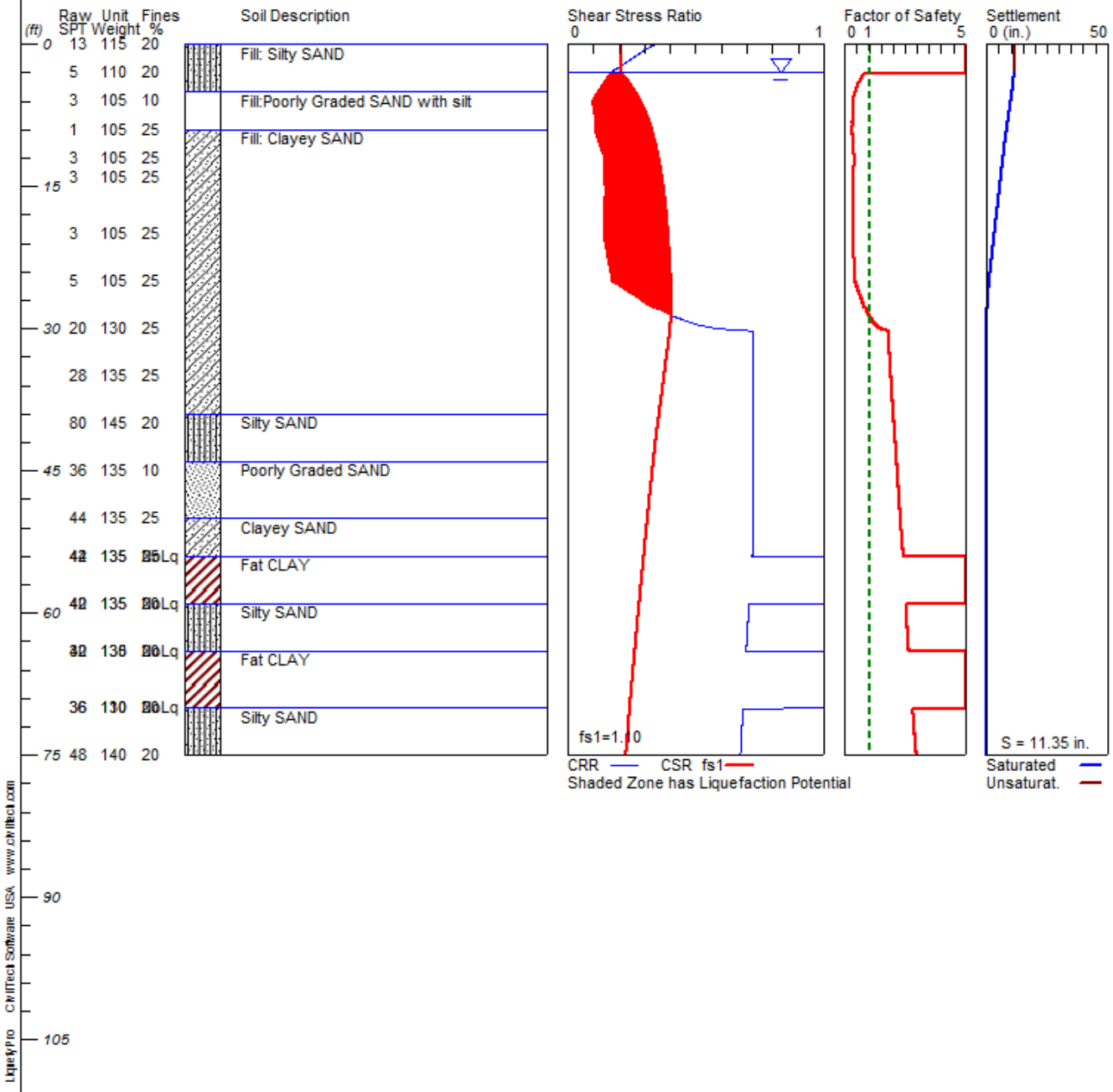


LIQUEFACTION ANALYSIS

Wharf Bravo-Guantanamo Bay

Hole No.=B105 Water Depth=3 ft Surface Elev.=5

Magnitude=6.5
Acceleration=0.29g

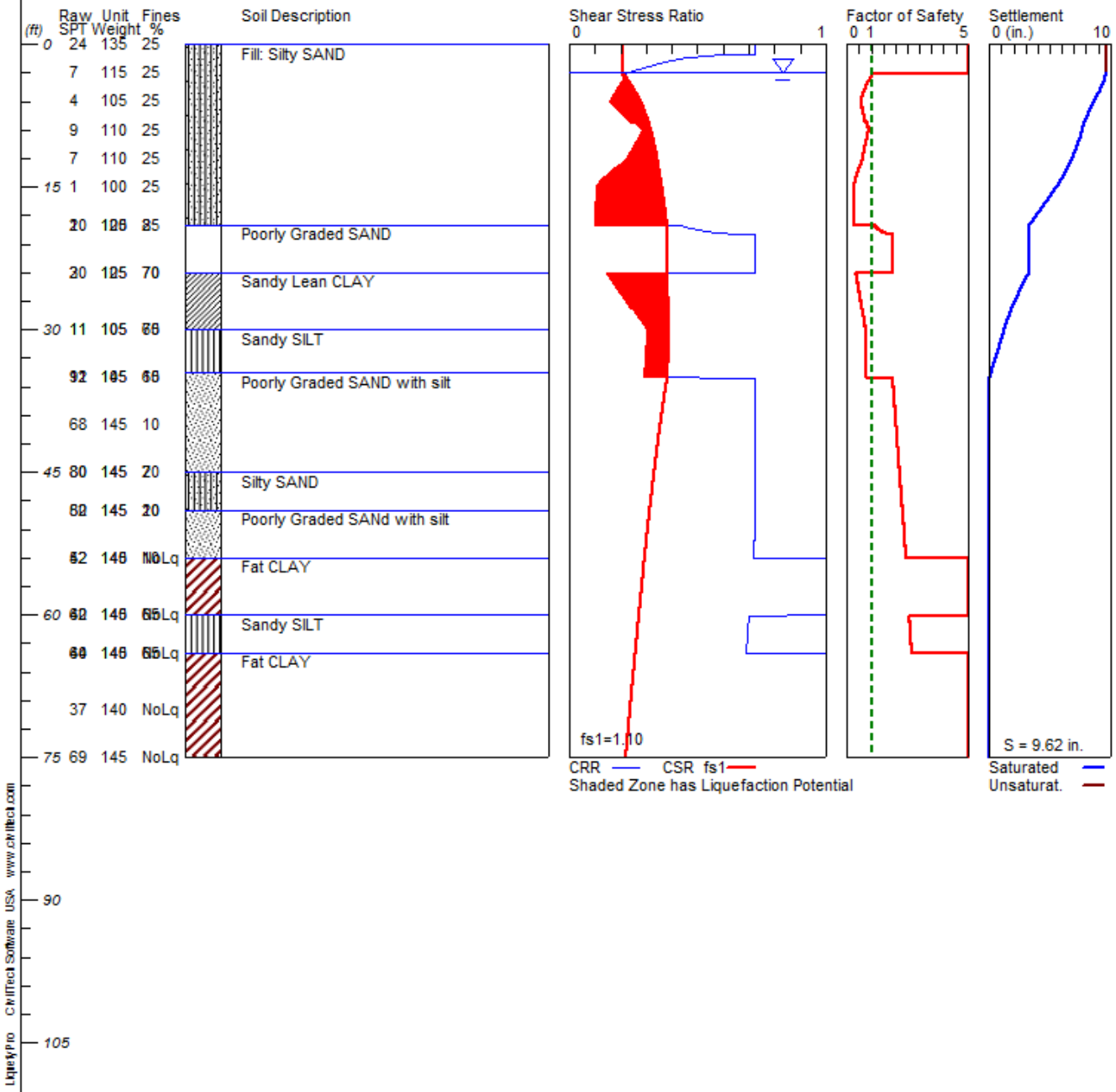


LIQUEFACTION ANALYSIS

Wharf Bravo-Guantanamo Bay

Hole No.=B106 Water Depth=3 ft Surface Elev.=5

Magnitude=6.5
Acceleration=0.29g



APPENDIX D

ENGINEERING CALCULATIONS

Slope Stability Analyses Results
Stability Check Calculations for B-101, B-102 & B-103
Earth Pressure Diagram for Wall Portion near Boring B-103
Calculations for Design Kh Value for Walls

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SLOPE STABILTIY ANALYSES RESULTS

CASE 1 - (B -101)
LIQUEFIED SOIL CONDITION

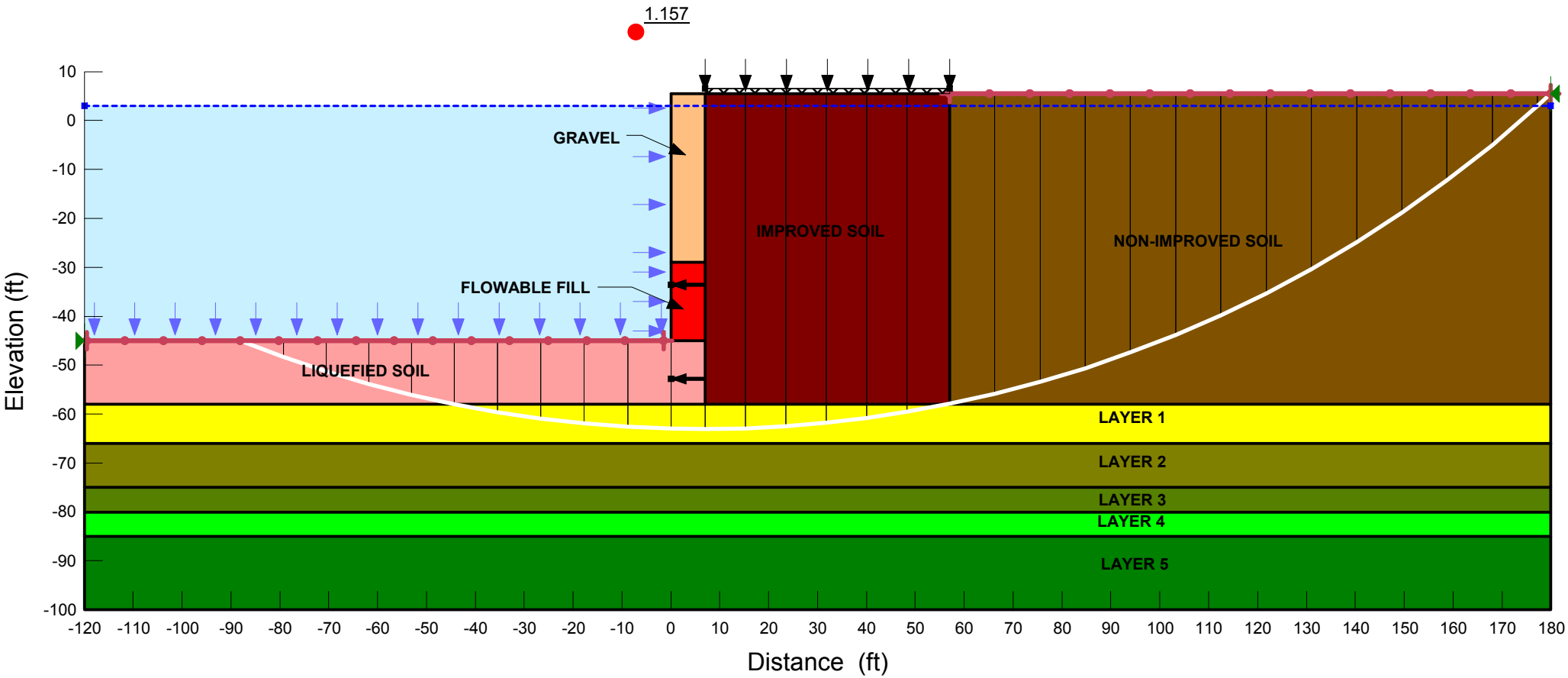
MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Liquified Soil Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 100 psf Phi': 0 °
Name: Non-Improved Soil Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 100 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 32 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 3,000 psf Phi': 0 °
Name: Layer 3 Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 36 °
Name: Layer 4 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 2,500 psf Phi': 0 °
Name: Layer 5 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 0 psf Phi': 40 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °

Seismic acceleration 0.12 g

Loads:

Point Load - Pfront: -16,700 lbs
Point Load - Pliq-front-dyn: -700 lbs
Surcharge Load: 225 pcf



CASE 2 - (B -101)
NONLIQUEFIED SOIL CONDITION

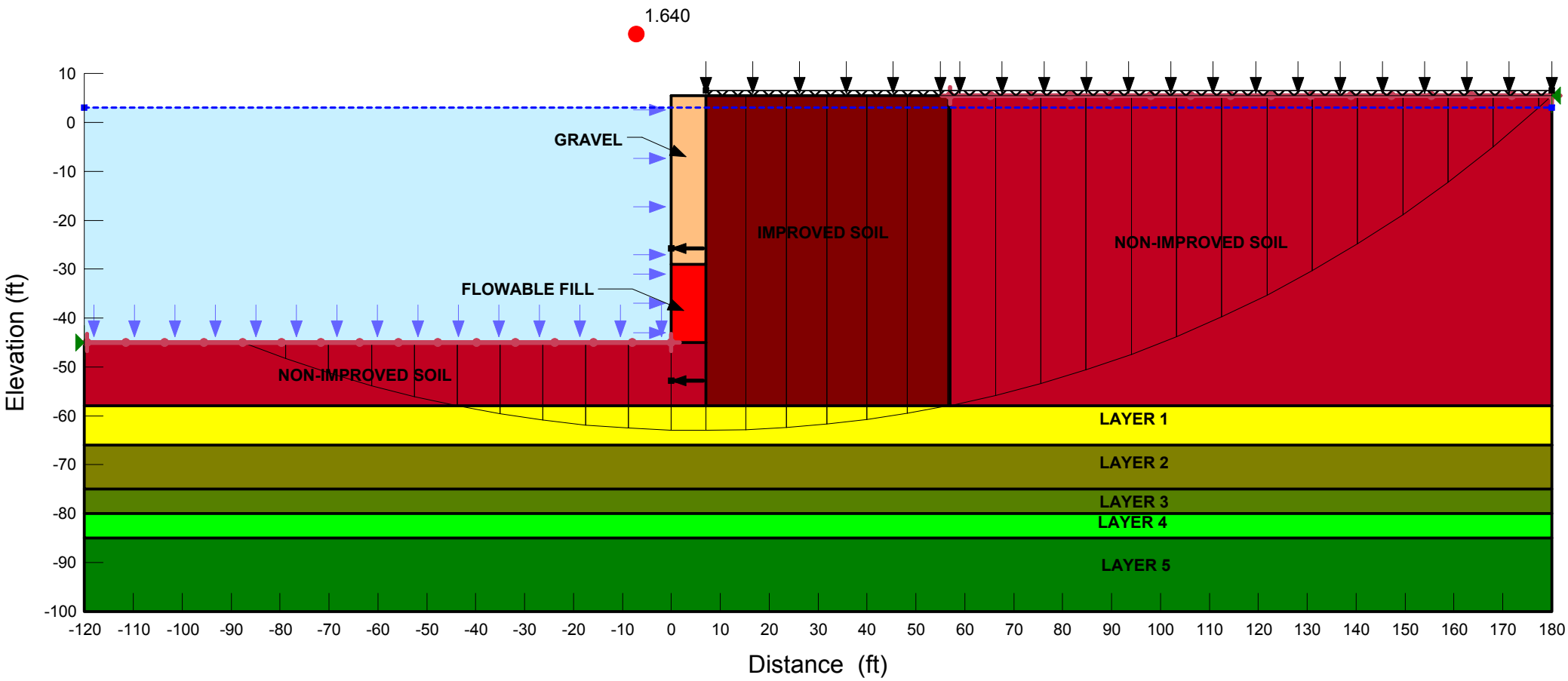
MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 32 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 3,000 psf Phi': 0 °
Name: Layer 3 Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 36 °
Name: Layer 4 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 2,500 psf Phi': 0 °
Name: Layer 5 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 0 psf Phi': 40 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Non-Improved Soil (Non-liquified Condition) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 °

Seismic acceleration 0.12 g

Loads:

Point Load - Pfront: -10,300 lbs
Point Load - Pliq-front-dyn: 0 lbs
Surcharge Load: 225 pcf



CASE 3 - (B -101)
NONLIQUEFIED SOIL CONDITION
STATIC CASE

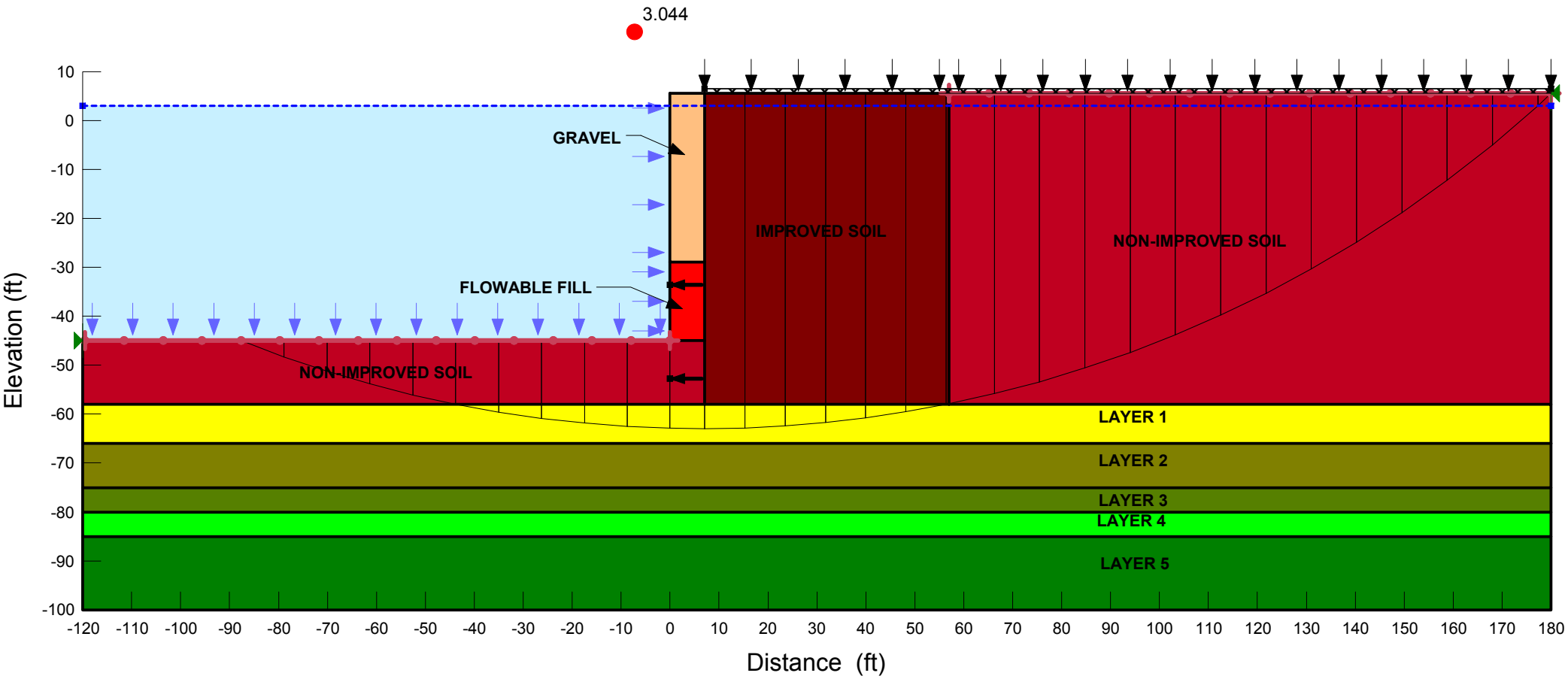
MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 32 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 3,000 psf Phi': 0 °
Name: Layer 3 Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 36 °
Name: Layer 4 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 2,500 psf Phi': 0 °
Name: Layer 5 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 0 psf Phi': 40 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Non-Improved Soil (Non-liquified Condition) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 °

Seismic acceleration 0 g

Loads:

Point Load - Pfront: 0 lbs
Point Load - Pliq-front-dyn: 0 lbs
Surcharge Load: 300 pcf



CASE 1 - (B -102)
LIQUEFIED SOIL CONDITION

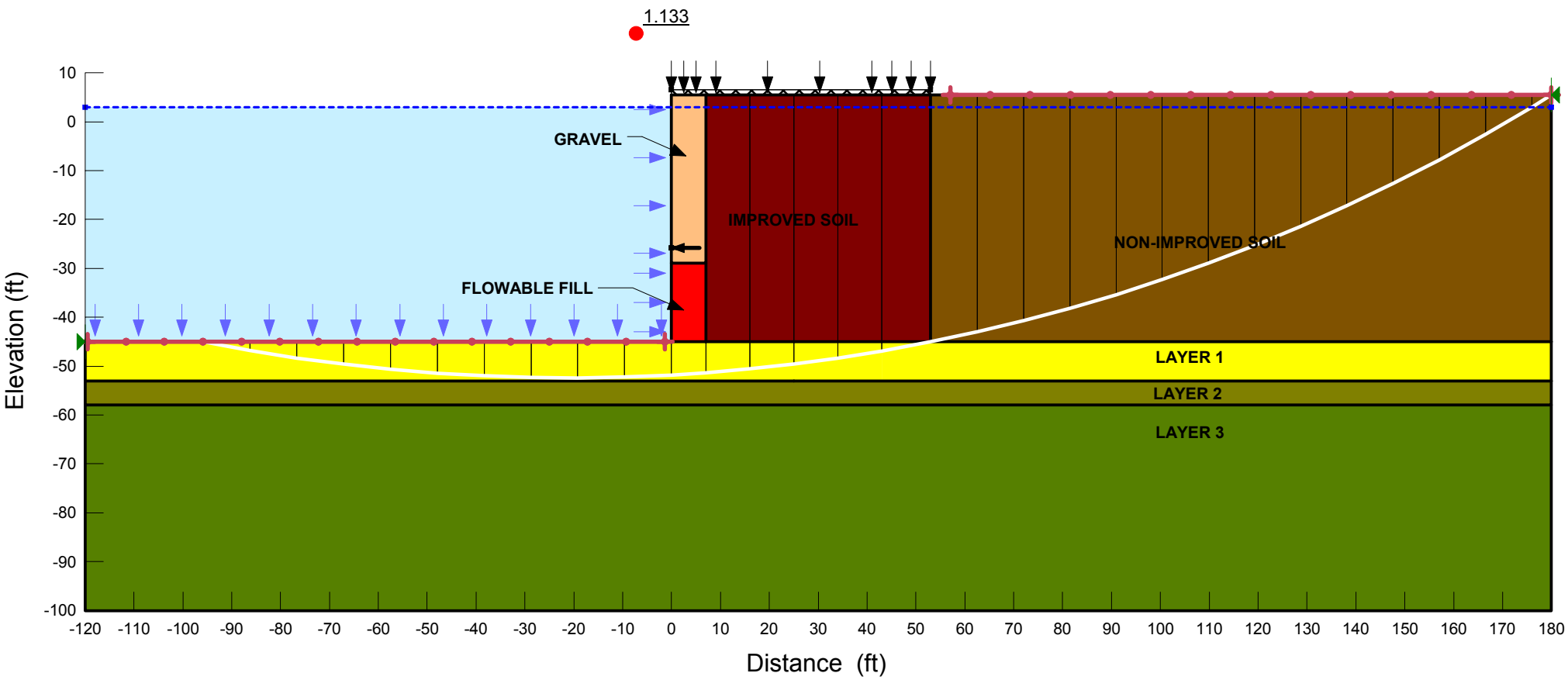
Seismic acceleration 0.12 g

MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Non-Improved Soil Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 100 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 4,000 psf Phi': 0 °
Name: Layer 3 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 0 psf Phi': 38 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °

Loads:

Point Load - Pfront: -10,300 lbs
Surcharge Load: 225 pcf



CASE 2 - (B -102)
NONLIQUEFIED SOIL CONDITION

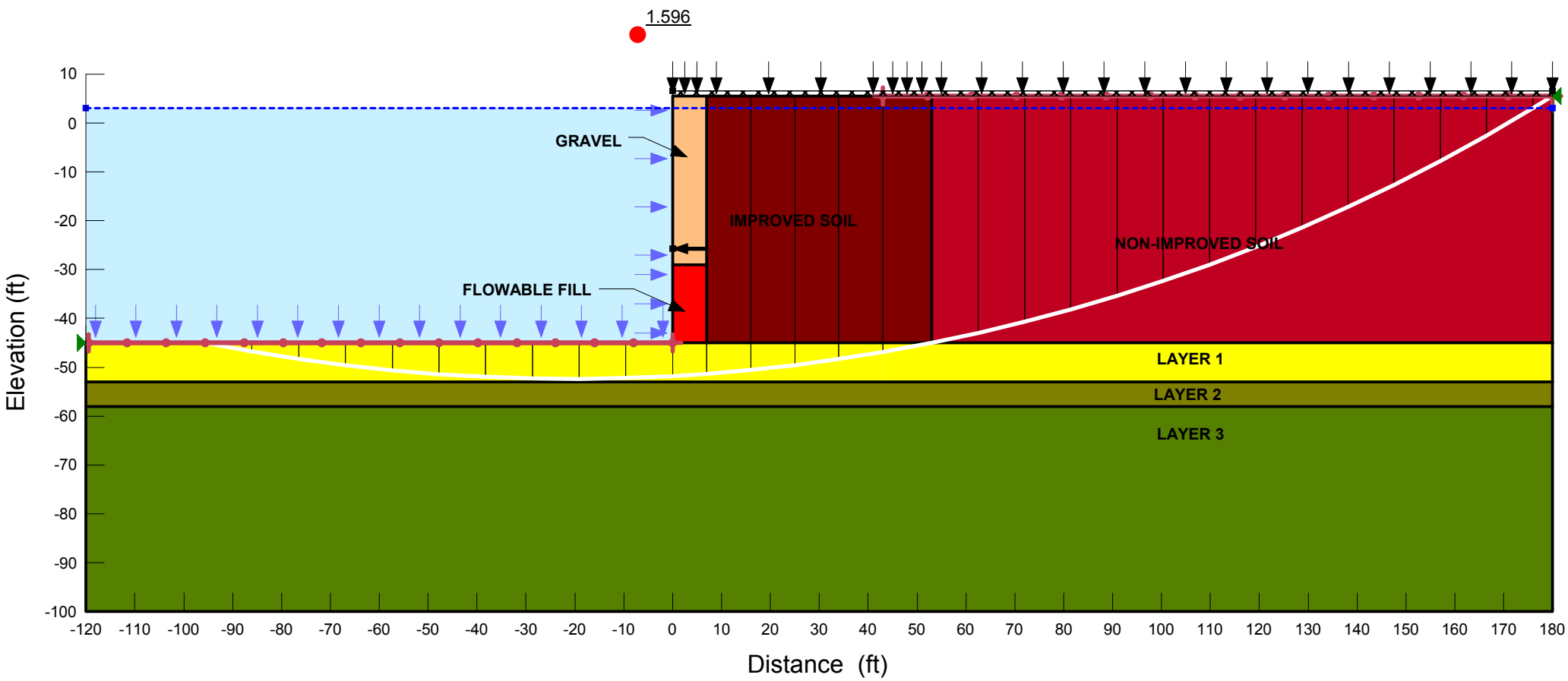
Seismic acceleration 0.12 g

MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 4,000 psf Phi': 0 °
Name: Layer 3 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 0 psf Phi': 38 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Non-Improved Soil (Non-liquefied Condition) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 °

Loads:

Point Load - Pfront: -10,300 lbs
Surcharge Load: 225 pcf



CASE 3 - (B -102)
NONLIQUEFIED SOIL CONDITION
STATIC CASE

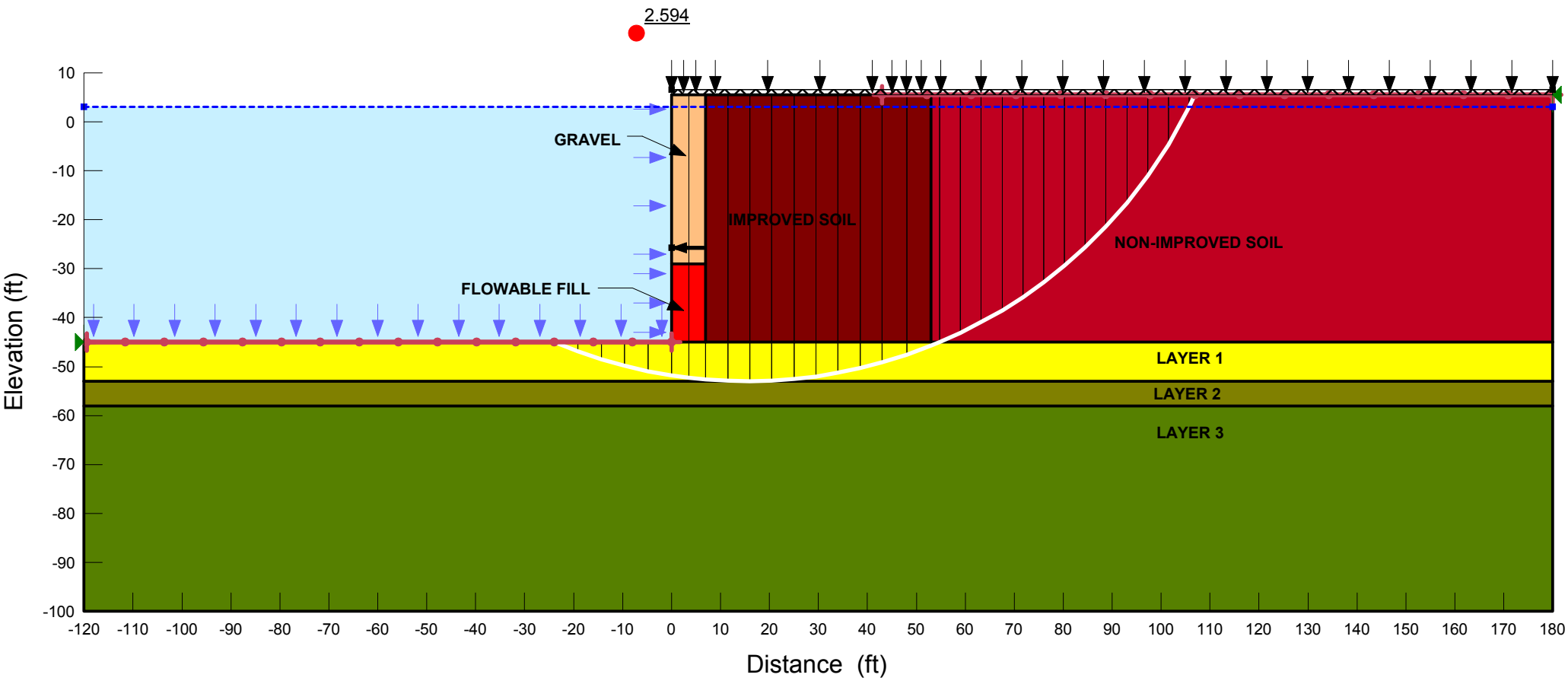
Seismic acceleration 0 g

MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 35 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 4,000 psf Phi': 0 °
Name: Layer 3 Model: Mohr-Coulomb Unit Weight: 140 pcf Cohesion': 0 psf Phi': 38 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Non-Improved Soil (Non-liquefied Condition) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 °

Loads:

Point Load - Pfront: 0 lbs
Surcharge Load: 300 pcf



CASE 1 - (B -103)
LIQUEFIED SOIL CONDITION

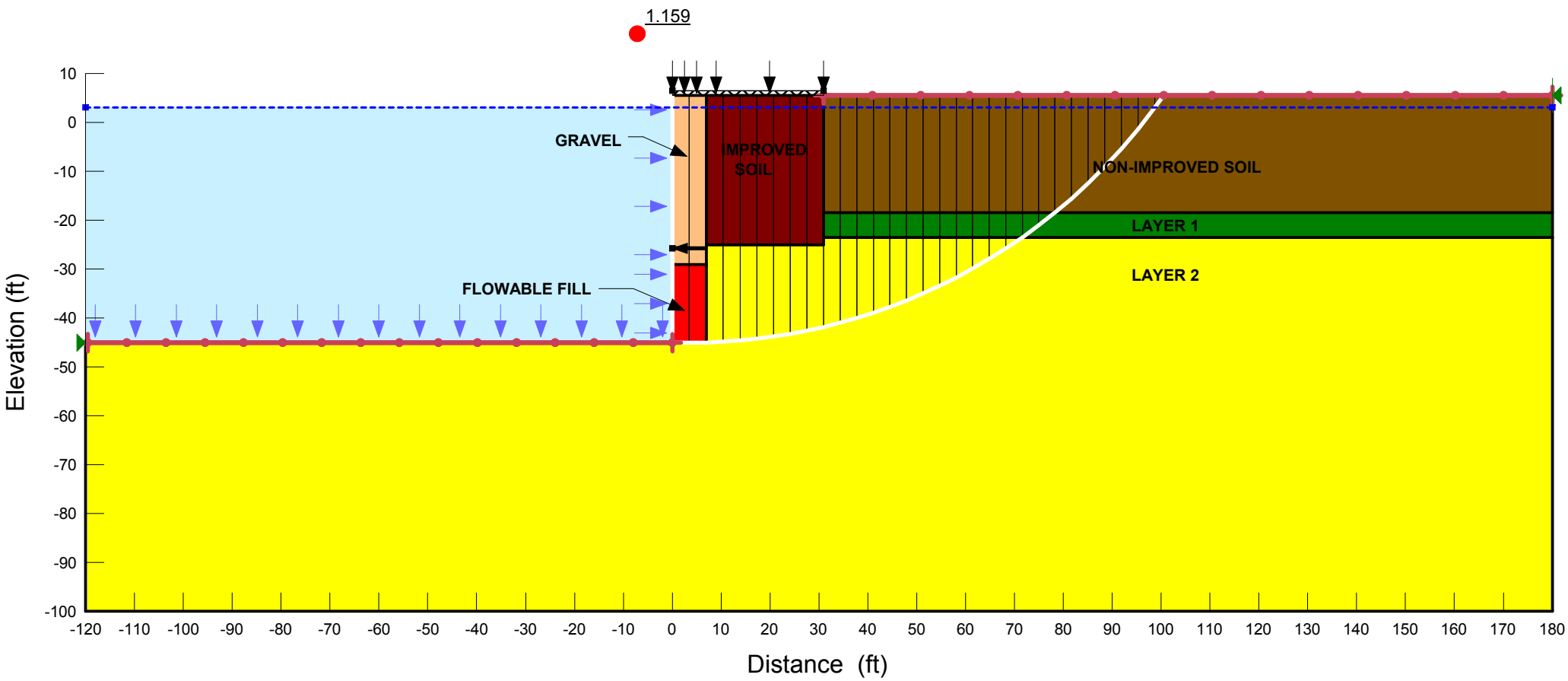
Seismic acceleration 0.12 g

Loads:

Point Load - Pfront: -10,300 lbs
Surcharge Load: 225 pcf

MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Non-Improved Soil Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 100 psf Phi': 0 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 1,400 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 750 psf Phi': 0 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °



CASE 2 - (B -103)
NONLIQUEFIED SOIL CONDITION

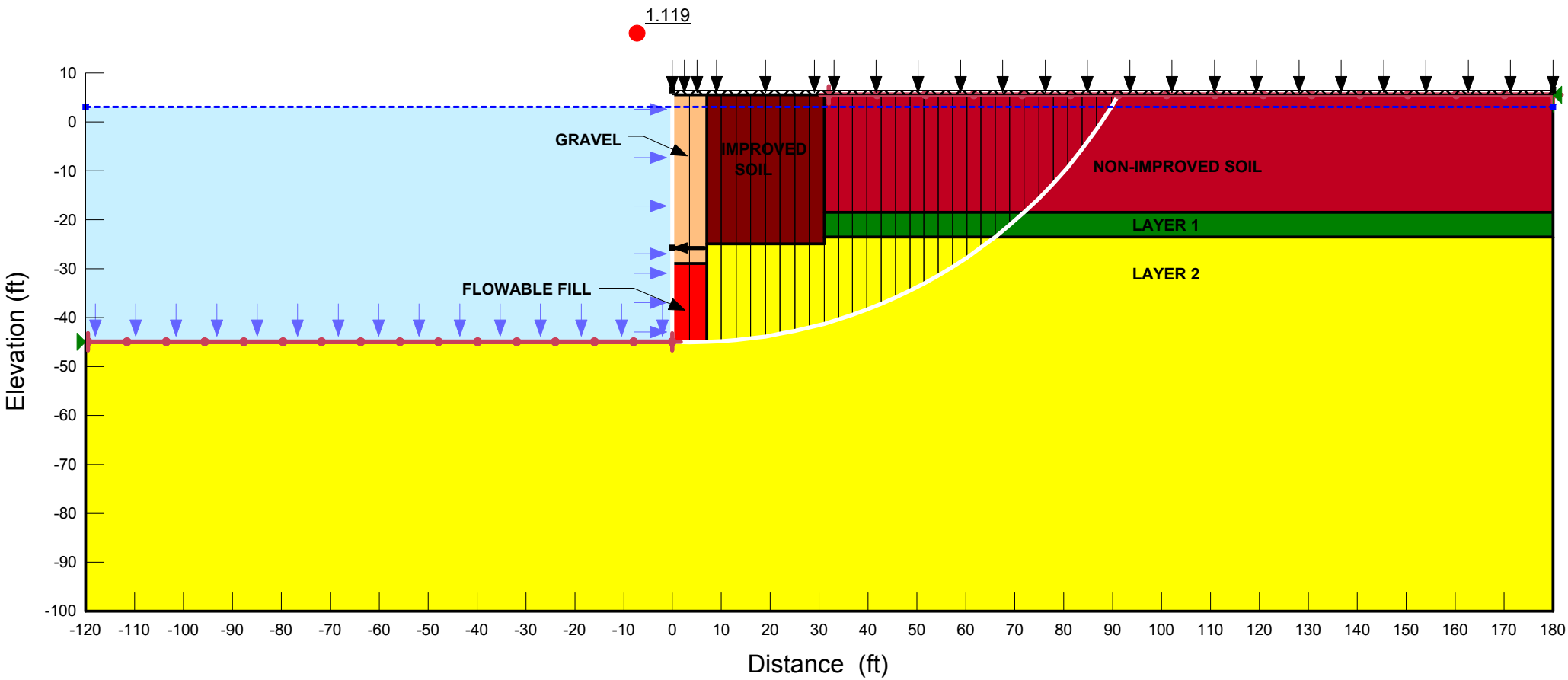
Seismic acceleration 0.12 g

Loads:

Point Load - Pfront: -10,300 lbs
Surcharge Load: 225 pcf

MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 1,400 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 750 psf Phi': 0 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Non-Improved Soil (Non-liquified Condition) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 °



CASE 3 - (B -103)
NONLIQUEFIED SOIL CONDITION
STATIC CASE

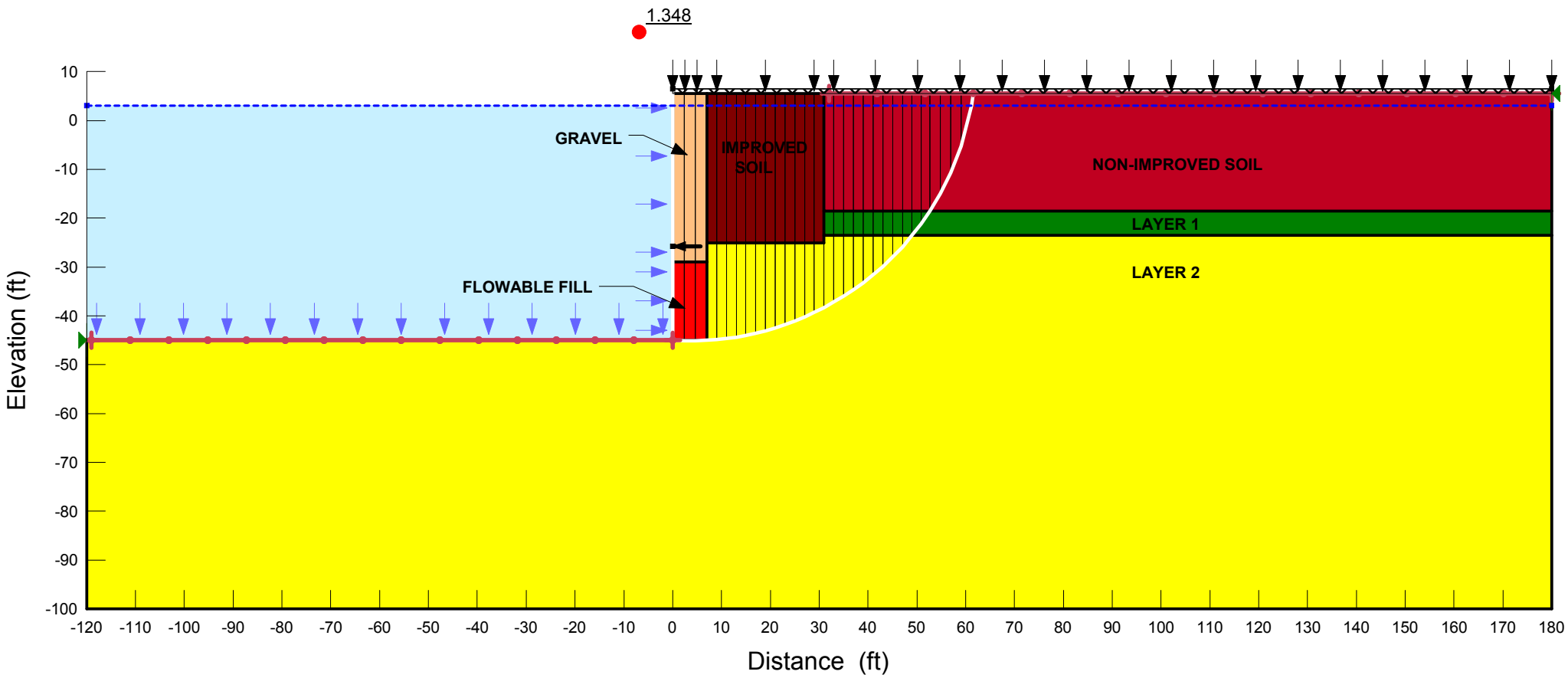
Seismic acceleration 0 g

Loads:

Point Load - Pfront: 0 lbs
Surcharge Load: 300 pcf

MATERIAL PROPERTIES

Name: Flowable Fill Model: Mohr-Coulomb Unit Weight: 100 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Layer 2 Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 1,400 psf Phi': 0 °
Name: Layer 1 Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 750 psf Phi': 0 °
Name: Gravel Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 40 °
Name: Improved Soil Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 21,600 psf Phi': 0 °
Name: Non-Improved Soil (Non-liquified Condition) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 °



STABILTIY CHECK CALCULATIONS

Stability Check

B-101

Static Case

Weight of the improved soil mass plus surcharge(W_{is}) = 63.5X0.068X50+0.225X50 =227.15 K/ft
Weight of the flowable fill plus soil (W_{ff}) = 7X0.058X50.5+8X7X0.053 = 23.5 K/ft
Active Earth pressure (Ka =0.31) (P_a+P_{as}) = 0.5X0.31X0.058X63.5X63.5 + 0.225X0.31X63.5
= 36.25+4.42 = 40.7 K/ft
Resistance = 227.15Xtan(32) + 23.5Xtan(30)= 141+94+13.57=155.51 Kips/ft

F.S against sliding = 155.51/40.7 = 3.8

Driving moment = 36.25X0.3333X63.5 + 4.42X0.5X63.5 = 907.6 Kip-ft/ft
Resisting moment = 227.15X32+23.5X3.5 = 7351.05 Kip-ft/ft

F.S against overturning = 8.1

Seismic Case

Weight of the improved soil mass plus surcharge (W_{is})= 63.5X0.068X50+0.225X50 =227.15 K/ft
Weight of the flowable fill plus soil (W_{ff})= 7X0.058X50.5+8X7X0.053=23.5 K/ft
Earth pressure of liquefied soil (P_l)= 0.5X0.058X63.5X63.5 = 116.94 K/ft
Inertia Force of improved soil ($P_{in\text{-}is}$)= 50X63.5X0.13X0.12 = 49.53 Kips/ft
Inertia Force of flowable fill ($P_{in\text{-}ff}$)= 7X63.5X0.12X0.12 = 6.40 Kips/ft
Westergard force of water on sea side ($P_{w\text{-}se}$)= $\frac{7X0.062X63.5X63.5X0.12}{12}$ = 17.5 kips/ft
Westergard force of liquefied soil on land side ($P_{w\text{-}ld}$)= $\frac{7X0.12X63.5X63.5X0.12}{12}$ = 33.87 kips/ft
Base resistance is 227.15Xtan(32)+23.5Xtan(30) = 141.94+13.6 = 155.51 Kips/ft
Driving forces = inertia forces and earth pressure = 49.53+6.4+116.94 = 172.87 Kips/ft
Total resistance = base resistance + Westergard forces = 155.6+17.5+33.87 = 206.88 Kips/ft

F.S against sliding = 1.2, which is OK.

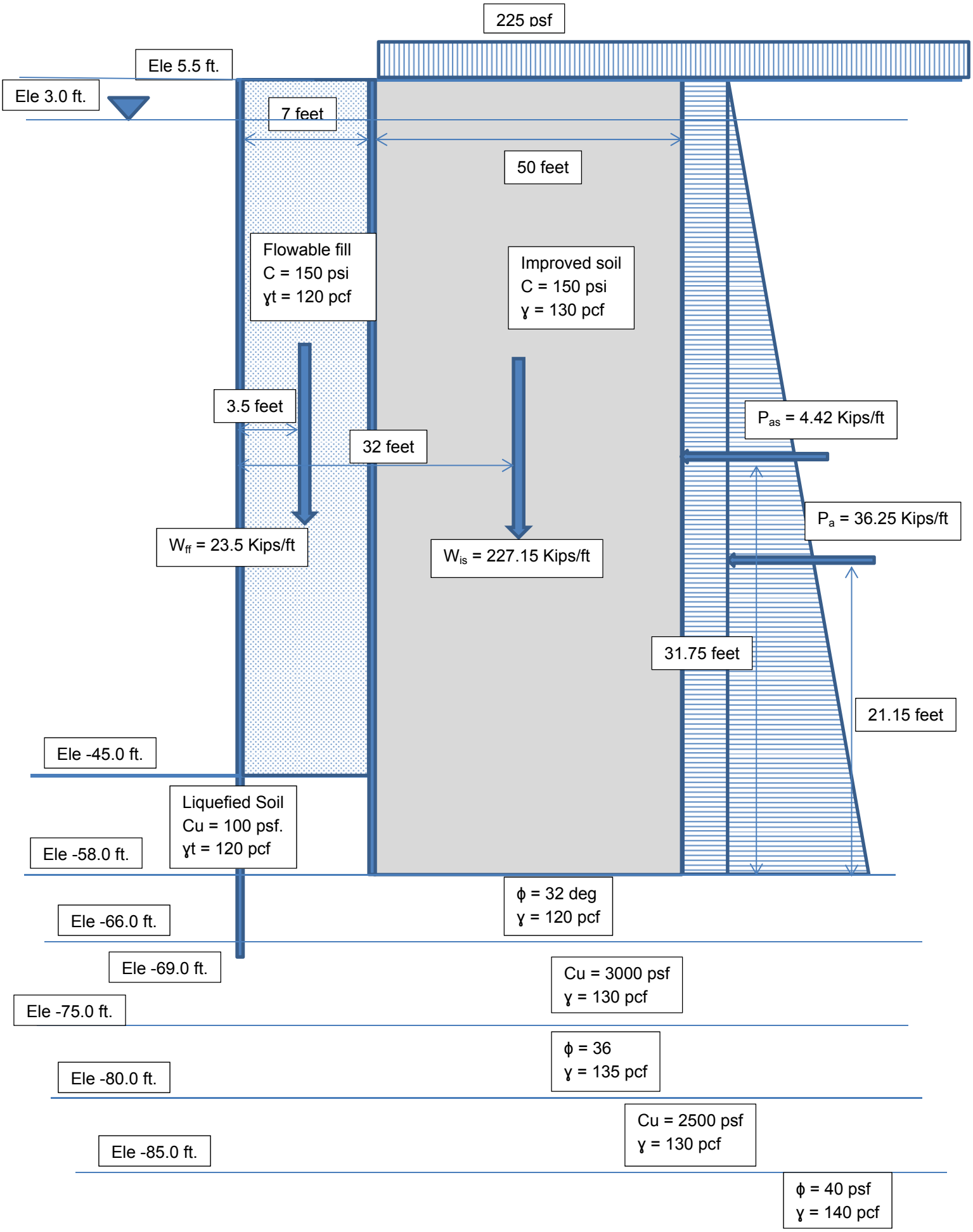
Driving moment = Moment due to inertia forces and liquefied soil = 49.53X0.5X63.5+6.4X0.5X63.5 +116.94X0.333X63.5 = 4250.76 Kip-ft/ft

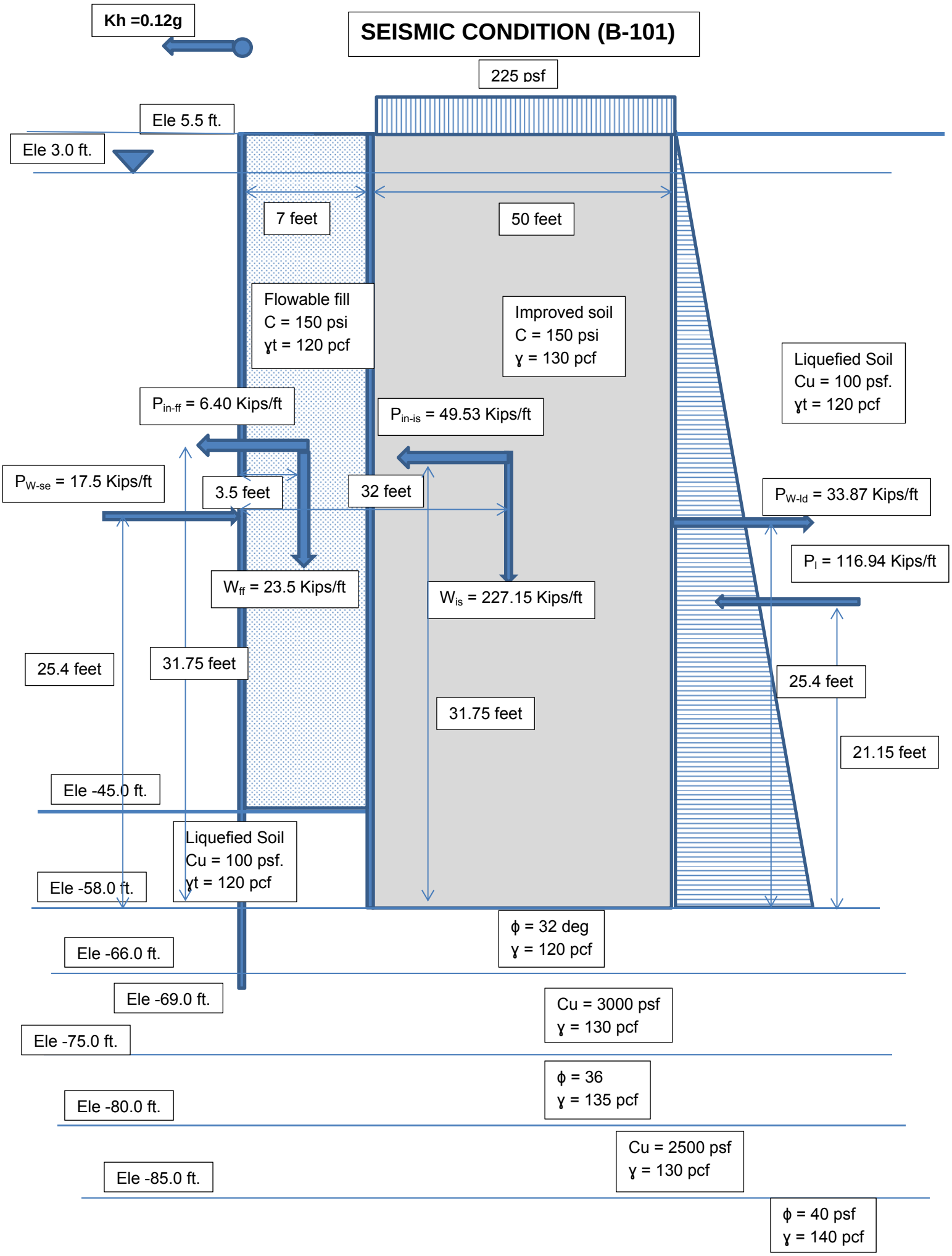
Resisting moment = Moments due to Westergard forces and weight =
17.5X0.4X63.5+33.87X0.4X63.5+227.25(7+25)+23.5X3.5=8655.85 Kips/ft

F.S against overturning = 2.04, which is OK.

Therefore, the earth pressures behind the improved soil mass for static and seismic cases for the wall portion near boring B-101 need not be considered when estimating for embedment.

STATIC CONDITION (B-101)




Kh =0.12g
SEISMIC CONDITION (B-101)
225 psf
Ele 5.5 ft.
Ele 3.0 ft.
7 feet
50 feet
Flowable fill
C = 150 psi
γt = 120 pcf
Improved soil
C = 150 psi
γ = 130 pcf
Liquefied Soil
Cu = 100 psf.
γt = 120 pcf
P in-ff = 6.40 Kips/ft
P in-is = 49.53 Kips/ft
P W-se = 17.5 Kips/ft
3.5 feet
32 feet
P W-ld = 33.87 Kips/ft
P l = 116.94 Kips/ft
W ff = 23.5 Kips/ft
W is = 227.15 Kips/ft
25.4 feet
31.75 feet
25.4 feet
31.75 feet
21.15 feet
Ele -45.0 ft.
Liquefied Soil
Cu = 100 psf.
γt = 120 pcf
Ele -58.0 ft.
ϕ = 32 deg
γ = 120 pcf
Ele -66.0 ft.
Ele -69.0 ft.
Cu = 3000 psf
γ = 130 pcf
Ele -75.0 ft.
ϕ = 36
γ = 135 pcf
Ele -80.0 ft.
Cu = 2500 psf
γ = 130 pcf
Ele -85.0 ft.
ϕ = 40 psf
γ = 140 pcf

Stability Check

B-102

Static Case

Weight of the improved soil mass plus surcharge (W_{is}) = 50.5X0.068X46+0.225X46 =168.31 K/ft
Weight of the flowable fill (W_{ff})= 7X0.058X50.5 =20.5 K/ft
Active earth pressure (Ka =0.31) (P_a+P_{as})= 0.5X0.31X0.058X50.5X50.5 + 0.225X0.31X50.5
= 22.93+3.52 = 26.45 K/ft
Resistance = 168.31Xtan(35)+20.5Xtan(30)=117.85+11.83 = 129.68 Kips/ft

F.S against sliding is greater than 1.5 which is OK.

Driving moment = 22.93X0.3333X50.5 + 3.52X0.5X50.5 = 474.5 Kip-ft/ft
Resisting moment = 168.31X(7+23)+20.5X3.5 = 5121.05 Kip-ft/ft

F.S against overturning = 10.8. and it is OK.

Seismic Case

Weight of the improved soil mass plus surcharge(W_{is}) = 50.5X0.068X46+0.225X46 =168.31 K/ft
Weight of the flowable fill (W_{ff})= 7X0.058X50.5 =20.5 K/ft
Earth pressure of liquefied soil(P_l) = 0.5X0.058X50.5X50.5 =73.96 K/ft
Inertia Force of improved soil($P_{in\text{-}is}$) = 46X50.5X0.13X0.12 = 36.24 Kips/ft
Inertia Force of flowable fill ($P_{in\text{-}ff}$)= 7X50.5X0.12X0.12 = 5.10 Kips/ft
Westergard force of water on sea side ($P_{w\text{-}se}$)= $\frac{7X0.062X50.5X50.5X0.12}{12}$ = 11.1 kips/ft
Westergard force of liquefied soil on land side($P_{w\text{-}ld}$) = $\frac{7X0.12X50.5X50.5X0.12}{12}$ = 21.4 kips/ft
Base resistance is 168.31Xtan(35)+20.5Xtan(30) = 117.85+11.8 = 129.6 Kips/ft
Driving forces = inertia forces and earth pressure = 36.24+5.1+73.96 = 115.3 Kips/ft
Total resistance = base resistance + Westergard forces = 129.6+11.1+21.4 = 162.1 Kips/ft

F.S against sliding = 1.4, which is OK.

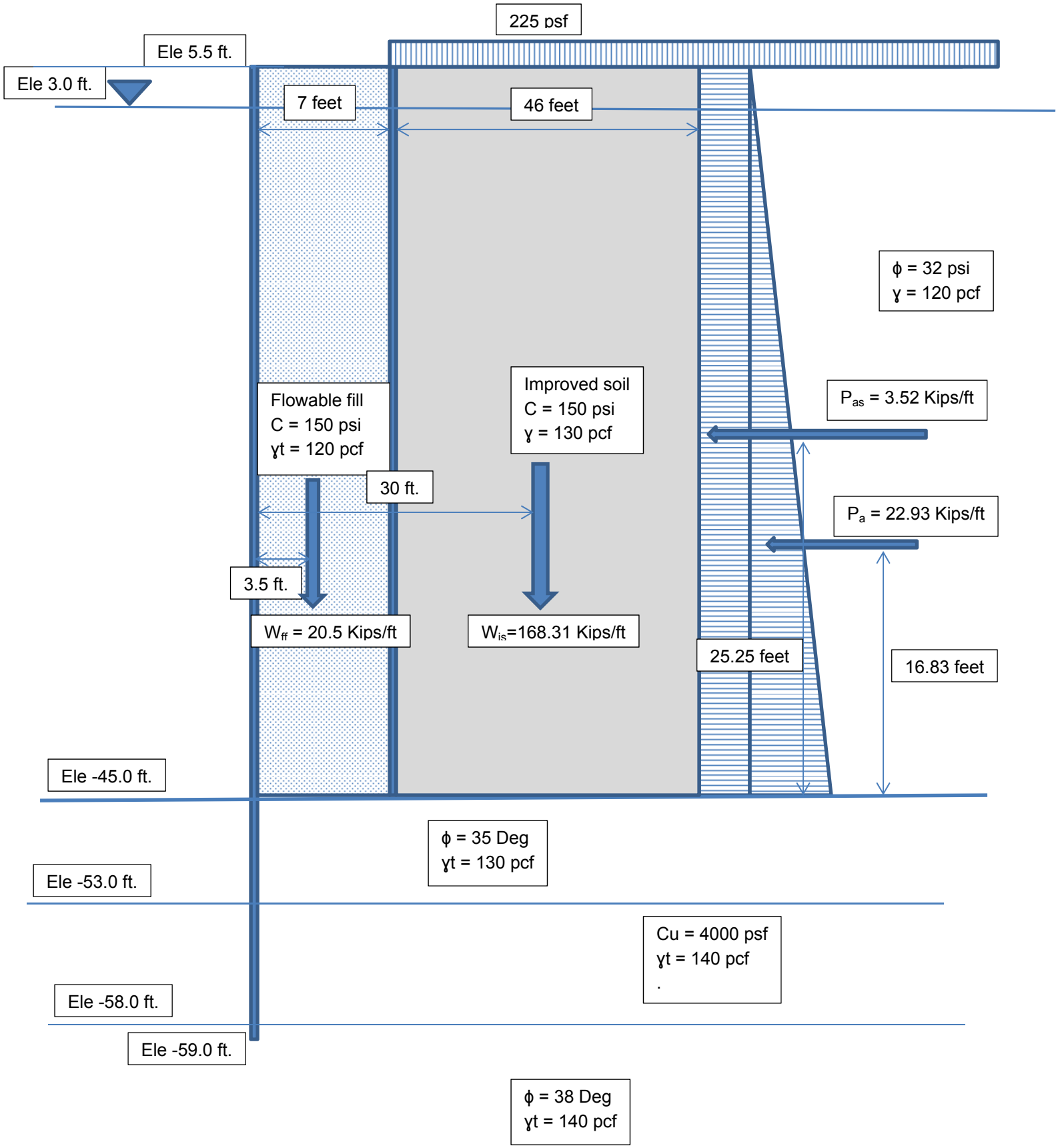
Driving moment = Moment due to inertia forces and liquefied soil = 36.24X0.5X50.5+5.1X0.5X50.5 +73.96X0.333X50.5 = 2288.58 Kip-ft/ft

Resisting moment = Moments due to Westergard forces and weight =
(11.1+21.4)X0.4X50.5+168.31(7+23)+20.5X3.5=5777.55 Kips/ft

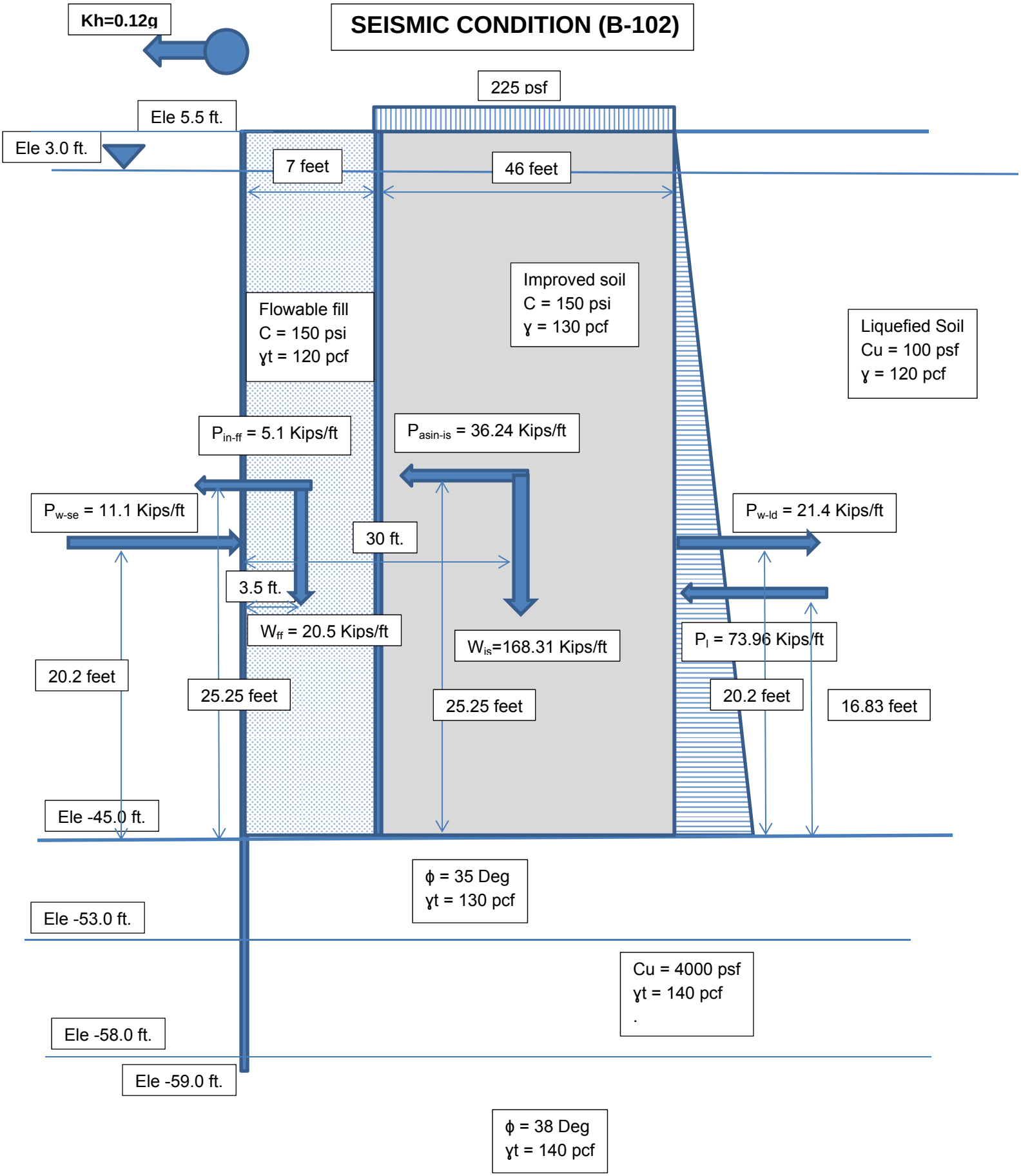
F.S against overturning = 2.52, which is OK.

Therefore, the earth pressures behind the improved soil mass for static and seismic cases for the wall portion near boring B-102 need not be considered when estimating for embedment.

STATIC CONDITION (B-102)



SEISMIC CONDITION (B-102)



Stability Check

B-103

Static Case

It appears that the blocks of improved soil and flowable fills will likely slide at their bases since they are likely the weakest planes for frictional resistance. The horizontal plane of failure through the flowable fill is not likely since the strength is high enough to resist it. This will likely be the weakest case (conservative).

Weight of the improved soil mass plus surcharge (W_{is}) = 30.5X0.068X24+0.225X24 = 55.18 K/ft
Weight of the flowable fill (W_{ff})= 7X0.058X50.5+=20.5 K/ft
Active earth pressure (Ka =0.31 for upper sand and Ka = 0.13 for lower sand) ($P_{as\text{-}us}$+$P_{a\text{-}us}$+ $P_{as\text{-}cl1}$+ $P_{as\text{-}cl2}$ + $P_{a\text{-}cl}$ + $P_{as\text{-}ls}$+$P_{a\text{-}ls}$) = 0.5X0.31X0.058X25.5X25.5 + 0.225X0.31X25.5 + (0.225+25.5X0.058 -2X0.4)X5+ +(0.225+30.5X0.068-2X0.4)X3+0.5X0.048X8X8+ (0.225+30.5X0.068+3X0.048)X0.13X17+ 0.5X0.13X0.078X17X17 = 5.85+1.78 + 4.52 + 4.5+1.54+ 5.4 + 1.47 = 25.06 K/ft
Resistance = 0.4X24+20.5Xtan(30) = 21.44 Kips/ft

F.S against sliding = 21.44/25.06 less than 1.0, which is not OK. Therefore, overturning check was not performed.

Seismic Case

Weight of the improved soil mass plus surcharge (W_{is}) = 30.5X0.068X24+0.225X24 = 55.18 K/ft
Weight of the flowable fill (W_{ff})= 7X0.058X50.5=20.5 K/ft
Earth pressure of liquefied soil (P_l) = 0.5X0.058X25.5X25.5 = 18.86 K/ft
Earth pressure of clay between Ele -20 ft. and -28 ft. ($P_{as\text{-}cl1}$+ $P_{as\text{-}cl2}$ +$P_{a\text{-}cl)}$ = 4.52+4.5+1.54 = 10.56 Kips/ft.
Earth pressure of sand between Ele -28 feet and -45 feet (Kae = 0.28) ($P_{aes\text{-}ls}$+$P_{ae\text{-}ls)}$ = (0.225+30.5X0.068+3X0.048)X17X0.28+0.5X0.28X0.078X17X17 = 11.63+3.16=14.79 Kips/ft

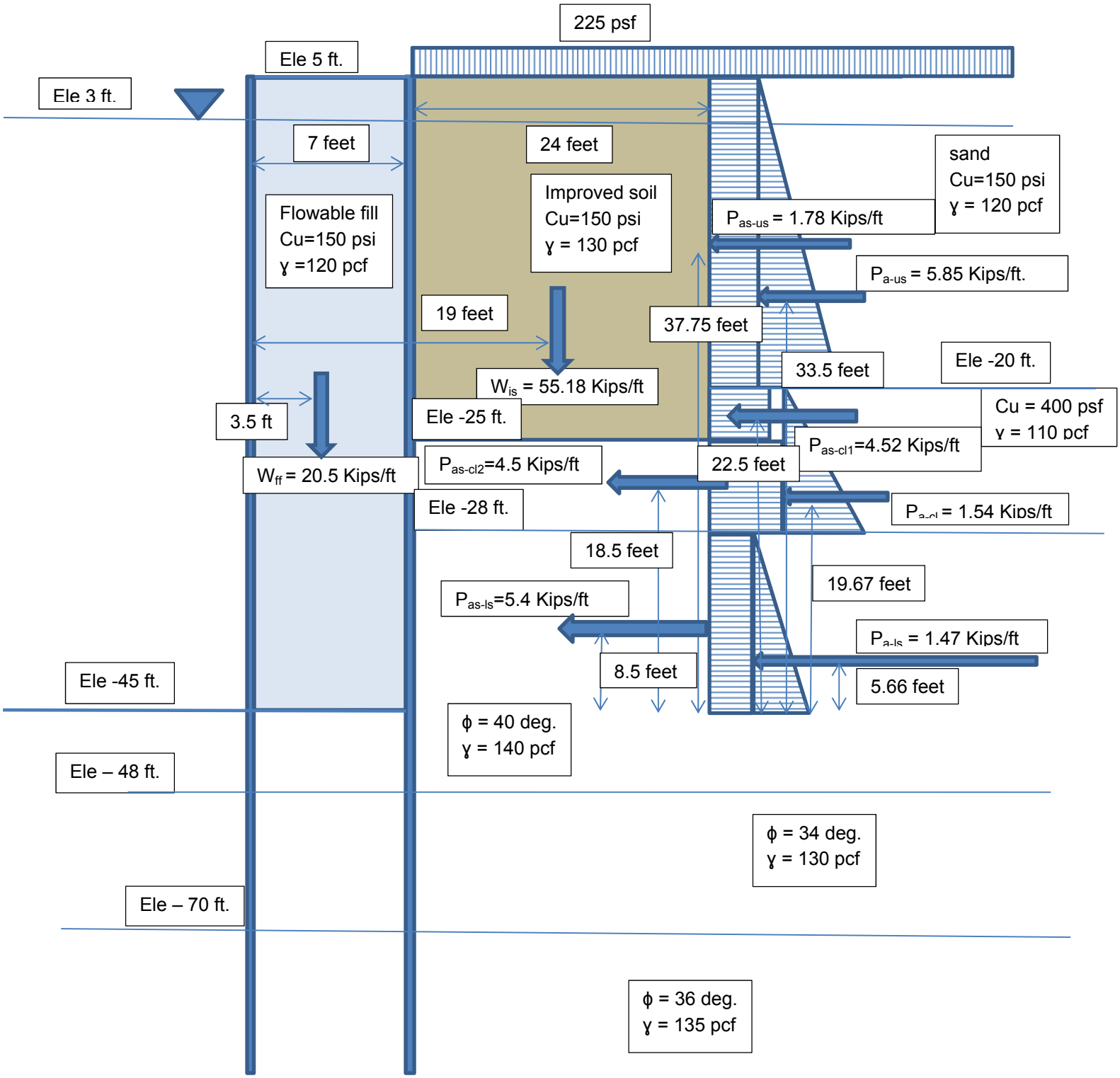
Inertia Force of improved soil ($P_{in\text{-}is}$)= 24X25.5X0.13X0.12 = 9.55 Kips/ft
Inertia Force of flowable fill ($P_{in\text{-}ff}$)= 7X50.5X0.12X0.12 = 5.1 Kips/ft
Westergard force of water on sea side ($P_{w\text{-}se}$) = $\frac{7X0.062X50.5X50.5X0.12}{12}$ = 11.07 kips/ft
Westergard force of liquefied soil on land side ($P_{w\text{-}ld}$) = $\frac{7X0.12X25.5X25.5X0.12}{12}$ = 5.5 kips/ft
Resistance at the base = 0.4X24+20.5Xtan(30) = 21.44 Kips/ft

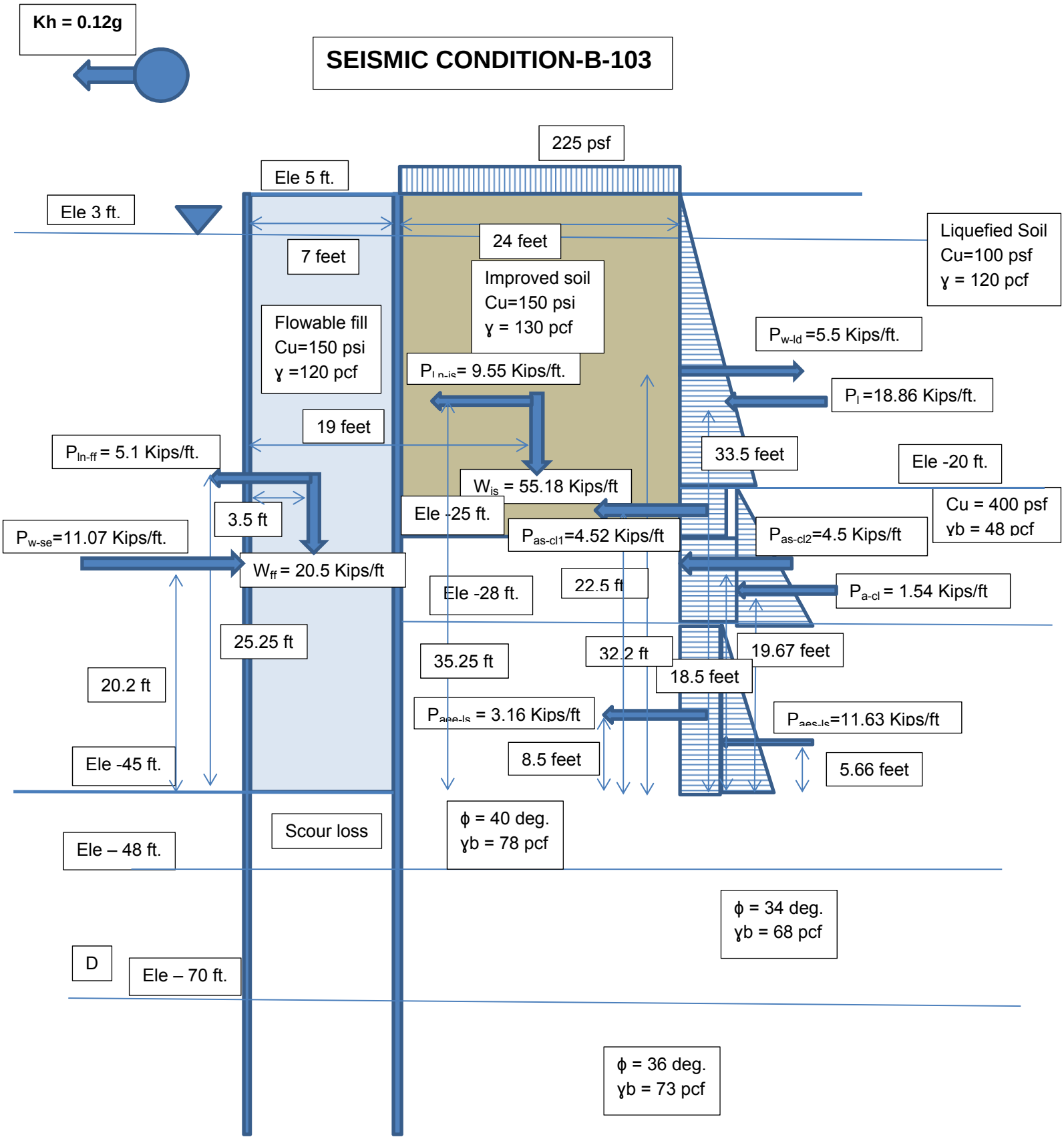
Total resistance = Westergard forces + base resistance = 11.07+5.5+21.44 = 38.01 Kips/ft
Total driving forces = earth pressures + inertia forces = 18.86+10.56+14.79 +9.55+5.1 = 58.86 Kips/ft

Since the F.S. against the sliding is way less than 1, F.S. Therefore, the check against overturning was not evaluated.

Therefore, the earth pressures behind the improved soil mass for static and seismic cases should be considered in the design of sheet pile and for embedment.

STATIC CONDITION-B-103




Kh = 0.12g
SEISMIC CONDITION-B-103
225 psf
Ele 5 ft.
Ele 3 ft.
7 feet
24 feet
Liquefied Soil
Cu=100 psf
γ = 120 pcf
Improved soil
Cu=150 psi
γ = 130 pcf
Flowable fill
Cu=150 psi
γ =120 pcf
Pw-ld =5.5 Kips/ft.
Pl =18.86 Kips/ft.
Pl n-is= 9.55 Kips/ft.
19 feet
Pln-ff = 5.1 Kips/ft.
33.5 feet
Ele -20 ft.
Wis = 55.18 Kips/ft
Cu = 400 psf
γb = 48 pcf
3.5 ft
Ele -25 ft.
Pw-se=11.07 Kips/ft.
Pas-cl1=4.52 Kips/ft
Pas-cl2=4.5 Kips/ft
Wff = 20.5 Kips/ft
22.5 ft
Ele -28 ft.
Pa-cl = 1.54 Kips/ft
25.25 ft
35.25 ft
32.2 ft
19.67 feet
18.5 feet
20.2 ft
Paes-ls = 3.16 Kips/ft
Paes-ls=11.63 Kips/ft
8.5 feet
5.66 feet
Ele -45 ft.
Scour loss
ϕ = 40 deg.
γb = 78 pcf
Ele – 48 ft.
ϕ = 34 deg.
γb = 68 pcf
D
Ele – 70 ft.
ϕ = 36 deg.
γb = 73 pcf

EARTH PRESSURE CALCULATIONS & DIAGRAMS FOR

WALL PORTION NEAR BORING B-103

EARTH PRESSURE CALCULATIONS FOR WALL PORTION NEAR BORING B-103

CALCULATIONS

Assumptions:

1. Return period of the design earth quake is 475 Years (10% exceedance in 50 years)
2. Ground improvement using deep soil mixing is recommended to a distance of 24 feet behind the existing wall down to Ele -25 feet.
3. Existing wall is marginally stable for static loading and will likely be not stable under seismic conditions.
4. Presence of upper 2 feet of dry soil is considered as submerged for the easiness of calculations. It will not have any significance in the design by considering the F.S values and apparent pressure distributions that are used here.
5. The loading combinations with live loads with their appropriate load will be incorporated by the structural engineer during the structural design of the system.
6. Seismic earth pressure coefficients were estimated using Mononabe-Okabe equations.
7. Loose sediments between Ele -45 feet and Ele -48 feet in front of the existing wall is assumed.
8. Sheet piles will be able to be driven through the cemented layer between Ele -28 feet and -48 feet.
9. We consider the fill between new and existing wall will act as a gravitational wall.
10. The stiffness of the existing sheet pile wall is not considered.

Static Case

For soil behind the wall between Ele 5.5 feet and -20 feet, Ka = 0.31
a = 0.225X0.31= 0.07 Ksf
b = 0.058X25.5X0.31 = 0.46 Ksf

For soil behind the wall between Ele -20 feet and -28 feet,
c = $\gamma H-2C(Ka)^{1/2}$ = 0.225+30X0.068 -2X0.4 = 1.47 Ksf
d = 0.048X8 = 0.38 Ksf
e = 0.225+30.5X0.068-2X0.4 = 1.5 Ksf

For the in-situ soil between Elevation -28 feet. And -48 feet, Ka = 0.13
f = (0.225 + 30X0.068+ 3X0.048)X0.13 = 0.32 Ksf
g = 0.13X0.078X(48-28) = 0.20 Ksf

For soil between Ele -48 feet and -70 feet, Ka = 0.28 and Kp = 3.53, Kp/1.5 = 2.36
h = 0.068X22X2.36 = 3.53 Ksf
i = (0.225+30.5X0.068+3X0.048+20X0.078)X0.28 = 1.12 Ksf
j = 0.078X22X0.28 = 0.48 Ksf

For soils below Ele -70 feet, Ka = 0.26, Kp = 3.95, Kp/1.5 = 2.57

k = 0.073X2.57X(D-25) = 0.19 (D-25) Ksf
l = 0.068X22X2.57= 3.85 Ksf
m = (0.225+30.5X0.068+3X0.048+20X0.078+22X0.068)X0.26 = 1.04 Ksf
n = 0.073X0.26X(D-25) = 0.02(D-25) Ksf

Seismic Case

For liquefied soil behind the wall between Ele 5.5 feet and -20 feet, Ka = 0.31
a = 0.058X25.5 = 1.48 Ksf

For soil behind the wall between Ele -20 feet and -28 feet,
b = γH-2C$(Ka)^{1/2}$ = 0.225+30X0.068 -2X0.4 = 1.47 Ksf
c = 0.048X8 = 0.38 Ksf
d = 0.225+30.5X0.068-2X0.4 = 1.5 Ksf

For the in-situ soil between Elevation -28 feet. And -48 feet, Kae = 0.28 (for Kh = 0.12g)
e = (0.225 + 30X0.068+ 3X0.048)X0.28 = 0.68 Ksf
f = 0.28X0.078X(48-28) = 0.44 Ksf

For soil between Ele -48 feet and -70 feet, Ka = 0.28 and Kpe = 4.3, Kp/1.5 = 2.87 (for Kh = 0.29 g)
g = 0.068X22X2.87= 4.29 Ksf
h = (0.225+30.5X0.068+3X0.048+20X0.078)X0.28 = 1.12 Ksf
i = 0.078X22X0.28 = 0.48 Ksf

For soils below Ele -70 feet, Ka = 0.26, Kpe = 5.1, Kp/1.5 = 3.4

j = 0.073X3.4X(D-25) = 0.25 (D-25) Ksf
k = 0.068X22X3.4= 5.10 Ksf
l = (0.225+30.5X0.068+3X0.048+20X0.078+22X0.068)X0.26 = 1.04 Ksf
n = 0.073X0.26X(D-25) = 0.02(D-25) Ksf

Dynamic water Pressure

Dynamic water force on land side ($P_{dyn\text{-}land}$) = $\frac{7X0.12X0.12X25.5X25.5}{12}$ = 5.5 Kips/ft
This force will act at 0.4X25.5 +28 feet above Ele -48 feet= 38.2 ft.

Dynamic water force on sea side ($P_{dyn\text{-}sea)}$ = (7/12)*K_h*γ_w*h_w^2 = $\frac{7X0.12X0.062X53.5X53.5}{12}$ = 12.42 Kips/ft
This force will act at 0.4X53.5 feet above Ele -48 feet = 21.4 feet.

Inertia Force

Inertia Force of Improved soil ($P_{in\text{-}is}$) = 24X25.5X0.13X0.12 = 9.55 Kips/ft
This force acts at 23+0.5X25.5 feet above Ele -53 feet = 35.75 feet.

Inertia Force of Flowable Fill ($P_{in\text{-}ff}$) = 7X50.5X0.12X0.12 = 5.1 Kips/ft
This force acts at 3+0.5X50.5 feet above Ele -53 feet = 28.25 feet.

AASHTO MANUAL

- Yield of structural members making up the wall, such as with a pile-supported wall,
- Loads applied to the lateral support systems (e.g., ground anchors in anchored wall systems; see Article 11.9.6) that exceed the available factored resistance, and
- Unacceptable deformation or damage to any facilities located in the vicinity of the wall.

the reduction in earth pressure due to cohesion should not be combined with a reduction in earth pressure due to horizontal wall displacement.

As described in Article 11.6.5.3, an alternate approach for determining the seismic active earth pressure involves use of the generalized limit equilibrium method. If used for the design of a nongravity cantilever wall, the geometry of the slope stability model should extend from the ground surface to the bottom or toe of the sheet pile or other nongravity cantilever walls in which the wall is continuous both above and below the excavation line in front of the wall. For soldier pile walls, the analysis extends to the excavation level. The seismic active pressure is determined as described in Appendix A11.

The static lateral earth pressure force acting behind the wall is already included in P_{AE} (i.e., P_{AE} is the combination of the static and seismic lateral earth pressure). See Articles 3.11.6.3 and 11.10.10.1 for definition of terms in Figure 11.8.6.2-1 not specifically defined in this Article.

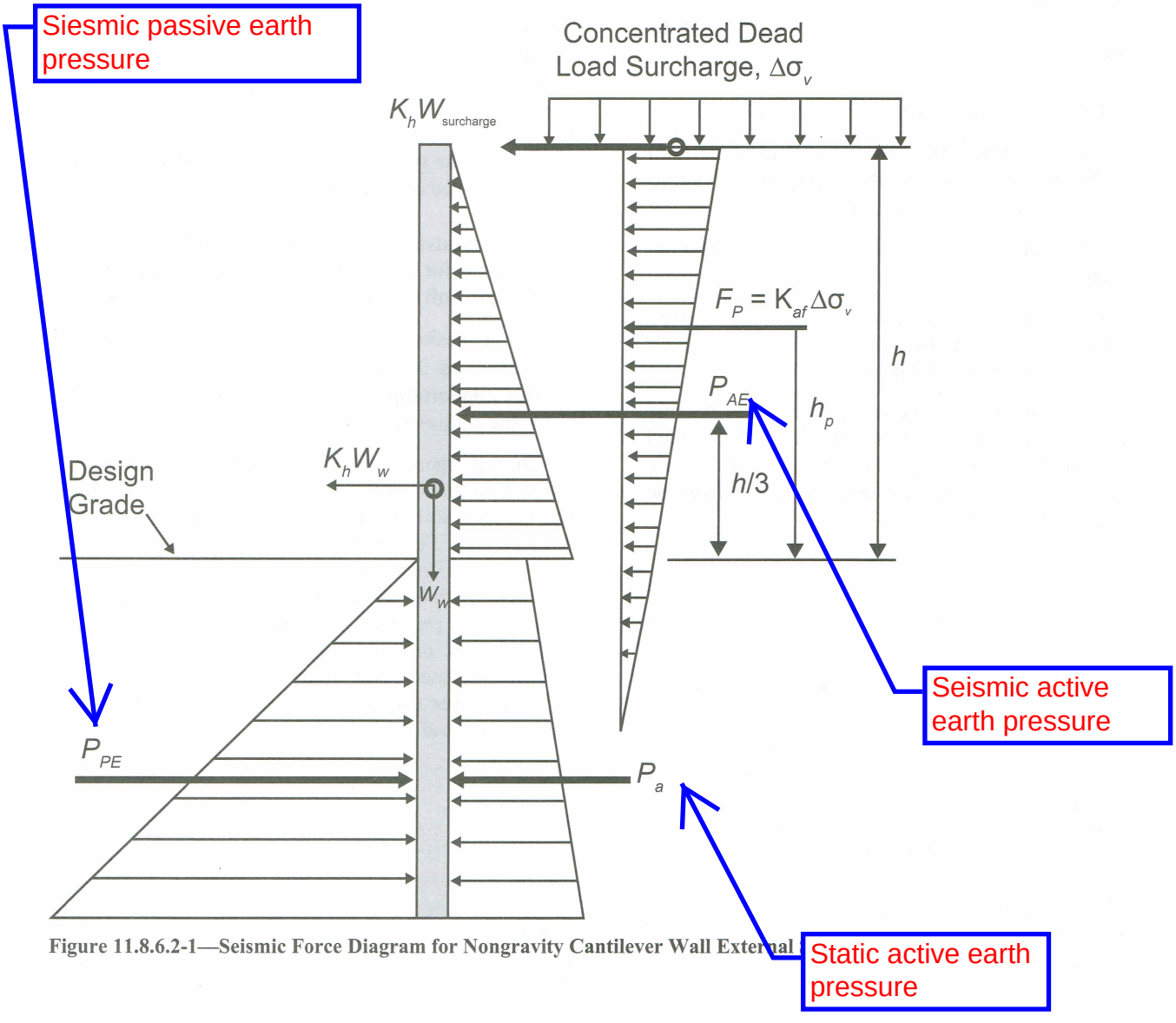


Figure 11.8.6.2-1—Seismic Force Diagram for Nongravity Cantilever Wall External

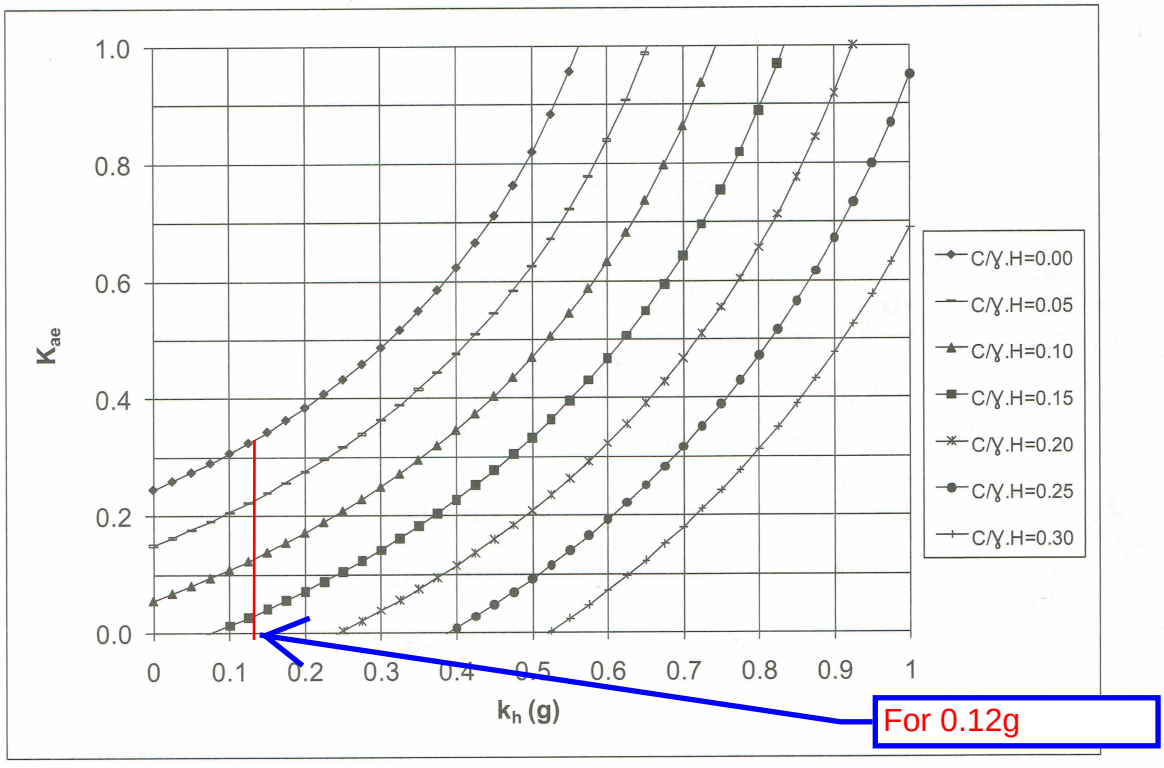


Figure A11.3.2-3—Seismic Active Earth Pressure Coefficient for $\phi = 35$ degrees (c = soil cohesion, γ = soil unit weight, and H = retaining wall height)

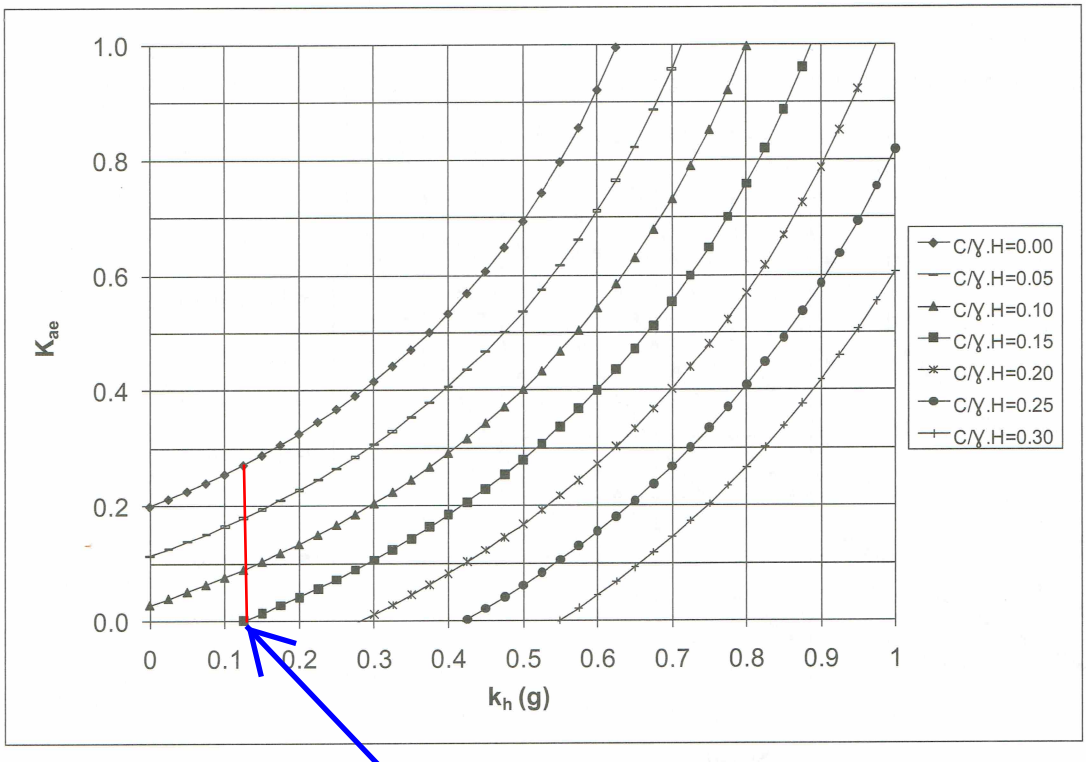
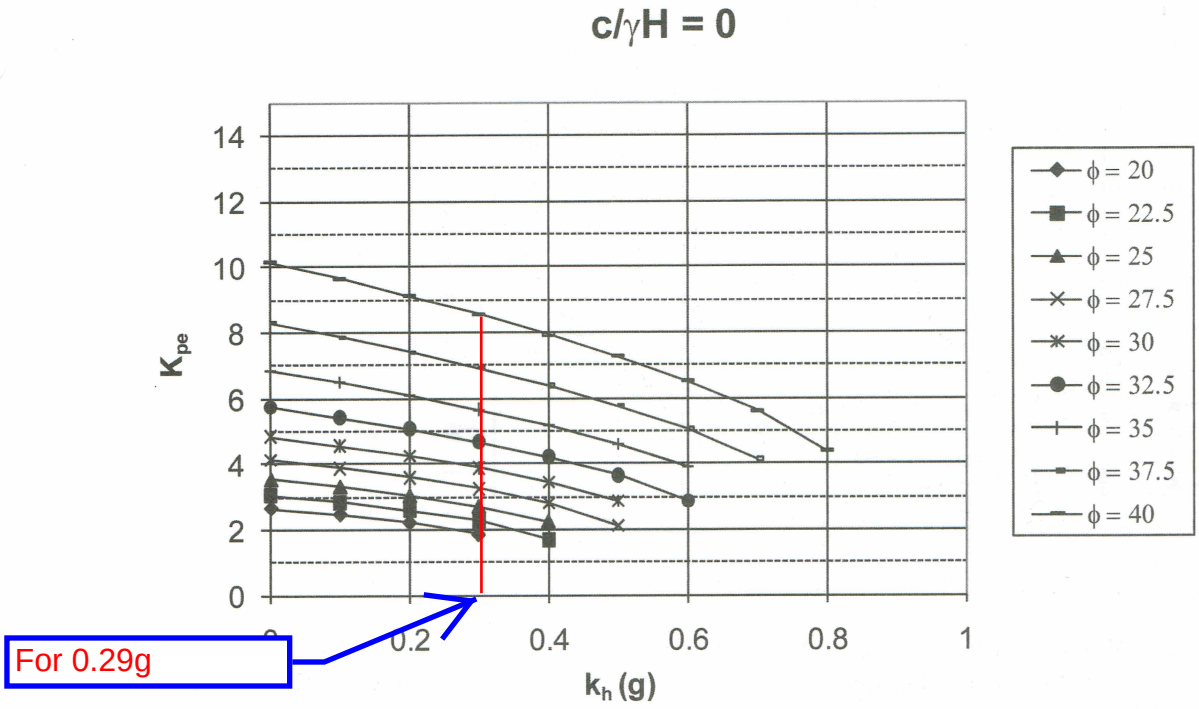


Figure A11.3.2-4—Seismic Active Earth Pressure Coefficient for $\phi = 40$ degrees (c = soil cohesion, γ = soil unit weight, and H = retaining wall height)

0.12g



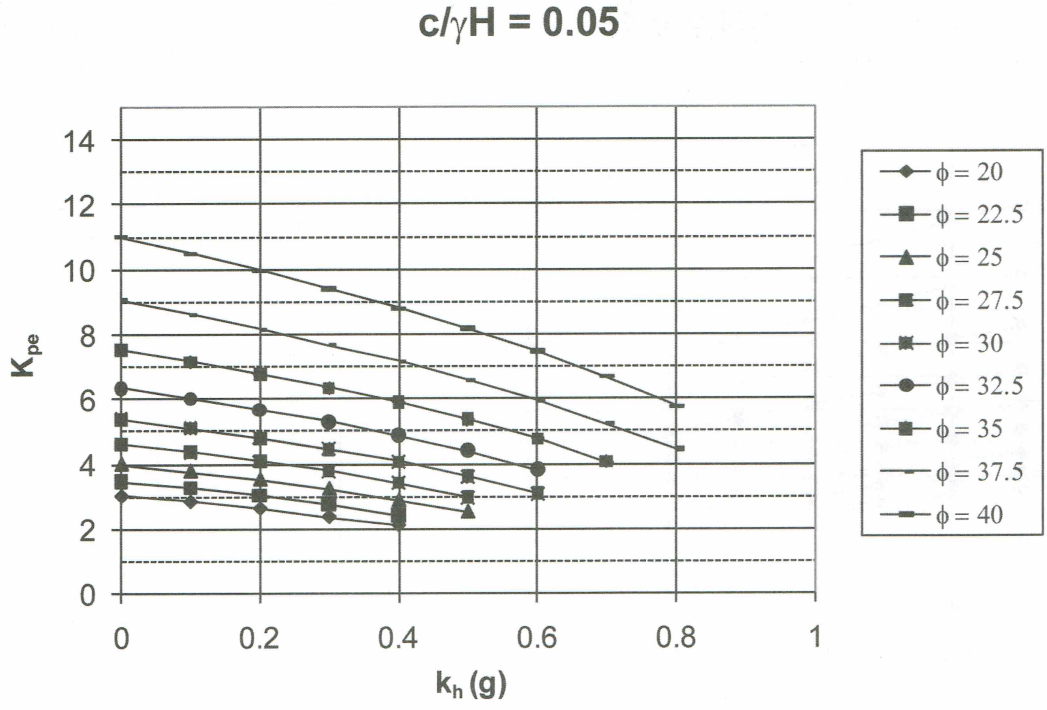


Figure A11.4-2—Seismic Passive Earth Pressure Coefficient Based on Log Spiral Procedure for $c/\gamma H$ = 0 and 0.05 (c = soil cohesion, γ = soil unit weight, and H = height or depth of wall over which the passive resistance acts)

Note: $k_h = A_s = k_{ho}$ for wall heights greater than 20 ft.

CALCULATIONS FOR DESIGN Kh VALUE FOR WALL

Design PGA for Walls

Site Class is ‘D” (at the base of the Wall)

PGA for B/C boundary conditions with 475 years of return period is 0. 29g (based on the phone conversation with NAVFAC)

Wall Height is 46 feet.

Fa = 1.2

S1 = 0.22g (based on the USGS Website)

Fv = 1.96

PGA (Corrected) = 0.29X1.2 = 0.348g

β = (0.22X1.96)/0.348 = 1.24

α = 1 +0.01X46(0.5X1.24-1) = 0.83

Therefore, the design PGA is = 0.83X0.29 g = 0.24g

If we allow a permanent displacement of 2 inches or more for the wall during the seismic event, it can be further reduced to 0.5X0.24g = 0.12g

We believe, it is likely to be the case for the revised system.

$$k_{av} = \alpha \cdot k_{max} \qquad 6\text{-}2$$

where α = a slope height reduction factor and k_{av} is the average peak acceleration in the potential failure mass, taking into account spatial incoherence (or wave scattering).

The following relationship is presented in NCHRP Report 611 for the value of α for slopes and embankments of up to 100 ft in height founded upon Site Class C, D, and E soil conditions:

$$\alpha = 1 + 0.01 \cdot H \cdot (0.5 \cdot \beta - 1) \qquad 6\text{-}3$$

where H = slope height (feet) and β is a function of the shape of the acceleration response spectrum and is given by:

$$\beta = F_v \cdot S_1 / k_{max} \qquad 6\text{-}4$$

where F_v = AASHTO site factor for the spectral acceleration at 1 second and S_1 = the spectral acceleration at 1 second for Site Class B.

For Site Classes A and B (hard and soft rock foundation soils) the value of α from Equation 6-3 is increased by a factor of 1.2.

Figure 6-3 shows Equation 6-3 in graphical form. The curved lines in Figure 6-3 are fit to the data points developed using numerical analysis while the straight lines in the figure are engineering approximations represented by Equation 6-3. Note that the engineering approximations for α remain constant after a height of 100 ft. While a smaller value of α may be appropriate for slope heights greater than 100 ft, special studies are recommended to justify the use of smaller values of α than the value for H = 100 ft. Similar height adjustment factors are recommended for evaluating the seismic coefficient for design of retaining walls, as discussed in Chapter 11.

Values of β less than 1.0 in Equation 6-3 and in Figure 6-3 would be typically associated with seismic conditions in the eastern United States, firm ground conditions, and lower acceleration levels, while values of β greater than 1.0 would be associated with the Western U.S., higher accelerations, and Site Class C or D site conditions.

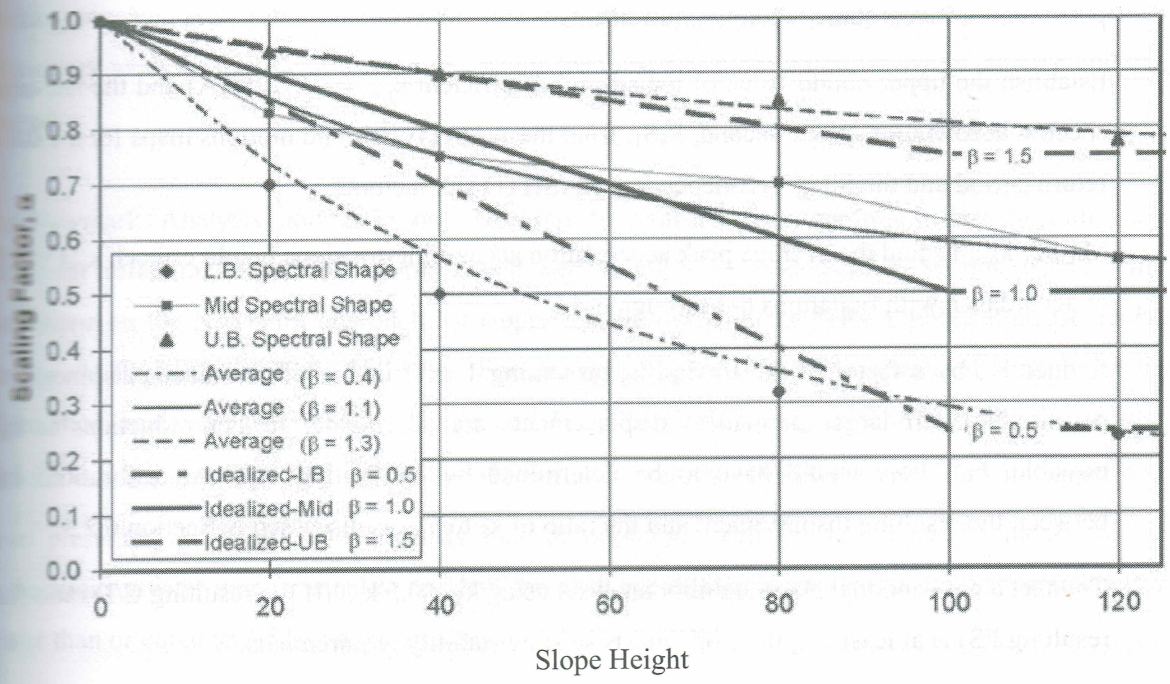


Figure 6-3 Simplified Height-Dependent Incoherence Reduction Scaling Factor, α, Recommended for Slope Stability Analysis (NCHRP 2008)

Based upon seismic displacement analyses, NCHRP Report 611 recommends that the average seismic coefficient given by Equation 6-2 be reduced by 50% to find the seismic coefficient for a required C/D ratio of 1.1, assuming the slope can accommodate 1 to 2 inches of permanent seismic displacement:

$$k_s = 0.5 \cdot \alpha \cdot F_{pga} \cdot PGA \qquad 6\text{-}5$$

where k_S is the seismic coefficient for a required C/D ratio of 1.1 assuming 1 to 2 inches of permanent seismic displacement is allowable.

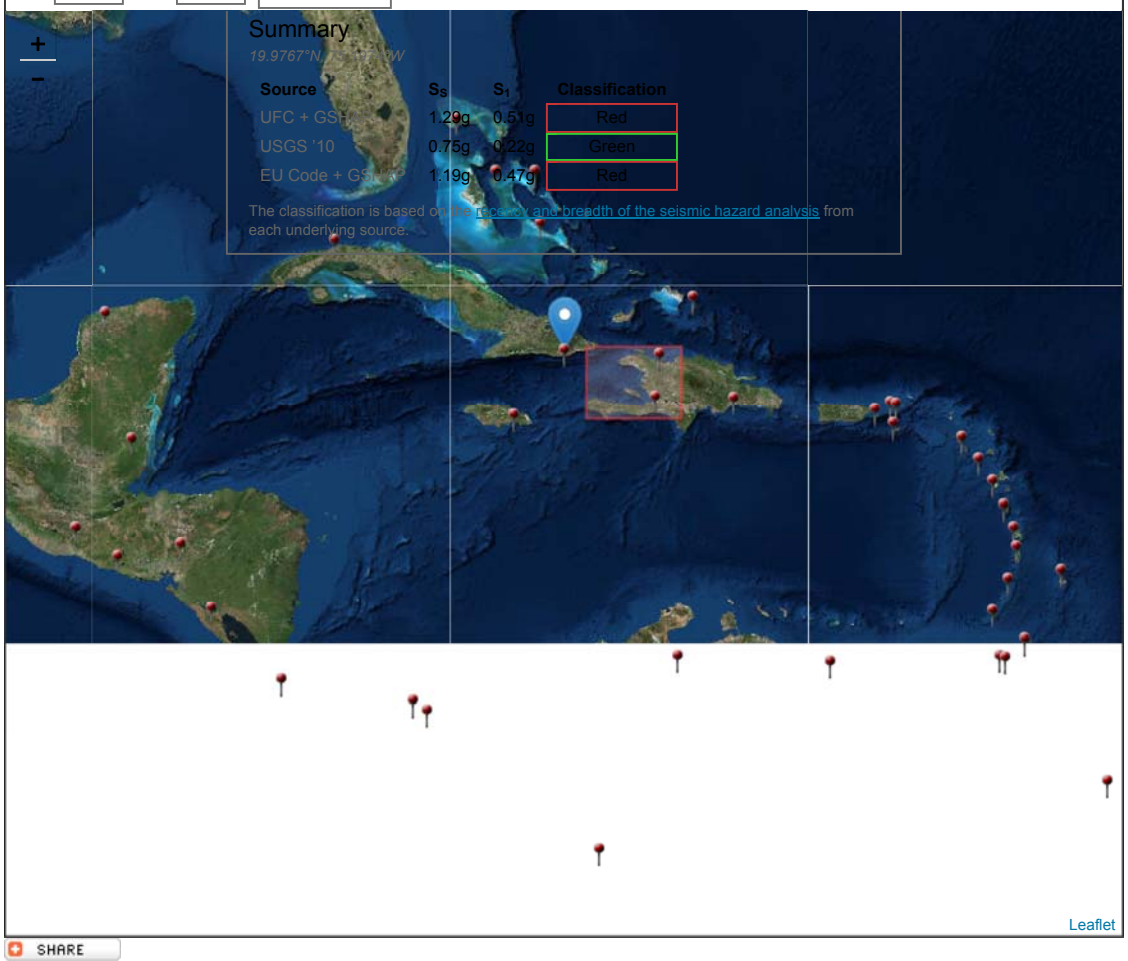
In summary, based upon the recommendations in NCHRP Report 611, the limit equilibrium seismic coefficient design approach entails the following steps:

Geologic Hazards Science Center

Worldwide Seismic Design Tool (Beta)

This tool is a Beta release. It provides an informal and incomplete collection of S_S and S_1 values derived from existing studies. Seismic design parameter values for sites within the U.S.A. and its Territories can be accessed through the U.S. Seismic Design Maps web application.

Lat 19.9767 Lon -75.197 Set Location



SHARE

APPENDIX E

PREVIOUS TEST BORING DATA

1995 Boring Data from NAVFAC Contract N62470-91-B-1269

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BORING LOGS

BORING Nº 5A

Material Description	Stratum Depth, Ft.
CONCRETE 6"	
Dark brown, dry to moist, soft to stiff, fine to medium Sandy CLAY (CL-SC), some gravel, marine shell fragments, and coral fragments (Fill)	10.0
Brown and gray, very moist to saturated, very loose to loose, Clayey fine to medium SAND (SC), some gravel, marine shell fragments and coral fragments (Fill)	23.0
Light greenish gray, very moist to saturated, soft to medium stiff, fine to medium Sandy CLAY (CL-SC), some gravel, marine shell fragments and coral fragmetns (Fill)	
Light greenish gray, very moist to sa·urted, soft to medium stiff, fine t[o m]edium Sandy CLAY (CL-SC), some g[ra]vel, marine shell fragments and coral fragments (Fill)	45.0
Bottom of boring 45.0'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery
1	x/4 7/8	14
2	6/6 8/6	16
3	3/2 2/3	24
4	3/3 4/4	20
5	3/4 3/3	19
6	3/2 3/3	19
7	3 4/3	16
8	3 2/2	18
9	3 3/2	18
10	2 2/2	18
11	2 3/3	18
12	4 4/3	18
13	4 4/4	18

Boring and Sampling Notes:
- Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
- Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
- *Caved in @ 18.5'

BORING Nº 6A

Material Description	Stratum Depth, Ft.
CONCRETE 8"	
Brown and gray, moist to very moist, very soft to stiff, fine Sandy CLAY (CL) and gravel, trace marine shell fragments (Fill)	8.0
Light greenish gray, very moist to saturated, very soft to medium stiff, fine Sandy CLAY (CL-SC), some coral fragments and marine shell fragments (Fill)	
Light greenish gray, very moist to saturated, very soft to meidum stiff, fine Sandy CLAY (CL-SC), some coral fragments and marine shell fragments (Fill)	45.0
Bottom of boring 45.0'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery
1	x/6 5/5	14
2	8/7 6/5	16
3	3/2 1/2	19
4	4/2 0/1	16
5	4/1 0/1	19
6	2/1 1/1	19
7	1 1/1	18
8	3 2/2	18
9	3 2/2	18
10	3 3/3	18
11	4 3/3	18
12	3 3/3	18
13	3 4/4	18

Boring and Sampling Notes:
- Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
- Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
- *Caved in @ 19.0'

BORING Nº 7A

Material Description	Stratum Depth, Ft.
CONCRETE 9.5"	
Light and dark gray, moist to saturated, very soft to stiff, fine Sandy CLAY (CL), some gravel, marine shell fragments and coral fragments (Fill)	8.0
Gray, very moist to saturated, very soft to very stiff, fine to medium Sandy CLAY (CL-SC), some marine shell fragments, coral fragments and gravel (Fill)	38.0
Light gray, saturated, medium dense, Clayey fine SAND (SC), some marine shell fragments, and coral fragments	45.0
Bottom of boring 45.0'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery
1	x/1 1/2	12
2	5/7 6/7	20
3	4/3 2/2	20
4	2/2 2/2	19
5	4/5 3/3	24
6	2/1 1/1	18
7	2 1/0	18
8	2 1/2	18
9	3 2/2	18
10	4 4/4	18
11	6 7/11	18
12	6 8/7	18
13	5 8/8	18

Boring and Sampling Notes:
- Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
- **Gray, very moist to saturated, very soft to very stiff, fine to medium Sandy CLAY (CL-SC), some marine shell fragments, coral fragments and gravel (Fill)
- *Caved in @ 16.5'

BORING Nº 9A

Material Description	Stratum Depth, Ft.
Concrete 8.5"	
Dark gray and brown, dry to moist, loose to medium dense, Clayey fine to coarse SAND (SC) and gravel, marine shell fragments and coral fragments (Fill)	10.0
Dark gray, very moist, soft to stiff, fine to medium Sandy CLAY (CL-SC), some gravel, marine shell fragments and coral fragments (Fill)	28.0
Light greenish gray, very moist to saturated, medium dense, Clayey fine SAND (SC), and marine shell fragments and coral fragments (Possible fill)	
Light greenish gray, very moist to saturated, medium dense, Clayey fine SAND (SC), and marine shell fragments and coral fragments	45.0
Bottom of boring 45.0'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery
1	x/5 6/6	12
2	5/4 6/17	16
3	5/5 6/5	10
4	6/6 5/5	16
5	2/3 1/3	19
6	2/2 3/2	16
7	3 6/5	18
8	5 5/5	18
9	5 4/5	18
10	6 7/10	18
11	7 10/12	18
12	9 9/14	18
13	8 7/9	18

Boring and Sampling Notes:
- Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
- *Caved in @ 22.0'

BORING Nº 8A

Material Description	Stratum Depth, Ft.
CONCRETE 7"	
Tan and brown, moist to very moist, soft to very soft, fine to coarse Sandy CLAY (CL), some gravel (Fill)	6.5
Bottom of boring 6.5'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery
1	x/3 7/12	9
2	9/8 8/7	12
3	2/2 3/2	10
4	3 100/5"	3

Boring and Sampling Notes:
- Refusal at 6.5'
- *Caved in @ 5.0'

BORING Nº 10

SURFACE ELEVATION

Material Description	Stratum Depth, Ft.
Concrete	1.0
Gray and brown, moist, medium dense to loose, Silty SAND (SM) gravel and shells (Fill)	4.0
Gray, very moist to saturated, loose to very loose, Clayey, fine SAND (SC) with shells, gravel and coral	13.0
Gray, very moist, medium stiff, fine Sandy ~~CLAY (CL-SC) with trace shells~~ and coral gravel	22.0
Light gray, saturated, medium dense to dense, Silty, fine to medium SAND (SM) with trace Clay and coral gravel	37.0
Gray and brown, moist, very dense, Clayey, fine to medium SAND (SC) and coral	39.0
Bottom of Boring - 39.0'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery, in.
1	-/- 7/8	12
2	5/4 4/3	18
3	4/3 3/2	18
4	2/2 2/2	10
5	3/3 2/1	12
6	3/3 2/3	10
7	2 3/3	18
8	4 3/3	18
9	9 9/9	18
10	13 12/12	18
11	21 27/46	18
12	50 4"	

Boring and Sampling Notes:
- Refusal at 39.0'
- Cave-in @ 13.0'

BORING Nº 11

SURFACE ELEVATION

Material Description	Stratum Depth, Ft.
Concrete - 1.0'	1.0
Gray and brown, moist, medium dense, Silty SAND, gravel, shell and coral (Fill)	8.0
Gray, very moist, very loose, Silty, fine SAND (SM) with trace Clay and shell fragments	13.0
Gray, very moist to saturated, medium dense, Silty, fine to medium SAND (SM) with trace Clay and coral gravel	22.0
Light gray to yellow, very moist, very stiff, fine Sandy CLAY (CL) with shells and gravel	32.0
Light gray, saturated, very dense, Silty SAND (SM) and coral with trace shells	39.0
Bottom of Boring - 39.0'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery, in.
1	-/- 11/10	18
2	6/7 7/6	12
3	8/8 8/8	6
4	7/7 6/6	12
5	2/1 1/2	24
6	3/3 3/3	24
7	5/6 6/5	13
8	7/7 6/6	18
9	7 8/10	18
10	4 4/13	18
11	27 31/33	16
12	50 4"	4

Boring and Sampling Notes:
- Cave-in @ 14.0'
- Refusal - 39.0'

BORING Nº 12A

Material Description	Stratum Depth, Ft.
Concrete 11"	
Dark brown, dry to moist, medium dense, Clayey fine SAND (SC-CL), some gravel, wood chips, marine shell fragments and coral fragments (Fill)	8.0
Refusal at 8.0'	
Bottom of boring 8.0'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery
1	x/x 2/11	10
2	7/7 6/6	20
3	7/7 4/8	16
4	12/7 6/4	12
5	100/3	2
6		
7		
8		
9		
10		
11		

*Refusal at 7.0'

BORING Nº 13

SURFACE ELEVATION

Material Description	Stratum Depth, Ft.
Concrete - 1.0'	1.0
Gray and brown, moist, loose, Silty, fine to medium SAND (SM) with trace Clay, gravel, shell and cinders. (Hydrocarbon odor) (Fill)	8.0
Gray, very moist to saturated, loose to medium dense, Silty, fine to medium SAND (SM) with trace shells and Clay	13.0
Light gray to yellow, saturated, medium stiff to very stiff, Sandy CLAY (CL) with shells and coral gravel	27.0
Reddish brown, very moist, very dense, Silty SAND (SM) and coral	30.0
Bottom of Boring - 30.0'	

Sample No.	Blows/6 in: Three 6 in. Increments	Recovery, in.
1	-/- 4/4	18
2	3/4 3/3	18
3	3/4 3/4	18
4	5/4 4/5	12
5	5/5 5/5	18
6	6/5 6/6	18
7	4 5/5	18
8	6 6/9	18
9	16 19/10	18
10	15/25 50 2"	18

REVISIONS

STROUD, PENCE & ASSOCIATES, LTD.
CONSULTING STRUCTURAL ENGINEERS
VIRGINIA BEACH, VIRGINIA 23462

A/E CONTRACT NO. N62470-90-B-7081

ACTIVITY - SATISFACTORY TO — DATE 7/18/95

COMMONWEALTH OF VIRGINIA — ROLAND E. DUBBE — No. 8825 — PROFESSIONAL ENGINEER

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
ATLANTIC DIVISION — NORFOLK, VIRGINIA
NAVAL STATION — U.S. NAVAL STATION — GUANTANAMO BAY, CUBA

REPAIRS TO WHARF BRAVO (PHASE II)

BORING LOGS

CODE I.D. NO. 80091	SIZE D
SCALE:	NONE
EFD NO.	349506
STA. PROJ. NO.	R27-92
SPEC. NO.	05911269
CONSTR. CONTR. NO.	N62470-91-B-1269
NAVFAC DRAWING NO.	4249506
SHEET	9 OF 22

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BORING Nº 1A

MATERIAL DESCRIPTION	STRATUM DEPTH, FT.	DEPTH, FT.	SAMPLE NO.	BLOWS/6 IN; THREE 6 IN. INCREMENTS	RECOVERY	SHELBY TUBE NO.	BORING AND SAMPLING NOTES
CONCRETE 9.5"							
Dark brown, dry to moist, very soft to medium stiff, fine to medium Sandy CLAY (CL-SC), some gravel, marine shell fragments, coral fragments		5	1	x/x 2/2	10		Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
			2	3/2 1/1	16		
			3	3/1 1/1	14		
			4	3/3 2/3	15		
		10	5	3/1 3/3	12		
			6	3/2 2/2	16		
		15	7	3 4/4	16		
(Fill)	18.0						
Dark gray, very moist, medium stiff, fine Sandy CLAY (CL), coral fragments, and marine shell fragments		20	8	4 4/4	18		
(Fill)	23.0						
Gray and brown, very moist to saturated, very soft to medium stiff, fine to medium Sandy CLAY (CL-SC), some marine shell fragments, gravel and coral fragments (Fill)		25	9	1 1/1	18		Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
		30	10	1 2/1	18		
		35	11	4 3/3	16		
Gray and brown, very moist to saturated, very soft to medium stiff, fine to medium Sandy CLAY (CL-SC), some marine shell fragments, gravel and coral fragments		40	12	4 4/5	18		Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
(Fill)	45.0	45	13	5 4/6	18		
Bottom of boring 45.0'							Caved in @ 6.5'

BORING Nº 2A

MATERIAL DESCRIPTION	STRATUM DEPTH, FT.	DEPTH, FT.	SAMPLE NO.	BLOWS/6 IN; THREE 6 IN. INCREMENTS	RECOVERY	SHELBY TUBE NO.	BORING AND SAMPLING NOTES
CONCRETE 10"							
**	2.0		1	x/x 16/5	8		**Gray and tan, moist, medium dense, Clayey fine to coarse SAND SC), some gravel and coral fragments (Fill)
Greenish gray, very moist, medium stiff to stiff, fine Sandy CLAY (CL), trace marine shell fragments and fine gravel (Fill)	6.0		2	3/3 6/7	14		
		5	3	6/6 4/6	12		
Greenish gray, moist to very moist, medium dense to loose, Clayey fine to medium SAND (SC), some coral fragments, gravel trace Silt and marine shell frag. (Fill)	10.0		4	6/9 8/8	10		
		10	5	3/5 5/3	14		
Light greenish gray, very moist to saturated, very loose to medium dense, Clayey fine to medium SAND (SC-CL), some coral fragments, little marine shell fragments, trace roots			6	7/9 9/14	12		Although the material is generally the same SAND and CLAY proportions vary from sample to sample
		15	7	5 9/12	16		
		20	8	5 4/4	14		
(Fill)		25	9	7 4/6	18		
		30	10	2 1/4	18		
		35	11	5 7/7	18		
Light greenish gray, very moist to saturated, very loose to medium dense, Clayey fine to medium SAND (SC-CL), some coral fragments, little marine shell fragments, trace roots		40	12	5 6/8	16		Although the material is generally the same, SAND and CLAY proportions vary from sample to sample
(Fill)	45.0	45	13	7 6/7	12		
Bottom of boring 45.0'							*Caved in @ 27.0'

BORING Nº 3

MATERIAL DESCRIPTION	STRATUM DEPTH, FT.	DEPTH, FT.	SAMPLE NO.	BLOWS/6 IN; THREE 6 IN. INCREMENTS	RECOVERY, in.	SHELBY TUBE NO.	BORING AND SAMPLING NOTES
SURFACE ELEVATION							
Concrete - 1.0'	1.0						
Brown, moist, loose, Clayey, fine SAND (SC) with shells and gravel (Fill)	4.0		1	+/- 7/9	3		
Dark gray, moist to very moist, loose, Silty, fine to medium SAND (SM) with trace Clay and gravel hydrocarbon odor (Fill)	8.0	5	2	5/5 4/3	18		
			3	3/6 6/3	18		
			4	4/5 3/3	18		
Gray to brown, very moist, very loose to medium dense, Silty, fine SAND (SM) with trace Clay and trace shell fragments		10	5	2/2 2/2	14		
			6	1/2 2/2	12		
		15	7	6 6/6	18		
	22.0	20	8	6 7/8	18		
Light gray, saturated, very loose to loose, Clayey, fine to medium SAND (SC) with trace shell fragments and coral		25	9	3 3/3	18		
		30	10	3 2/1	18		
		35	11	1 2/2	18		
Light gray, saturated, very loose to loose, Clayey, fine to medium SAND (SC) with trace shell fragments and coral		40	12	3 2/3	18		
		45	13	2 2/2	18		
		50	14	4 3/4	18		
		55	15	4 3/4	18		
	57.0						
Light gray, very moist to saturated, very stiff, fine Sandy CLAY (CL) with trace shell fragments and coral		60	16	5 7/9	16		
		65	17	7 7/11	18		
		70	18	9 10/10	18		
		75	19	11 11/14	18		
		80	20	16 32/39	18		Cave-in @ 13.0' Bottom of Boring-80.0'

BORING Nº 4A

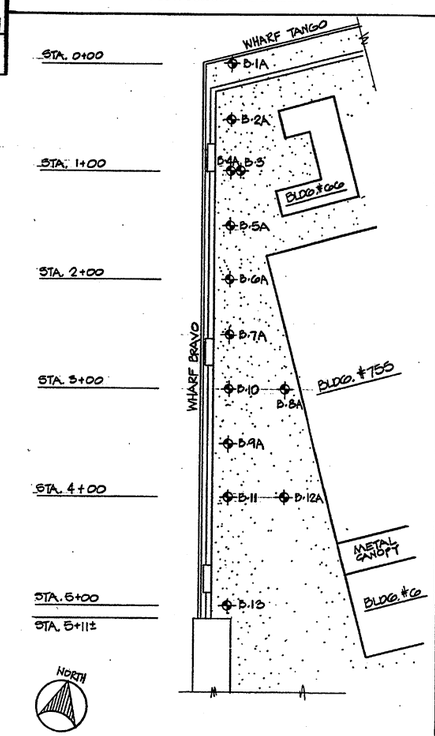
MATERIAL DESCRIPTION	STRATUM DEPTH, FT.	DEPTH, FT.	SAMPLE NO.	BLOWS/6 IN; THREE 6 IN. INCREMENTS	RECOVERY	SHELBY TUBE NO.	BORING AND SAMPLING NOTES
CONCRETE 8"							
Brown, moist to very moist, medium stiff to very stiff, fine Sandy CLAY (CL-SC), some gravel, little marine shell fragments and coral fragments	3A		1	x/x 4/5	10		Although the material is generally the same SAND and CLAY proportions vary from sample to sample
			2	6/7 9/11	14		
		5	3	5/6 6/10	24		
			4	7/9 9/12	20		
		10	5	4/3 3/4	24		
			6	4/4 4/3	18		
		15	7	4 2/5	18		
(Fill)	18.5						
Gray, very moist to saturated, very loose to loose, Clayey fine SAND (SC-CL), some gravel, marine shell fragments and coral fragments		20	8	4 4/3	10		Although the material is generally the same SAND and CLAY proportions vary from sample to sample
		25	9	3 4/1	18		
(Fill)		30	10	3 2/2	16		
		35	11	3 3/3	14		
Gray, very moist to saturated, very loose to loose, Clayey fine SAND (SC-CL), some gravel, marine shell fragments, and coral fragments		40	12	4 3/3	18		Although the material is generally the same SAND and CLAY proportions vary from sample to sample
(Fill)	45.0	45	13	3 5/5	18		
Bottom of boring 45.0'							*Caved in @ 17.5'

BORING LOG LEGEND:

- B-X = DENOTES BORING DRILLED 4/90.
- B-XA = DENOTES BORING DRILLED 11/89.
- = DENOTES WATER LEVEL FIRST NOTED ON ROD.
- = DENOTES WATER LEVEL OBSERVED AT COMPLETION.

SOIL BORING NOTES

1. SOIL BORINGS DENOTED B-XA WERE DRILLED BY ATEC ASSOCIATES OF VIRGINIA, INC., NORFOLK, VIRGINIA, ON 11/89. SOIL BORINGS DENOTED B-X WERE DRILLED BY ATEC ASSOCIATES OF VIRGINIA, INC., NORFOLK, VIRGINIA ON 4/90.
2. ALL DEPTHS AND LOCATIONS ARE APPROXIMATE.
3. DRILLING WAS ACCOMPLISHED BY CONTINUOUS FLIGHT HOLLOW-STEM AUGER. STANDARD PENETRATION TEST IS OBTAINED BY DRIVING A 2.0" O. D., 1-3/8" I.D., SAMPLER A DISTANCE OF 1.0 FOOT INTO UNDISTURBED SOIL WITH A 140 POUND HAMMER, FREE FALLING A DISTANCE OF 30.0 INCHES. IT IS CUSTOMARY FOR THE TESTING LABORATORY TO DRIVE THE SPOON 6.0 INCHES TO SEAT INTO UNDISTURBED SOIL, THEN PERFORM THE TEST. THE NUMBER OF HAMMER BLOWS FOR SEATING THE SPOON AND MAKING THE TEST ARE RECORDED FOR EACH 6.0 INCHES OF PENETRATION OF THE SPOON (EXAMPLE - 6/8/9.) THE STANDARD PENETRATION TEST RESULT CAN BE OBTAINED BY ADDING THE LAST TWO FIGURES (I.E. 8+9 = 17 BLOWS/FT.). (ASTM D-1586-67). 50/2" INDICATES 50 BLOWS FOR 2" OF PENETRATION.
4. AUGER REFUSAL INDICATES BOREHOLE ADVANCEMENT TERMINATED TO AVOID DAMAGING EQUIPMENT.
5. STRATA CHANGES - IN THE COLUMN "MATERIAL DESCRIPTION" ON THE DRILL LOG THE HORIZONTAL LINES REPRESENT STRATA CHANGES. A SOLID LINE (___) REPRESENTS AN ACTUALLY OBSERVED CHANGE, A DASHED LINE (---) REPRESENTS AN ESTIMATED CHANGE.
6. GROUND WATER OBSERVATIONS WERE MADE WHEN FIRST NOTED ON RODS (INDICATED BY ▽), AND AT COMPLETION OF THE BORING (INDICATED BY ▼). POROSITY OF SOIL STRATA, WEATHER CONDITIONS, TIDAL VARIATIONS, ETC., MAY CAUSE CHANGES IN THE WATER LEVELS INDICATED ON THE LOGS. OBSERVATIONS ARE REFERENCED TO EXISTING GRADES AT TIME OF DRILLING.
7. SOIL CLASSIFICATIONS (SP, SM, CH, CL, ETC.) ARE IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM, AND ARE BASED ON VISUAL INSPECTION OF THE SAMPLES BY THE LABORATORY TECHNICIAN.
8. SEE KEY PLAN BELOW FOR BORING LOCATIONS.



KEY PLAN
NOT TO SCALE

REVISIONS					
TITL	DESCRIPTION	APPROVED	DATE		

DRAWN DAK; DESIGN RAJL; REVIEW BWP; CHIEF DESIGN EWP; PROJECT MANAGER RJY; FIELD ENGINEER DAK; QUALITY CONTROL RJY; BRANCH MANAGER RJY; DESIGN DIRECTOR RJY

STROUD, PENCE & ASSOCIATES, LTD. CONSULTING CIVIL & STRUCTURAL ENGINEERS VIRGINIA BEACH, VIRGINIA

SP

A/E CONTRACT NO. N62470-90-D-7064

ACTIVITY - SATISFACTORY TO

DATE 7/18/95

APPROVED

THE A/E FOR CONSTRUCTION PURPOSES

STATE OF VIRGINIA ROLAND E. DUBBE REG. NO. 8825 PROFESSIONAL ENGINEER

NAVAL FACILITIES ENGINEERING COMMAND

DEPARTMENT OF THE NAVY — ATLANTIC DIVISION — NORFOLK, VIRGINIA

NAVAL STATION — U.S. NAVAL STATION — GUANTANAMO BAY, CUBA

REPAIRS TO WHARF BRAVO (PHASE II)

BORING LOGS, KEY PLAN AND NOTES

CODE I.D. NO. 80091 SIZE D

SCALE: AS NOTED

EFD NO. 349505

STA. PROJ. NO. R27-92

SPEC. NO. 05911269

CONSTRN. CONTR. NO. N62470-91-B-1269

NAVFAC DRAWING NO. 4049505

SHEET 8 OF 22

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SECTION 31 23 00.00 20

EXCAVATION AND FILL
02/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2010) Installation of Ductile-Iron Water Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)

ASTM C136/C136M	(2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM D1140	(2014) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D1556/D1556M	(2015) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2321	(2014; E 2014) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	(2015) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

1.2 DEFINITIONS

1.2.1 Degree of Compaction

Degree of compaction is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557, for general soil types, abbreviated as percent laboratory maximum density.

1.2.2 Hard Materials

Weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" but which usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.3 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.4 Pile Supported Structure

As used herein, a structure where both the foundation and floor slab are pile supported.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Submit 15 days prior to starting work.

SD-05 Test Reports

Cementitious Flowable Fill mix design; G

SD-06 Test Reports

Borrow Site Testing; G

Fill and backfill test

Select material test

Porous fill test for capillary water barrier

Density tests

Cementitious Flowable Fill tests

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

1.4 DELIVERY, STORAGE, AND HANDLING

Perform in a manner to prevent contamination or segregation of materials.

1.5 REQUIREMENTS FOR OFF SITE SOIL

Soils brought in from off site for use as backfill shall be tested for petroleum hydrocarbons, BTEX, PCBs and HW characteristics (including toxicity, ignitability, corrosivity, and reactivity). Backfill shall not contain concentrations of these analytes above the appropriate State and/or EPA criteria, and shall pass the tests for HW characteristics. Determine petroleum hydrocarbon concentrations by using appropriate State protocols. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5035/8260B. Perform complete TCLP in accordance with EPA SW-846.3-3 Method 1311. Perform HW characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide borrow site testing for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory evidence), with at least one test from each borrow site. For each borrow site, provide borrow site testing for HW characteristics from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring material onsite until tests results have been received and approved by the Contracting Officer.

1.6 QUALITY ASSURANCE

1.6.1 Utilities

Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Common Fill

Approved, unclassified soil material with the characteristics required to compact to the soil density specified for the intended location.

2.1.2 Backfill and Fill Material

ASTM D2487, classification GW, GP, GM, SW, SP, SM, with a maximum ASTM D4318 liquid limit of 35, maximum ASTM D4318 plasticity index of 12, and a

maximum of 25 percent by weight passing ASTM D1140, No. 200 sieve.

2.1.3 Select Material

Provide materials classified as GW, GP, SW, SP, or by ASTM D2487 where indicated.

Sieve Size	Percent Passing by Weight
2 1/2 inches	100
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60
No. 200	5 - 25

2.2 UTILITY BEDDING MATERIAL

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Backfill to top of pipe shall be compacted to 95 percent of ASTM D698 maximum density. Plastic piping shall have bedding to spring line of pipe. Provide ASTM D2321 materials as follows:

a. Class I: Angular, 0.25 to 1.5 inches, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

b. Class II: Coarse sands and gravels with maximum particle size of 1.5 inches, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

2.3 BORROW

Obtain borrow materials required in excess of those furnished from excavations from sources outside of Government property.

2.4 CEMENTITIOUS FLOWABLE FILL

Cementitious flowable fill shall be a mixture of cement, fly ash, fine aggregates, potable water, and admixtures. Mininum mix design requiremetns are as follows:

a. Cement: ASTM C150/C150M, Type I or II. 100 pounds per cubic yard, minimum.

b. Fly Ash: ASTM C618, 100 pounds per cubic yard, minimum. Maximum 80% by weight of total cementitious material.

c. Fine Aggregate: ASTM C33/C33M fine aggregate. Proportion to yield 1 cubic yard batch.

d. Water: Potable, producing self leveling flowable fill at time of placement with a minimum ASTM D6103 flowability of 6 inches.

e. Air Content: ASTM C260/C260M air-entraining admixture dosage as recommended by manufacturer to provide 30% air content, maximum.

f. Anti-Washout Admixture: Dosage as recommended by manufacturer to prevent washout of cementitious material and fines during placement and prevent mix segregation.

g. Unit Weight: 145 pounds per cubic foot, maximum.

h. Compressive Strength: ASTM D4832200 psi 1,000 psi minimum at 28 days.

2.5 DETECTION WIRE FOR NON-METALLIC PIPING

Detection wire shall be insulated single strand, solid copper with a minimum of 12 AWG.

PART 3 EXECUTION

3.1 PROTECTION

3.1.1 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.1.1 Drainage

So that construction operations progress successfully, completely drain construction site during periods of construction to keep soil materials sufficiently dry. The Contractor shall establish/construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site, the area immediately surrounding the site, and the area affecting operations at the site shall be continually and effectively drained.

3.1.1.2 Dewatering

Groundwater flowing toward or into excavations shall be controlled to

prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material.

3.1.2 Underground Utilities

Location of the existing utilities indicated is approximate. The Contractor shall physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor shall contact the Public Works Department for assistance in locating existing utilities.

3.1.3 Machinery and Equipment

Movement of construction machinery and equipment over pipes during construction shall be at the Contractor's risk. Repair, or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Unless indicated otherwise, remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations within the clearing limits. Remove stumps entirely. Grub out matted roots and roots over 2 inches in diameter to at least 18 inches below existing surface.

3.2.2 Stripping

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Material unsuitable for use as topsoil shall be wasted. Locate topsoil so that the material can be used readily for the finished grading. Where sufficient existing topsoil conforming to the material requirements is not available on site, provide borrow materials suitable for use as topsoil. Protect topsoil and keep in segregated piles until needed.

3.2.3 Unsuitable Material

Remove vegetation, debris, decayed vegetable matter, sod, mulch, and rubbish underneath paved areas or concrete slabs.

3.3 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Reuse excavated materials that meet the specified requirements for the material type required at the intended location. Keep excavations free from water. Excavate soil disturbed or weakened by Contractor's operations, soils softened or made unsuitable for subsequent construction due to exposure to weather. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory material encountered below the grades shown shall be removed as directed. Refill with

satisfactory material and compact to 95 percent of ASTM D1557 maximum density. Unless specified otherwise, refill excavations cut below indicated depth with satisfactory material and compact to 95 percent of ASTM D1557 maximum density. Satisfactory material removed below the depths indicated, without specific direction of the Contracting Officer, shall be replaced with satisfactory materials to the indicated excavation grade; except as specified for spread footings. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Contracting Officer.

3.3.1 Pile Cap Excavation and Backfilling

Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Contracting Officer. Backfill and compact overexcavations and changes in grade due to pile driving operations to 95 percent of ASTM D1557 maximum density.

3.3.2 Pipe Trenches

Excavate to the dimension indicated. Grade bottom of trenches to provide uniform support for each section of pipe after pipe bedding placement. Tamp if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least 6 inches below the bottom of the pipe.

3.3.3 Excavated Materials

Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory material shall be disposed of as specified in Paragraph "DISPOSITION OF SURPLUS MATERIAL."

3.3.4 Final Grade of Surfaces to Support Concrete

Excavation to final grade shall not be made until just before concrete is to be placed. Only excavation methods that will leave the foundation rock in a solid and unshattered condition shall be used. Approximately level surfaces shall be roughened, and sloped surfaces shall be cut as indicated into rough steps or benches to provide a satisfactory bond. Shales shall be protected from slaking and all surfaces shall be protected from erosion resulting from ponding or flow of water.

3.4 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials as directed by the Contracting Officer. The surface shall be scarified to a depth of 6 inches before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 6 inches, pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 12 inches and compacted as specified for the adjacent fill.

Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Minimum subgrade density shall be as specified herein.

3.4.1 Proof Rolling

Proof rolling shall be done on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. Proof roll the existing subgrade of the site with six passes of a dump truck loaded with 212 cubic feet of soil or 15 ton, pneumatic-tired roller. Operate the roller or truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2 1/2 to 3 1/2 miles per hour. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Proof rolling shall be performed in the presence of the Contracting Officer. Rutting or pumping of material shall be undercut as directed by the Contracting Officer and replaced with select material.

3.5 FILLING AND BACKFILLING

Fill and backfill to contours, elevations, and dimensions indicated. Compact each lift before placing overlaying lift.

3.5.1 Backfill and Fill Material Placement

Provide for paved areas and under concrete slabs, except where select material is provided. Place in 6 inch lifts. Do not place over wet or frozen areas. Place backfill material adjacent to structures as the structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against the structure.

3.5.2 Backfill and Fill Material Placement Over Pipes and at Walls

Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Backfill shall be brought to indicated finish grade . Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 2 feet above sewer lines and 1 foot above other utility lines shall be free from stones larger than 1 inch in any dimension. Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Backfill shall not be placed against foundation walls prior to 7 days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall.

3.5.3 Trench Backfilling

Backfill as rapidly as construction, testing, and acceptance of work

permits. Place and compact backfill under structures and paved areas in 6 inch lifts to top of trench and in 6 inch lifts to one foot over pipe outside structures and paved areas.

3.5.4 Bulkhead Backfilling

Cementitious flowable fill shall be used to backfill between the existing sheet pile retention structure and new steel sheet pile bulkhead as indicated. Starting at the mudline, place flowable using tremie methods. Maintain a 3 foot minimum tremie embeddment at all times. Not more than one, 6 foot lift of flowable fill shall be placed in a 24 hour period. Material shall achieve a minimum compressive strength of 50 psi between subsequent lifts. See Structural Sheet S001 for flowable fill minimum strength requirements.

3.6 BORROW

Where satisfactory materials are not available in sufficient quantity from required excavations, approved borrow materials shall be obtained as specified herein.

3.7 BURIED WARNING AND IDENTIFICATION TAPE

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.8 BURIED DETECTION WIRE

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. The wire shall extend continuously and unbroken, from manhole to manhole. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. The wire shall remain insulated over it's entire length. The wire shall enter manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, the wire shall terminate in the valve pit at the pump station end of the pipe.

3.9 COMPACTION

Determine in-place density of existing subgrade; if required density exists, no compaction of existing subgrade will be required.

3.9.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 90 percent of ASTM D698.

3.9.2 Structures, Spread Footings, and Concrete Slabs

Compact top 12 inches of subgrades to 95 percent of ASTM D698. Compact select material to 95 percent of ASTM D698.

3.9.3 Adjacent Area

Compact areas within 5 feet of structures to 90 percent of ASTM D698.

3.9.4 Paved Areas

Compact top 12 inches of subgrades to 95 percent of ASTM D1557. Compact fill and backfill materials to 95 percent of ASTM D1557.

3.10 FINISH OPERATIONS

3.10.1 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.10.2 Topsoil and Seed

3.10.3 Protection of Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.11 DISPOSITION OF SURPLUS MATERIAL

Waste in Government disposal area surplus or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber.

3.12 FIELD QUALITY CONTROL

3.12.1 Sampling

Take the number and size of samples required to perform the following tests.

3.12.2 Testing

Perform one of each of the following tests for each material used. Provide additional tests for each source change.

3.12.2.1 Fill and Backfill Material Testing

Test fill and backfill material in accordance with ASTM C136/C136M for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D4318 for liquid limit and for plastic limit; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

3.12.2.2 Select Material Testing

Test select material in accordance with ASTM C136/C136M for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

3.12.2.3 Porous Fill Testing

Test porous fill in accordance with ASTM C136/C136M for conformance to gradation specified in ASTM C33/C33M.

3.12.2.4 Density Tests

Test density in accordance with ASTM D1556/D1556M, or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556/D1556M density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556/D1556M density test at the start of the job, and for every 10 ASTM D6938 density tests thereafter. Test each lift at randomly selected locations every 2000 square feet of existing grade in fills for structures and concrete slabs, and every 2500 square feet for other fill areas and every 2000 square feet of subgrade in cut. Include density test results in daily report.

3.12.2.5 Cementitious Flowable Fill Tests Testing

Collect a minimum of five random samples daily during placement. Prepare and test samples in accordance with ASTM D4832. Two specimens shall be tested at 24 hours and two at 28 days. The additional sample shall be held for testing in the event additional strength data is needed.

-- End of Section --

SECTION 31 32 23

JET GROUTING
08/08

PART 1 GENERAL

1.1 SCOPE PROJECT OBJECTIVES & JOB SITE CONDITIONS

1.1.1 Scope

This Section specifies requirements for furnishing all labor, equipment, materials, and supplies necessary for soil stabilization by jet grouting as required to meet the project objectives specified herein.

The work shall consist of installation, monitoring and testing of Jet Grouting within the limits indicated on the Contract Drawings and Contractor's Design Drawings.

In connection with the Jet Grouting program, as shown on the Contract Drawings and Contractor's Design Drawings, the Jet Grouting contractor shall provide all labor, materials and equipment to accomplish the following items of work:

a. Design of Jet Grout columns to prevent liquefaction under trench
b. Mobilization & demobilization
c. Drilling
d. Jet-grouting
e. Quality assurance/quality control and verification
f. Spoil containment, collection and disposal.

This section is a performance type specification in so far that the contractor shall be responsible for selection of jet grouting parameters, equipment, and construction of the Jet Grouted elements to meet the design intent and the Engineer is responsible for the overall design of the jet grouted soil element or soil cement structure.

1.1.2 Project Objectives

The following sub-articles attempt to outline common applications for jet grouting. It is unlikely that we have captured all the possible applications of jet grouting in this document, therefore it is imperative that the Engineer clearly outline the project objective and remove irrelevant sub-articles listed below.

Construction of soil cement Jet-Grouted columns with the following characteristics:

a. Minimum Unconfined Compressive Strength (UCS): 500 psi
b. Vertical and horizontal tolerances: 4" max
c. Minimum soil stabilization under trench and near adjacent bulkhead as to provide liquefaction restraint under the trench by fully jammed stabilized soil between sheet pile bulkhead and deep soil mix soil improvements.

1.1.3 Job Site Conditions

The grouting contractor shall conduct a site inspection; review available subsurface information (including all geotechnical engineering and data reports).

The Contractor shall be responsible for obtaining any local permits (if required) and conforming to all local regulations

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C150/C150M	(2015) Standard Specification for Portland Cement
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C 989	(2009a) Standard Specification for Slag Cement for Use in Concrete and Mortars

CONTRACT DOCUMENTS

a. Jet grouting plan (concept)on Structural Sheet S003
b. Existing site conditions/utilies plan
c. Project geotechnical report or geotechnical investigation information shall be verified by Contractor's Geotechnical Engineer.

1.3 DEFINITIONS

1.3.1 Jet Grouting

An in-situ injection technique employed with specialized equipment that includes grout pump(s), grout mixer, drill rig, drill rods and injection monitor with horizontal radial nozzles delivering high velocity fluids to erode, mix, and stabilize in-situ soils using an engineered grout slurry.

1.3.2 Single Fluid Jet Grouting

The jet grouting technique where a single fluid, typically neat cement grout, is injected at high velocity through horizontal radial nozzle(s) to directly erode, and mix with, the in-situ soil.

1.3.3 Double Fluid Jet Grouting

The jet grouting technique where one fluid, typically neat cement grout, is injected at high velocity through horizontal radial nozzle(s) and is assisted by a second fluid, typically air, delivered through a coaxial nozzle(s), to directly erode and mix with the in-situ soil.

1.3.4 Monitor (Adjusted for Single and Double Systems)

A single or double fluid drill pipe attached to the end of a drilling

string and designed to deliver one to two elements of the Jet Grouting process, typically air/water and grout. The monitor has one or more injection points (nozzles).

1.3.5 Jet Grouting Supervisor

The individual on site who is in responsible charge for the Jet Grouting work.

1.3.6 Soil-Cement

Mixture of grout slurry and in-situ soils formed by the jet grouting process.

1.3.7 Soil-Cement Element

A column or panel (planar shape) of soil-cement formed by jet grouting, used as a component of a soil-cement structure.

1.3.8 Soil-Cement Structure

A single zone or block of jet grout elements that are partially or fully interlocked as indicated on the Contract Drawings. Soil cement structures shall be comprised of soil cement elements of sufficient pattern and spacing as to stabilize the soil mass within the limits shown on the Contract Drawings to meet the performance requirements specified in this Section.

1.3.9 Jet Grouting Parameters

Pressure of the fluid(s) within the jet grouting string; flow rate of the fluid(s); grout composition; rotational speed of the jet grouting string; and rate of withdrawal or insertion of the jet grouting string.

1.3.10 Jet Grouting String

Jointed rods with simple, double or triple inner conduit that conveys the jet grouting fluid(s) to the monitor.

1.3.11 Primary-Secondary Sequence

Method in which installation of an overlapping element cannot commence before a specified hardening time or achievement of predetermined strength of the adjacent previously constructed elements(s).

1.3.12 Spoil Return

All materials including, but not limited to: liquids, semi-solids, and solids, which are discharged above ground surface during, or as a result of jet grouting.

1.3.13 UCS

Unconfined Compressive Strength at 28 days.

1.4 QUALIFICATIONS

Due to the specialized nature of the jet grouting portion of the work, the Jet Grouting Contractor shall be pre-qualified before bidding on this work.

Contractors must meet the following experience criteria:

1.4.1 Project Experience

The Jet grouting contractor must have at least five years jet grouting experience over the last ten years; and have completed at least five (5) Jet Grouting projects, with at least two (2) projects having jet-grouting system behind an existing elevated bulkhead.

1.4.2 Personnel Experience

The Jet grouting supervisor must have at least three (3) years on site experience managing jet grouting field operations of similar size and scope, and must have supervised at least two (2) projects within the past five (5) years employing the jet grouting technique proposed for this project. The supervisor shall have experience and knowledge of all aspects of jet grouting as required for the project and shall be present at the work site at all times during jet grouting operations.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications and Resumes of Key Personnel; G
Field Demonstration Test Program; G

SD-03 Product Data

Drilling Equipment; G
Grouting Equipment; G
Grout Plant; G

SD-05 Design Data

Grout Mix Design; G
Jet Grouting Procedure; G

SD-05 Test Reports

Soil-Cement Reports; G
Data Monitoring and Recording; G

SD-11 Closeout Submittals

Daily Reports; G

1.6 DELIVERY, STORAGE, AND HANDLING

Transportation and storage of materials shall be in accordance with section 03 31 29 MARINE CONCRETE. A sufficient quantity of cement shall be stored at or near the site of the work to insure that grouting operations will not be delayed by shortage of cement. In the event the cement is found to contain lumps or foreign matter of a nature and in amounts which, in the opinion of the Contracting Officer, may be deleterious to the grouting

operations, screening through a standard 100 mesh screen may be required. No payment will be made for such screening.

1.7 PROJECT/SITE CONDITIONS

The program shown and described is based on currently available information. Conditions encountered during construction may require additions or deletions. The grouting program shall not be modified or curtailed as a construction expediency. It is a required part of design and shall not become secondary to any time or scheduling restrictions. Grouting mixes, pressures, injection rate and the sequence in which the holes are drilled and grouted will be determined in the field and shall be as directed.

PART 2 PRODUCTS

2.1 GROUTING MATERIAL

Provide grout composed of water and cement and pozzolans. The grout mixes will be designed by the Contractor. Grout slurry composition shall not be changed unless requested in writing by the Contractor and accepted in writing by the Contracting Officer. The various materials to be furnished shall conform to the specifications listed in paragraphs below.

2.1.1 Water

Potable Water or approved other source shall be free of deleterious materials that may adversely affect the grout.

2.1.2 Cement

Cement used in grout shall conform to the requirements of ASTM C91/C91M and ASTM C150/C150M. The use of bulk cement will be permitted provided the Contractor employs methods of handling, transporting, and storage that are satisfactory to the Contracting Officer, otherwise only cement furnished in cloth or paper bags will be accepted to use in the work. Storage of cement shall be in accordance with paragraph DELIVERY, STORAGE, AND HANDLING.

2.1.3 Pozzolans

Pozzolans shall be Class F fly ash conforming to ASTM C618 and/or ground granulated blast furnace slag conforming to ASTM C 989. Sampling will be done by an authorized representative of the Government. All tests will be made by and at the expense of the Government. Pozzolans may be furnished in paper sacks or in bulk. It shall be transported, handled, and stored so as to avoid damage, waste, or absorption of moisture.

PART 3 EXECUTION

3.1 EQUIPMENT

The use of internal combustion engines within dam galleries for operation of drilling and grouting equipment will not be permitted. Submit details and data on the drilling and grouting equipment.

3.1.1 General

All equipment used for drilling boreholes; lowering, raising and rotating jet monitors; mixing grout; supplying pressurized grout and air-water to

jet monitors; and jet monitors shall have proven performance records for use in Jet Grouting work, as demonstrated by the information to be submitted under Section 1.5

Jet grouting operations shall occur so as not to destabilize existing and new sheet pile walls and utility trenches. Sequence grouting locations such that jet grout columns are not placed within 50 feet or 3 column diameters (whichever is greater) of uncured adjacent jet grout columns. Jet grouting shall not occur in a location until adjacent soil stabilization areas have reached their 28-day strength.

3.1.2 Drilling Equipment

Use drilling equipment of a type and capacity suitable for drilling required hole diameters and depths, and lowering, raising, and rotating jet grout monitors to the depths and at the rates required to perform the work as shown on the Contract Drawings and as specified herein. The drill rig shall be equipped with automated controls to regulate and maintain consistent rod retraction rate, and rod RPM and have pressure gauges for all fluids injected.

3.1.3 Grouting Mixing and Injection Equipment

Grout Mixing and Injection Equipment: Use grout mixers and holding tanks, water tanks, air compressors, and pumps of sufficient capacity to ensure adequate supply of grout, air, and water at required pressure to the Jet Grouting monitors during a full work shift to produce grout elements of the quality and dimensions necessary.

3.1.4 Jet Grouting Pump

Shall be capable, with the nozzles proposed, of providing the required velocity and a delivery rate adequate for the execution of the work.

3.1.5 Compressor(for double Jet-Grouting)

Shall be capable of producing the pressure and to deliver the flow rate values proposed by the contractor depending on the parameters chosen.

3.1.6 Jet Grout Tools

Use Jet Grouting monitors with appropriate nozzles with the capacity suitable for producing jet grout elements in the soil types identified during Subsurface Explorations performed at the site, and of the size and depth shown on the Contract Drawings and as specified herein. The drill hole diameter shall be sufficiently large to be a clear path for continuous spoil return during all jetting operations.

3.1.7 Equipment Instrumentation

Provide instrumentation that allows continuous monitoring and automatic recording of data throughout the jet grouting operations. As a minimum, the following shall be provided versus depth:

a. Pressure gauges/devices at the drilling rig to automatically record pressures of cement grout, water, and air during the grouting process.
b. Flow meter(s) to monitor and record the rate and total volume of grouting fluids through the grouting monitor at every element.
c. Devices that automatically monitor and record the rate of monitor

rotation and withdrawal.

3.2 PRODUCTION WORK

3.2.1 Jet Grout Elements

Install jet grout elements, such that continuous spoil return up the borehole annulus is achieved during all work.

3.2.2 Centerline of Elements

Centerline of the elements shall not be more than 3” from the indicated plan location. All jet grouted columns shall not deviate from plumbness more than 1:200.

3.2.3 Sequence

The sequence of the Jet-Grouting, Primary and Secondary is the responsibility of the jet grouting contractor and will be based on the results of the successful test program.

3.2.4 Site

Maintain a clean site and dispose of all spoil debris, water, and spilled material during jet grouting operations.

3.2.5 Equipment

Equipment for mixing, holding, and pumping grout shall be in a secure location and shall be operated to minimize spillage of material. No material will be allowed to enter the basin.

3.2.6 Monitor

The grouting contractor shall monitor movement of the seaward most bulkhead during all jetting work. Horizontal movement of the top of the wall shall not exceed 1".

3.2.7 Interruption

If jet-grouting is interrupted during the execution of a column, the re-start of the jetting shall be undertaken at least 6” below the stopping point.

3.2.8 Site Access

Site access shall be provided to representatives of the Contracting Officer for observation of the work.

3.3 QUALITY CONTROL/QUALITY ASSURANCE

3.3.1 Jet Grouting

All Jet Grouting shall be performed in the presence of the Owner’s QC/QA Representative. Owner’s QC/QA representative shall be notified prior to initiating jet grouting. Monitoring and logging of Jet Grouting operations for both test areas and production work shall be performed by the jet grouting contractor.

3.3.2 Equipment

The Contractor's equipment shall be configured to record and continuously show all fluid flows and pressures, rotational speed, depth and rod retraction rates. The rod retraction rate and rod RPM shall be set by the driller then automatically controlled by the drill rig during the entire jet grouting process and recorded on the jet grout installation log.

3.3.3 Data

All the data monitored and recorded, as described in point 3.3.2, shall be made available to the Contracting Officer in a format previously agreed on prior to the work. The Contractor shall supply the Contracting Officer with the software used for this task. The software shall be capable of processing the data recorded and graphic in a satisfactory manner. Proposal of the software to be used shall be described in advance.

3.3.4 Grout Mix Proportions

Grout mix proportions shall be measured and documented by the Contractor per the submittal requirements in section 1.5.4 above. Appropriate records shall be kept by the Contractor and submitted to the Contracting Officer to verify that grout mixture(s) are as accepted.

3.3.5 Jet Grouting Operations

Throughout the jet grouting operations, perform continuous coring to full depth on 10 percent of production columns to obtain drill cores of the jet grouted soil. The drill core will be evaluated for compliance with specific acceptance criteria defined in 3.5 herein. The contractor shall be notified immediately if the soil-cement samples do not meet the acceptance criteria outlined herein.

3.4 DAILY REPORTS

3.4.1 Summary Daily Reports

Within one business day of a work shift, submit summary daily reports during test and production jet grouting that provide the information listed below. A sample of the report form proposed for use by the Contractor shall be submitted to the Contracting Officer for approval prior to the start of work.

a. Jet grout element number
b. Time and date of beginning and completion of each grout element, including interruptions to the jetting process or material supply
c. Grout mix data, including mix proportions and unit weight density measurements
d. Injection pressure of all fluids used to construct each grout element
e. Flow rates of all fluids used to construct each grout element
f. Rates of rotation and withdrawal of jet rods for each grout element
g. Flow rates of all fluids used to construct each grout element
h. Total grout quantity used for each element
i. Top and bottom elevations of the jet grout element
j. Continuous flow of spoils return.

3.4.2 Jet Grouting Parameters

Continuous recording of jet grouting parameters shall be provided for each

production column to verify consistency with the approved test program results.

3.5 ACCEPTANCE CRITERIA

3.5.1 Installation Records

Installation records from 3.3 and daily reports from 3.4 documenting that the approved parameters from the test program were accurately repeated for the production work.

3.5.2 Core Recovery

A minimum core recovery of 85% shall be provided.

-- End of Section --

SECTION 31 41 16

METAL SHEET PILING
08/09

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A572/A572M	(2012) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A6/A6M	(2012) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

1.2 SYSTEM DESCRIPTION

Submit to the Contracting Officer for approval descriptions of pile driving equipment to be employed in the work. Descriptive information includes manufacturer's name, model numbers, capacity, rated energy, hammer details, cushion material, helmet, templates, and jetting equipment.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Metal Sheet Piling; G

SD-03 Product Data

Driving
Pile Driving Equipment; G
Pulling and Redriving; G
Interlocked Joint Strength in Tension Test; G

SD-06 Test Reports

Materials Tests
Interlocked Joint Strength in Tension Test; G

SD-11 Closeout Submittals

Pile Driving Record

1.4 QUALITY ASSURANCE

1.4.1 Material Certificates

For each shipment, submit certificates identified with specific lots prior to installing piling. Include in the identification data piling type, dimensions, chemical composition, mechanical properties, section properties, heat number, and mill identification mark.

1.4.2 Interlocked Joint Tension Test

Submit, for approval, the procedure for testing the tension strength of piling interlocks prior to testing sheet piling.

1.5 DELIVERY, STORAGE, AND HANDLING

Materials delivered to the site shall be new and undamaged and shall be accompanied by certified test reports. Provide the manufacturer's logo and mill identification mark on the sheet piling as required by the referenced specifications. Store and handle sheet piling in the manner recommended by the manufacturer to prevent permanent deflection, distortion or damage to the interlocks; as a minimum, support on level blocks or racks spaced not more than 10 feet apart and not more than 2 feet from the ends. Storage of sheet piling should also facilitate required inspection activities and prevent damage to coatings and corrosion prior to installation.

PART 2 PRODUCTS

2.1 METAL SHEET PILING

Submit detail drawings for sheet piling, including fabricated sections, showing complete piling dimensions and details, driving sequence and location of installed piling.

a. Include in the drawings details of top protection, special reinforcing tips, tip protection, lagging, splices, fabricated additions to plain piles, cut-off method, corrosion protection, and dimensions of templates and other temporary guide structures for installing piling. Provide details of the method for handling piling to prevent permanent deflection, distortion or damage to piling interlocks.

b. Metal sheet piling shall be hot-rolled steel sections conforming to ASTM A572/A572M, Grade 50.

c. For protection of sheet piling, coat it in accordance with Section 09 97 13.26 COATING OF STEEL WATERFRONT STRUCTURES and provide cathodic protection in accordance with Section 26 42 13.00 20 CATHODIC PROTECTION BY GALVANIC ANODES.

2.1.1 Interlocks

The interlocks of sheet piling shall be free-sliding, provide a swing angle suitable for the intended installation but not less than 5 degrees when interlocked, and maintain continuous interlocking when installed.

2.1.2 General Requirements

Sheet piling including special fabricated sections shall be full-length sections of the dimensions shown. Provide fabricated sections conforming

to the requirement and the piling manufacturer's recommendations for fabricated sections. Fabricated tees, wyes and cross pieces shall be fabricated of piling sections with a minimum web thickness of 1/2 inch. Provide sheet piling with standard pulling holes. Metalwork fabrication for sheet piling shall be as specified and in Section 05 12 00 STRUCTURAL STEEL.

2.2 APPURTENANT METAL MATERIALS

Provide metal plates, shapes, bolts, nuts, rivets and other appurtenant fabrication and installation materials conforming to manufacturer's standards and to the requirements specified in the respective sheet piling standards and in Section 05 12 00 STRUCTURAL STEEL.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Requirements for material tests, workmanship and other measures for quality assurance shall be as specified and in Section 05 12 00 STRUCTURAL STEEL.

2.3.1 Materials Tests

Submit certified materials tests reports showing that sheet piling and appurtenant metal materials meet the specified requirements, for each shipment and identified with specific lots prior to installing materials. Material test reports shall meet the requirements of ASTM A6/A6M. Perform materials tests conforming to the following requirements. Sheet piling and appurtenant materials shall be tested and certified by the manufacturer to meet the specified chemical, mechanical and section property requirements prior to delivery to the site. Testing of sheet piling for mechanical properties shall be performed after the completion of all rolling and forming operations. Testing of sheet piling shall meet the requirements of ASTM A6/A6M.

PART 3 EXECUTION

3.1 EARTHWORK

Perform in accordance with Section 31 00 00 EARTHWORK.

3.2 INSTALLATION

3.2.1 Pile Driving Equipment

Submit complete descriptions of sheet piling driving equipment including hammers, extractors, protection caps and other installation appurtenances, prior to commencement of work. Provide pile driving equipment conforming to the following requirements.

3.2.1.1 Driving Hammers

Hammers shall be steam, air, or diesel drop, single-acting, double-acting, differential-acting, or vibratory type. The driving energy of the hammers shall be as recommended by the manufacturer for the piling weights and subsurface materials to be encountered. Repair damage to piling caused by use of a pile hammer with excess delivered force or energy.

3.2.2 Placing and Driving

3.2.2.1 Placing

Any excavation required within the area where sheet pilings are to be installed shall be completed prior to placing sheet pilings. Pilings properly placed and driven shall be interlocked throughout their length with adjacent pilings to form a continuous diaphragm throughout the whole length or run of the bulkhead.

a. Pilings shall be carefully located as shown on the drawings. Top of pile at elevation of cut-off shall be within 1/2 inch horizontally and 2 inches vertically of the location indicated. Manipulation of piles to force them into position will not be permitted. Any piles with unzipped interlock shall be extracted and re-driven at no cost to the government.

b. Provide temporary templates or guide structures to ensure that the pilings are placed and driven to the correct alignment. Templates shall be sufficiently rigid to resist lateral and driving forces and to adequately support the sheet piling until design tip elevation is achieved.

3.2.2.2 Driving

Submit records of the completed sheet piling driving operations, including a system of identification which shows the disposition of approved piling in the work, driving equipment performance data, piling penetration rate data, piling dimensions and top and bottom elevations of installed piling. Drive pilings with the proper size hammer and by approved methods so as not to subject the pilings to damage and to ensure proper interlocking throughout their lengths.

a. Maintain driving hammers in proper alignment during driving operations by use of leads or guides attached to the hammer.

b. Employ a protecting cap in driving when using impact hammers to prevent damage to the tops of pilings. Remove and replace pilings damaged during driving or driven out of interlock at the Contractor's expense.

c. Pile driving with aid of jetting is not allowed.

d. Pilings in each run or continuous length of piling wall shall be driven alternately in increments of depth to the required tip elevation.

e. If hard driving is encountered, sheet piles shall be equipped with chisel shoe. All sheet piles shall be driven to a tip elevation indicated on the drawings. Pilings shall be driven to depths shown and shall extend up to the elevation indicated for the top of pilings. A tolerance of one (1) inch above the indicated top elevation will be permitted. Pilings shall not be driven within 100 feet of concrete less than 7 days old.

f. Pre-augering or spudding of piles will not be permitted.

3.2.3 Cutting-Off and Splicing

Pilings shall be tip elevations indicated on the drawings. Pile cut off shall be within 1/2" tolerance of pile top elevation indicated on the

drawings. No pile splicing shall be permitted.

a. Cut holes in pilings for reinforcement and drains or utilities in a neat and workmanlike manner, as shown or as directed. Use a straight edge in cuts made by burning to avoid abrupt nicks. Holes in sheet piling shall be drilled or may be burned. Holes shall be reasonably smooth and 1/2" larger than the diameter of the inserted rebar.

3.2.4 Inspection of Driven Piling

Perform continuous inspection during pile driving. Inspect all piles for compliance with tolerance requirements. Bring any unusual problems which may occur to the attention of the Contracting Officer. Inspect the interlocked joints of driven pilings extending above ground. Pilings found to be out of interlock shall be removed and replaced at the Contractor's expense.

3.2.5 Pulling and Redriving

Submit the proposed method of pulling sheet piling, prior to pulling any piling. Pull, as directed, selected pilings after driving to determine the condition of the underground portions of pilings. Any piling so pulled and found to be damaged, to the extent that its usefulness in the structure is impaired, shall be removed and replaced at the Contractor's expense. Pilings pulled and found to be in satisfactory condition shall be redriven when directed.

3.3 REMOVAL

The removal of sheet pilings shall consist of pulling, sorting, cleaning the interlocks, inventorying and storing previously installed sheet pilings as shown and directed.

3.3.1 Pulling

The method of pulling piling shall be approved. Provide pulling holes in pilings, as required. Extractors shall be of suitable type and size. Care shall be exercised during pulling of pilings to avoid damaging piling interlocks and adjacent construction. If the Contracting Officer determines that adjacent permanent construction has been damaged during pulling, the Contractor will be required to repair this construction at no cost to the Government. Pull pilings one sheet at a time. Pilings fused together shall be separated prior to pulling, unless the Contractor demonstrates, to the satisfaction of the Contracting Officer, that the pilings cannot be separated. The Contractor will not be paid for the removal of pilings damaged beyond structural use due to proper care not being exercised during pulling.

3.3.2 Sorting, Cleaning, Inventorying and Storing

Pulled pilings shall be sorted, cleaned, inventoried and stored by type into groups as:

a. Piling usable without reconditioning.

b. Piling requiring reconditioning.

c. Piling damaged beyond structural use.

3.4 INSTALLATION RECORDS

Maintain a pile driving record for each sheet pile driven. Indicate on the installation record: installation dates and times, type and size of hammer, rate of operation, total driving time, dimensions of driving helmet and cap used, blows required per foot for each foot of penetration, final driving resistance in blows for final 6 inches, pile locations, tip elevations, ground elevations, cut-off elevations, and any reheading or cutting of piles. Record any unusual pile driving problems during driving. Submit complete records to the Contracting Officer.

-- End of Section --

SECTION 31 62 00

CEMENT DEEP SOIL MIXING AND LOW PRESSURE CEMENT GROUTING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 23	(2008) Standard Method of Test for Making and Curing Concrete Test Specimens in the Field
AASHTO T 225	(2006) Standard Method of Test for Diamond Core Drilling for Site Investigation

ASTM INTERNATIONAL (ASTM)

ASTM C 150	(2009) Standard Specification for Portland Cement
ASTM D 2166	(2006 Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
ASTM C 150	(2009) Standard Specification for Portland Cement

Unified Facilities Criteria (UFC)

FC 1-300-09N	(2014) Navy and Marine Corps Design Procedures

1.2 WORK INCLUDED

1.2.1 Cement Deep Soil Mixing (CDSM)

CDSM consists of furnishing transportation, labor, materials and equipment to construct CDSM columns and perform related earthwork. The work covered by this specification consists of providing all supervision, labor, materials, and equipment required to construct CDSM columns and low pressure grouting at the locations, to the elevations and to the requirements shown on the Contract Drawings, the Contractor's Design and developed from test area results. The documentation of the CDSM installations is included in the work scope. The execution of a test program at the sites shown on the Drawings is a part of this specification.

1.2.2 CDSM Construction

CDSM construction includes, but is not limited to:

a. Furnish all equipment, materials, power, water, cement, and other

necessary items required for CDSM column installation.

b. Construct runoff containment ponds and working pad, if necessary, to access job site and work area.

c. Construct CDSM columns (including test areas) as shown on the Contract Drawings and the Contractor's design Drawings.

d. Cooperate with inspection activities.

e. Coordinate and conduct verification tests, including wet grab soil mix samples, cement content estimate and continuous corings.

f. Regrade and compact job site, including runoff containment pond areas.

g. Remove equipment, unused materials and all waste products/spoils off site.

h. Comply with all local and federal requirements.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Soil Stabilization Design and Calculations; G

CDSM Improvement Plan; G

Mitigation Plan; G

SD-06 Test Reports

Cement

CDSM Verification Test Results; G

Test Area CDSM Program Report and Survey; G

Final Report; G Signed and Sealed

SD-08 Manufacturer's Instructions

CDSM Improvement Statement; G

Monitoring

SD-11 Closeout Submittals

Documentation; G

1.4 SOIL STABILIZATION ANALYSIS AND DESIGN

Contractor shall provide soil stabilization analysis and design that meets or exceeds the performance requirements found in the contract drawings. Provide analysis and design documentation for Government review and acceptance. Submit prefinal and final design for SD-01 in accordance with FC 1-300-09N.

1.5 CDSM IMPROVEMENT

Contractor shall perform additional borings with a minimum of 5 at each phase of the project to supplement existing site geotechnical information. Purpose of borings is to support Contractor's design efforts for soil stabilization efforts required by this contract.Contractor shall submit to the Contracting Officer for approval a CDSM Improvement Statement and a CDSM Improvement Plan containing the following information:

a. A written procedure for accomplishing the work described in this section and shown on the Drawings. The written procedure shall:

1. Include a detailed description of the equipment and procedures to be used.

2. Include CDSM layout and construction sequence: The CDSM column layout shall include at a minimum: individual column designations, column center coordinates (northing and easting coordinates to the nearest 1 inch), vertical alignment, and anticipated column lengths (based on elevations shown in the plans). The CDSM column layout shall meet the minimum replacement ratio requirements per paragraph Acceptance Criteria . The anticipated column construction sequence shall be included in the submittal.

3. Indicate area of the low pressure cement grouting, spacing of the port points, cement grouting layout and construction sequence for soil improvement under existing trench.

4. Specifically describe how the equipment and procedures will be used to build the CDSM columns to meet the Specification and Drawings, and shall acknowledge the variability of the subsurface stratigraphy and intended improvement or column diameter to be achieved, as shown on the Drawings. Procedures shall include methods for locating the CDSM columns in the field and confirming that the columns are plumb.

5. Describe Contractor's quality control and documentation methods, and include:

a. A detailed description of the daily Quality Control Plan confirming design elevations, minimum replacement ratio, the required compressive strength, cement content, and required horizontal and vertical alignments.

b. Details describing soil-cement sampling devices and curing boxes.

c. Daily measures during CDSM to continuously monitor, modify and control: water-cement ratios; cement content estimate,

cement-grout injection pressures and quantities; mixing rotational speeds; penetration and withdrawal rates of the mixing equipment; horizontal and vertical alignments of the CDSM Columns; and other related aspects of the CDSM process.

d. Example formats of Daily Production Reports conforming to the requirements stated herein.

e. Names, certifications and licenses of the laboratory and companies responsible for performing quality control tests.

f. Proposed details and formats of required tabular and graphical data presentations to be submitted to the Contracting Officer during the course of the work.

6. Provide details of cement grout mix design including: cement type, cement source, cement compound composition, water-cement ratio by weight and other pertinent details. Limit water- cement ratio to (1:1 maximum), unless otherwise demonstrated in the Test Areas specified per paragraph Test Areas.

7. Describe the Contractor's plan for use of water containment areas, and prevention of water inflows into the harbor, and provide drawings showing layout of water containment ponds.

8. Provide details of mixing spoils: Submit sketches and narrative that describe the procedures to collect, contain, and temporarily store mixing spoils and disposal details.

9. Provide details of repairing CDSM areas that do not meet the acceptance criteria.

b. A written schedule for accomplishing the work described in this specification and shown on the Drawings. The schedule shall show the Contractor's planned number of machines, number of shifts, and working hours.

Mobilization of soil stabilization equipment shall not occur without the work plan being accepted by the Contracting Officer.

1.5.1 Documentation

Contractor shall institute and maintain a monitoring and documentation program during the installation of all CDSM columns (including test areas). The Contractor shall furnish all labor, equipment, materials, and incidentals to document the CDSM column installation. The Contractor shall provide competent and qualified personnel to continuously observe and record the required data. The program shall include, but is not limited to, the inspection, testing, and documentation of the following:

1. Daily Production/Quality Control Report shall be submitted to the Contracting Officer at the start of next working day. The Daily Production/Quality Control Report, shall be filled out, checked for correctness, and signed by the Contractor s field superintendent.

2. The report shall contain, but not be limited to, the following information:

a. Day, month, year, time of beginning and end of work shift; name of each superintendent in charge of the work for the contractor; a list of all workers names associated with each CDSM rig; and a summary of equipment used during the shift.

b. Details of predrilling activities, including but not limited to, elevation, diameter, drilling equipment, portion of boring backfill, and type of backfill materials used.

c. The locations, installation sequence, and as-installed top and bottom elevations of the CDSM columns installed during the work shift, and any deviations from the planned locations and vertical alignment.

d. Time of start and completion of each CDSM column installed during the work shift and a summary of any downtime during the shift including time of work stoppage, duration, reason, and if work stoppage occurred while mixing a CDSM column.

e. Specific gravity of the cement grout, continuous cement grout injection pressures and rates, quantities of cement, cement content, cement additives, and water used, mixing rotational speeds, penetration, and withdrawal rates of the mixing equipment, and mixing time at the bottom of the column for each CDSM column.

f. Include cement grout batching records and continuous real-time specific gravity measurements coinciding with CDSM column installation.

g. Other pertinent observations including, but not limited to, the operator's log including a description of the drill rig's performance, operators observations, description of spoil returns, cement grout escapes, ground settlement and/or heave, collapses of the CDSM column, remixing of columns, obstructions, and any unusual behavior of the equipment during the CDSM process.

h. Logs of core borings, photographs of every core taken with proper ID, elevation and date in the background, records of CDSM wet grab samples and core samples taken during the work shift including sample designation, date, time, plan location, elevation, and the name of the firm and person(s) obtaining the samples.

i. The report shall include as a minimum the results of the following QC parameter monitoring for each CDSM column:
   1) Rig number;
   2) Type of mixing tool;
   3) Date and time (start and finish) of CDSM column construction;
   4) CDSM column number and reference drawing number;
   5) CDSM column average diameter and length;
   6) CDSM column top and bottom elevations;
   7) Cement grout mix design designation or specific gravity measurements.
   8) Percent of cement content
   9) Description of obstructions, interruptions, or other difficulties during installation and how they were resolved.

j. The report shall also include the following parameters recorded for each CDSM column at intervals no greater than 6 inches and submitted in figures and tabulated data:
   1) Elevation vs. real time;

2) Mixing blade rotation number vs. elevation;
3) Penetration and withdrawal rates vs. elevation; and
4) Cement grout injection rate vs. elevation.

k. The Contracting Officer reserves the right to have a full-time or part-time representative observe and document the CDSM column, related construction, and verification exploration. The Contracting Officer reserves the right to obtain samples for testing from the cement-soil mix grab sample or cement grout-mix.

3. Provide results of the test and production areas including, but not limited to: 7-day and 28-day compressive strength of the soil-cement, cement-grout injection pressure and rates, mixing rotational speeds, cement content estimated as a percent of dry soil weight, penetration and withdrawal rates of the mixing tools, and mixing times at bottom of the CDSM columns when there is no vertical movement of the mixing tools, and description of mixing operations.

1.5.2 Mitigation Plan

If the CDSM acceptance criteria in paragraph Acceptance Criteria are not achieved the Contractor shall submit a proposed mitigation plan for remixing, or adding columns, and/or repair plan of failed sections for review and approval.

1.5.3 CDSM Verification Test Results

Submit to Contracting Officer within 24 hours following completion of each set of verification tests including test areas:

a. Field coring logs

b. Average cement content estimate for each CDSM column installed.

c. Strength results of tested core samples and grab samples.

1.5.4 Final Report

Upon the completion of soil improvement activities, the Contractor shall submit a final report summarizing the methods used, column installation data, and test results of all core and grab samples and their identifying locations. The Contractor shall submit, with the final report, an as-built drawing prepared at a 1:100 scale identifying the final locations of all installed CDSM columns with their respective column numbers. Final report shall be signed and sealed by a licensed Professional Geotechnical Engineer.

1.6 QUALITY ASSURANCE

Contractor shall employ the services of an independent registered Geotechnical Engineer for the verification testing. The Geotechnical Engineer shall have a minimum 5 years of relevant experience.

Contractor shall employ the services of an independent testing laboratory to provide the core and grab sample strength testing. The testing laboratory shall be subject to approval of the Contracting Officer.

1.7 MONITORING

1.7.1 Movement Criteria

Establish temporary benchmarks at locations approved by the Contracting Officer along existing sheet piles and pipe trench adjacent to the soil improvement area. Monitor the benchmarks daily during the soil improvement operation to detect any settlement, uplift, or lateral movement of the existing and new sheet piles(if performed after new sheet piling installation), existing trench, manholes and any other new and existing structures. If settlement, uplift, or lateral movement in excess of 0.5 inches for the new sheet piles or structures is detected and movement of buried utilities exceeds that which would cause damage to the utility, all soil improvement work shall immediately cease and the Contracting Officer shall be notified. Soil improvement work shall not recommence until corrective measures to prevent further settlement lateral movement or heave have been developed and implemented by the Contractor, with the approval of the Contracting Officer.

1.7.2 Corrective Measures

Within 48 hours of cessation of work, the Contractor shall provide written recommendations for support and protection of the existing and new sheet piles and any other existing structures during the completion of the soil improvement operation. These recommendations shall include shop drawings and a description and justification for the proposed method of support and protection. All costs incurred in providing protection and support shall be the responsibility of the Contractor. The Contracting Officer will respond to the Contractor's submittal within 72 hours of its receipt.

PART 2 PRODUCTS

2.1 MATERIALS

a. Cement grout: The material added to the blended in situ soils shall be a water-based Portland cement grout. The cement grout shall be premixed in a mixing plant which combines dry materials and water in predetermined proportions. Cement grout shall be stable and homogeneous. The grout shall be kept moving in the mixer until grout discharge. Contractor shall specify mixing time and set mixing time with adjustments for ambient temperature and hose exposure to the sun. The mix water temperature shall be kept below 70F. Contractor shall test each batch of grout mix and determine the setting time from the moment of introduction of water into the mix. Grout that was not used within that time shall be discarded.

b. Portland Cement: Cement shall conform to ASTM C 150 Standard Specification for Portland Cement Type II/V. The cement shall be adequately protected from moisture, direct sunlight and contamination while in transit to and in storage at the job site. Reclaimed cement or cement containing lumps or deleterious matter shall not be used. Cement containing lumps or foreign matter of a nature and in amounts that might be deleterious to the grouting operations shall not be used. All cement shall be homogeneous in composition and properties. Contractor shall submit cement certificate.

c. Water: Fresh potable water, free of deleterious substances that may

adversely affect the strength and mixing properties of the cement grout or any substance that may be considered an environmental concern, shall be used to manufacture cement grout.

d. Admixtures: Admixtures may be added to the mixture immediately before or during mixing. Admixtures of softening agents, dispersions, retarders or plugging or bridging agents may be added to the water or the cement grout to permit efficient use of the materials and proper workability of the cement grout. If admixtures are proposed, the Contractor shall provide a written statement from the manufacturer as to the use of any such admixture, its effect on the CDSM material, its long-term performance and stability, and its effect on the environment.

e. Blended Portland Cement: Additional solids such as ground slag may also be used in the cement grout mix design. Fly ash or other solids containing heavy metals or other substances that may be considered an environmental concern shall not be used in the cement grout mix design.

2.2 EQUIPMENT

The CDSM equipment shall meet the following requirements:

1. Single or multi-shaft mixing equipment is allowed. The mixing shaft(s) shall have mixing augers and blades (paddles) configured in a manner so that they are capable of thoroughly blending the in situ soils with cement grout. Auger flights and mixing paddles on the shaft(s) shall extend to the full diameter of the CDSM column being formed. Mixing equipment shall be capable of advancing through previously installed and hardened soil-cement. Air shall not be injected into the in-situ soils.

2. The power source for driving the mixing shafts shall be sufficient to maintain the required revolutions per minute (RPM) and penetration rate from a stopped position at the deepest elevation required. Mixing equipment shall be capable of advancing through previously installed and hardened CDSM material. Pre-drilling may be used to assist CDSM column installation.

3. All equipment shall have devices to permit accurate and continuous monitoring and control of: (1) specific gravity, (2) cement-grout injection pressures and quantities, (3) mixing tool rotation speeds, (4) Verticality of mixing shaft (5) advancement and withdrawal rates of the mixing tools, and (6) other operations required to install and mix CDSM materials.

4. As a minimum, the grout shall be premixed in a mixing plant that combines dry materials and water in predetermined proportions. The mixing plant shall consist of a jet valve, grout circulation pump and variable speed cement feeding system.

5. Progressive cavity pumps shall be used to transfer the grout from the mixing plant to the auger(s). Grout pumps shall be capable of pumping the required distance and elevations to provide and maintain an adequate supply of grout to the mixing augers or mixing tools. The grout shall be delivered to the slurry-injecting auger by an individual progressive cavity pump having an inline mass flow meter and pressure gauge. For

multiple-shaft equipment, each auger shall have its own inline mass flow meter. The mass flow meter shall be used to accurately determine mix proportions in terms of specific gravity. The Contractor shall provide the calibration sheet of the mass flow meter at the beginning of the project and monthly thereafter.

6. Pre drilling / coring equipment shall be of sufficient capacity to excavate the CDSM bore hole to the deepest design elevation required. Coring equipment/procedure shall be capable of retrieving core samples suitable for strength testing.

PART 3 EXECUTION

3.1 INSTALLATION OF CDSM

The ground improvement shall extend to the elevations shown on the plans, or as approved by the Contracting Officer. It is the contractor's responsibility to locate and verify location of existing tie rods, soil anchors and other buried structures. Take all measures and precautions not to damage tie-rods and soil anchors during augering operation. Contractor shall be aware of consequences to the existing bulkhead structure caused by the damage to the tie-rods and assume full responsibility for requiring repairs. It is Contractor's responsibility to verify all tie rod and soil anchor locations and clearly mark them on site in order to avoid tie rods with auger and drilling equipment. Maintain a minimum of 9 inches of stand-off from protected tie rods, soil anchors and other structures. Contractor shall assume full responsibility for any potential damage to the fuel trench caused by ground improvement operation. Any damage caused by ground improvement shall be repaired by contractor at no additional cost to Government.

CDSM shall be installed in uniformly distributed regular patterns and arrangements to achieve the minimum area replacement within the CDSM areas shown on the approved plans, and with CDSM columns conforming to the specified tolerances, required compressive strength, and cement content stated herein. CDSM Columns shall penetrate through the dense crust and underlying weaker materials to the required elevations shown on the plans.

Difficult soil cement installation is anticipated due to the presence of embedment requirements into groundwater, dense gravels, hard layers of limestone materials and subsurface debris. CDSM equipment shall be capable of advancing through previously installed and cured soil-cement.
After final installation of the CDSM columns, the Contractor shall obtain samples of in-situ soil-cement in accordance with the locations and frequencies listed under "Verification Testing" section of this specification.

Water, debris or spoil material shall not be dumped into or allowed to enter the CDSM columns.

CDSM Columns exhibiting partial or total instability shall be backfilled with cement grout and remixed full elevation, at the Contractor's expense. Signs of instability that may be observed during construction could include excess flow of cement grout from the hole, settlement of ground, and squeezing in on the drill rods.

During the first 60 days following successful completion of CDSM, no more than 5 feet of fill or 600 psf of vertical pressure may be placed within a clear distance of at least 26 feet from the face of the existing bulkhead.

3.1.1 Horizontal and Vertical Alignment Tolerances

The maximum horizontal deviation of the as-installed center of CDSM columns at the ground surface installation level shall not exceed 3 in from the layout center coordinate, shown on the Contractor's approved CDSM Improvement Statement submittal.

A variation of not more than 1 in per yard of CDSM column length from the vertical will be permitted. At the direction of the Contracting Officer, CDSM columns that exceed the allowable horizontal or vertical alignment tolerances shall be re-mixed or supplemented with one or more adjacent or overlapping columns, at the Contractor's cost.

3.1.2 Repair of Damage

The Contractor shall be responsible for the repair to sheet piles, tie rods, soil anchors, utilities, structures, buildings, etc., if the damage, as determined by the Contracting Officer, is caused by this ground improvement operation. Obtain approval from the Contracting Officer for repair action prior to repair work commencement. All corrective actions and any additional testing required by the Contracting Officer shall be at no additional cost to the Government.

3.1.3 Disposal of Water and Spoil Return

During and at completion of CDSM operations, the site shall be maintained cleared of debris and water. Spoil return and other spoil materials shall be piped or channeled to holding ponds, tanks or other retention structures or facilities. Dewatering and overflow of excess water and spoils into the harbor are prohibited and the Contractor is cautioned to use methods and equipment which will prevent water and spoils from rising excessively above the ground surface. Should surface runoff or permanent ponding of water occur as a result of the work, the Contractor shall, at no cost to the Government:

a. Meet all applicable laws and regulations concerning surface runoff, siltation, pollution and general disposal of the effluent from the construction of the CDSM columns and general site work. Remediate the damage caused by runoff of the polluted water.

b. Construct and relocate temporary ditches, swales, banks, dams, and similar facilities as necessary to control the flow of surface water and spoils during the work. Remove them when no longer required, and regrade the affected areas for acceptable drainage as specified for site grading.

c. Construct spoil settling ponds or tanks as required in locations approved by the Contracting Officer. Prevent inadvertent discharge of spoils into watercourses. Stockpile and dispose of all spoils as approved by the Contracting Officer.

d. Remove settling ponds and other structures when no longer required and regrade the areas for acceptable drainage as specified for site grading.

3.2 TEST AREAS

a. The Contractor shall perform Test Areas and verify as indicated on the plans.

b. The test area improvement program shall produce soil-cement mix design and procedures for production mixing including: 7-day and 28-day compressive strength of the soil-cement, cement-grout injection pressure and rates, cement content estimate, mixing rotational speeds, penetration and withdrawal rates of the mixing tools, mixing times at bottom of the CDSM columns when there is no vertical movement of the mixing tools, and complete description of mixing operations.

c. The Contractor shall submit Test Area CDSM Program Report and Survey to the Contracting Officer. The report shall include complete description of mixing operation, daily reports, core logs, testing results, proposed grout mix design to achieve minimum cement content and strength requirements, cement grout injection pressure, mixing rotational speeds, penetration and withdrawal rates of the mixing tools, mixing times and any other controlling parameters for the installation of production CDSM columns and proposed variations in installation methods. Allow for a Government review period of 7 calendar days. Refer to Specification 01 33 00 Submittal Procedures. Production installations shall not start until the Contracting Officer has completed his evaluation of the test area results, and has approved the improvement plan.

d. Test areas that are not accepted shall be repeated at another location approved by the Contracting Officer. Failed Test Areas shall be repaired according to Paragraph Mitigation Plan that is reviewed and approved by the Contracting Officer. Repaired Test Areas shall be tested to the satisfaction of the Contracting Officer. New Test Area, mitigation and testing of the failed test areas shall be performed at no cost to the Government.

3.3 PENETRATION

3.3.1 Treatment Elevation

CDSM columns shall be advanced to the full treatment elevation as indicated on the Contractor's Design Drawings, but not less than the depths indicated in Contract Drawings, or as directed by the Contracting Officer.

3.3.2 Obstructions(Other than Site Utilites and Anchors)

a. The Contractor is responsible for any obstruction within the newly placed fill. If the Contractor encounters an obstruction within the newly placed fill that prevents the CDSM improvements, the contractor shall remove the obstruction and complete the CDSM improvement at no cost to the Government.

b. The Contractor's equipment shall be of sufficient capacity to improve ground to the elevations shown on the plans, or as approved by the Contracting Officer.

3.4 VERIFICATION TESTING

The Contractor shall conduct verification testing in the test and production areas, at intervals, and locations as indicated on the plans. The Contractor shall coordinate and execute the verification testing.

3.4.1 Verification of Improvement

The Contractor shall obtain soil-cement samples, including wet-grab and core samples, and provide them to a laboratory approved by the Contracting officer for testing. The Contractor shall form, preserve, cure, transport, and test the samples and report test results to the Contracting Officer. The test results shall be signed and stamped by a licensed Geotechnical Engineer from the Laboratory. The Contractor shall coordinate sampling activities with the Laboratory. The Contractor shall supply incidental items, access, inside storage space, curing boxes and electrical power to the curing boxes. The Contractor shall supply molds for use in forming the samples.

3.4.1.1 Wet-Grab Samples

An in-situ wet-grab sampling shall be performed for every 30 square yards of area improved (excluding test areas) at locations and elevations as indicated on plans and selected by the Contracting officer. In addition, the Contractor may be required to obtain up to 20 additional wet grab sample tests as directed by the Contracting officer at no additional cost to the Government.

Sampling shall be conducted within 60 minutes of the completion of the soil-cement column. The device used to retrieve the wet grab soil-cement samples shall be capable of obtaining a discrete fluid sample of soil-cement at an elevation determined by the Contracting officer and shall be capable of accepting particles not thoroughly mixed that are up to 150 mm in dimension. The sampling system shall be capable of collecting samples at any elevation of the CDSM column installed. The sampler shall be lowered empty, air only, to the required elevation in the CDSM columns, and then opened. Once filled with the soil-cement, the sampler shall be closed to exclude entry or loss of soil-cement and shall be expeditiously raised to ground surface.

Retrieved soil-cement samples shall be of sufficient volume to produce a minimum of 6 full cylinders, 3 in diameter by 6 in high at each sample location. The Contractor shall separate and retain soil-cement retrieved from each elevation. The Contractor shall then cut retrieved particles of soil larger than 1 in into smaller pieces that will pass a 1 in sieve, and then immediately form the 6 cylinders with material passing through a 1 in sieve, including particles of soil that were cut up. Soil-cement samples shall be formed, cured and preserved in accordance with AASHTO T 23 and protected from freezing and extreme weather conditions which could have deleterious effect.

Unless otherwise directed by the Contracting officer, for each elevation sampled for each CDSM column, the onsite Laboratory shall test two cylinders at 7 days, and two cylinders at 28 days for unconfined compressive strength in accordance with ASTM D 2166.

3.4.1.2 Core Samples

The Contractor shall take core samples for obtaining samples to evaluate compressive strength, unit weight, vertical alignment, and composition of the soil-cement. Coring of soil-cement shall be performed in accordance with AASHTO T 225 and the requirements stated herein.

Continuous core samples of CDSM columns shall be obtained for every 60 square yards of area improved (excluding test areas) at locations selected

by the Contracting Officer and over the entire elevation of the CDSM column. The coring system used shall be capable of producing core samples for unconfined compressive strength testing in accordance with ASTM D 2166.

The Contractor's Geotechnical Engineer shall be on-site during coring and core samples shall be properly logged and photographed by the Contractor s Geotechnical engineer. Coring log shall include details in accordance with AASHTO T 225.

Immediately after retrieving the soil-cement core samples from each boring, the Contractor shall wrap and preserve samples selected by the Contracting Officer in each boring for unconfined compressive strength test by the Laboratory in accordance with ASTM D 2166. The Contractor shall cement grout and completely fill boreholes after coring with a cement mixture, minimum unconfined compressive strength of 220 psi.

The Contractor shall box, store, and preserve the remaining core samples until the completion of construction and until authorized by the Contracting officer to dispose of the samples. Core samples shall be protected from freezing and extreme weather conditions.

If recovered core samples from a boring provide less than 85% recovery, or less than 50% RQD (Rock Quality Designation), or fewer than 5 intact cores of length more than 8 inches in each core run, the Contracting Officer may direct the Contractor to drill up to 2 additional cores and recover additional core samples for testing. If the samples from either of these additional corings do not provide required recovery, this process shall be repeated until coring provides required samples. Additional corings and core sampling are at the Contractor s expense.

3.4.1.3 Vertical Alignment Profiles

The Contractor shall obtain vertical alignment profiles for each CDSM column and advise the Contracting officer within one hour after measuring the vertical alignment profile, of non-compliance with the depth of soil improvement indicated on the drawings.

3.4.2 Progress Verification

As the soil improvement work progresses, conduct tests at intervals described in "Verification of Improvement" to verify that no less than the specified minimum improvement is being achieved in every 60 square yards. If testing indicates that the minimum improvement is not being met, Contractor shall discontinue advancement into new areas and shall repeat the improvement process in the failed area(s), at no cost to the Government, making modifications in the process as necessary to provide no less than the specified minimum improvement. This cycle of improvement and testing shall be repeated until all specified requirements for soil improvement are met in all required areas. The Contracting Officer may require additional test as deemed necessary at no additional cost to the Government.

3.4.3 Acceptance Criteria

CDSM shall improve strength properties of the improved soil within the area shown on the plans. CDSM columns shall be placed in a uniformly distributed regular pattern to achieve the indicated replacement ratio.

In a core run of a CDSM column, the sum length of zones with unmixed soil

lumps of larger than 2 inches in largest dimension that extend entirely across the diameter of the core (full diameter lump) shall not exceed 15% of the total core length.

The average cement content within each CDSM columns shall be no less than 12%, as estimated as a percentage of dry soil weight. CDSM columns within every 60 square yards area of improvement shall have no more than 10% of total column length with a cement content less than 10%.

Unconfined compressive strength testing shall be performed in accordance with ASTM D 2166. The average 28-day unconfined compressive strength of soil-cement throughout the length of each CDSM column shall be no less than 150 psi. The 28-day unconfined compressive strength for a CDSM improvement shall have no more than 10% of the samples with unconfined compressive strength less than the minimum design value of 100 psi in every 60 square yard area of CDSM improvement. The Contractor may use 7-day or 28-day strength tests as strength predictors; however, the strength acceptance criteria will be based only on test results from 28-day tests.

3.4.4 Rejected Densification Conditions

If the Contracting Officer determines that CDSM work is unacceptable, the Contractor shall submit to the Engineer for approval a mitigation plan for repair, supplementation, or replacement for each rejected portion of the CDSM work. If the Contracting officer determines that it is not feasible to repair the rejected CDSM work, the Contractor shall not include repair as a means of mitigation and shall proceed with the submittal of a mitigation plan for replacement or supplementation of the rejected CDSM work.

All work to achieve the specified criteria, including installing additional CDSM replacement and performing additional verification testing shall be provided by the Contractor at no additional cost to the Government.

-- End of Section --

SECTION 31 62 16.16

STEEL H-PILES
11/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2015; Errata 2015) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A27/A27M	(2013) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A572/A572M	(2015) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

1.2 SYSTEM DESCRIPTION

The steel H-piles covered by this section are a part of a combination Z-sheet pile and H-pile system and shall be worked with Section 31 41 16 METAL SHEET PILING.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pile placement; G

Submit pile placement plan at least 30 days prior to delivery of piles to the job site.

Pile reinforcing tips or steel points

SD-03 Product Data

Pile driving equipment; G

Submit descriptions of pile driving equipment at least 30 days prior to commencement of work.

Pile driving records; G

Submit the proposed form for compiling pile driving records 30

days prior to commencement of work.

Delivery, storage, and handling; G

Submit delivery, storage, and handling plans for piles at least 30 days prior to delivery of piles to the job site.

SD-05 Design Data

Wave equation analysis

Submit wave equation analysis.

SD-11 Closeout Submittals

Pile driving records

Submit to the Contracting Officer complete and accurate job pile driving records as specified in paragraph entitled "Records" of this section, within 15 calendar days after completion of driving.

1.4 DELIVERY, STORAGE, AND HANDLING

Conform all delivery, storage, and handling of materials to the requirements specified herein. Develop and submit plans for the delivery, storage, and handling of piles.

1.4.1 Delivery and Storage

Stack piles during delivery and storage so that each pile is maintained in a straight position and is supported every 10 feet or less along its length (ends inclusive) to prevent exceeding the maximum camber or sweep. Do not stack piles more than 5 feet high.

1.4.2 Handling

Lift piles using a cradle or multiple points pick-up to ensure that the maximum permissible camber or sweep is not exceeded due to insufficient support, except that a one-point pick-up may be used for lifting piles that are not extremely long into the driving leads. Point pick-up devices must be of the type that clamp to both pile flanges at each pick-up point. Holes may be burned in the flanges or webs of piles above the cutoff length for lifting piles into the leads. Do not drag piles across the ground.

Inspect piles for excessive camber and sweep and for damage before transporting them from the storage area to the driving area and immediately prior to placement in the driving leads. Camber, curvature in the pile in the direction normal to the pile flanges, must be measured with the pile flange base laying on a flat surface and is the distance between the flange base at the mid-length of the pile and the flat surface. Sweep, curvature in the pile in the direction parallel to the pile flanges, must be measured with the pile flange tips laying on a flat surface and is the distance between the flange tips at the mid-length of the pile and the flat surface. The maximum permissible camber and sweep is 2 inches over the length of the pile. Piles having excessive camber or sweep will be rejected.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 H-Piles

ASTM A572/A572M, Grade 50. Provide square and blunt pile tips, as received from the mill. Provide pile tip reinforcements or cast steel points. Coat piles in accordance with Section 09 97 13.26 COATING OF STEEL WATERFRONT STRUCTURES, ZERO VOC, (SZC) SPLASH ZONE CONTROL. Provide H-piles of the shape and sections shown. Determine lengths of piles as specified in paragraph "Installation," subparagraph "Lengths of Job Piles" .

2.1.2 Pile Splices

Pile splices are not allowed.

2.1.3 Pile Points

ASTM A27/A27M for cast steel points. Pile points must be provided on all piles.

PART 3 EXECUTION

3.1 PRELIMINARY WORK

3.1.1 Wave Equation Analysis of Pile Drivability

a. Prior to driving any pile, the Contractor shall submit a pile Wave Equation Analysis, performed by his Geotechnical Consultant, for each size pile and distinct subsurface profile condition. These analyses shall take into account the proposed hammer assembly, pile cap block and cushion characteristics, the pile properties and estimated lengths and the soil properties anticipated to be encountered throughout the installed pile length based on static capacity analysis with consideration of driving gain/loss factors. Only one specific model of pile hammer may be used for each pile type and capacity.

b. The Wave Equation Analysis shall demonstrate that the piles will not be damaged during driving, shall indicate that the driving stresses will be maintained within the limits below and indicate the blow count necessary to achieve the required ultimate static pile capacities.

Allowable Driving Stresses

Steel Piles

Compression - 0.9 fy
Tension - 0.9 fy

Where fy is yield strength of steel

c. The cost of performing the Wave Equation Analyses shall be paid for by the Contractor and included in the base bid.

3.2 PILE DRIVING EQUIPMENT

Select the proposed pile driving equipment, including hammers and other required items, and submit complete descriptions of the proposed equipment

in accordance with paragraph "Submittals." Changes in the selected pile driving equipment will not be allowed after the equipment has been approved except as directed. No additional contract time will be allowed for Contractor proposed changes in the equipment.

3.2.1 Pile Driving Hammers

Provide impact and/or vibratory type pile driving hammers.

3.2.1.1 Impact Hammers

Provide steam, air, or diesel-powered impact pile hammers of the single-acting, double-acting, or differential-acting type. The size or capacity of hammers must be as recommended by the hammer manufacturer for the total pile weight and the character of the soil formation to be penetrated. Provide boiler,, compressor, or engine capacity sufficient to operate hammers continuously at the full rated speed. Hammers must have a gage to monitor hammer bounce chamber pressure for diesel hammers or pressure at the hammer for air and steam hammers. This gage must be operational during the driving of piles and be mounted in an accessible location for monitoring by the Contractor and the Contracting Officer. Provide two spare operational bounce chamber read out units on site. Provide bounce chamber pressure gage correction tables and charts for the type and length of hose to be used with the pressure gage to the Contracting Officer. Obtain driving energy by use of a heavy ram and a short stroke with low impact velocity, rather than a light ram and a long stroke with high impact velocity. Position a pile cap or drive cap between the pile and hammer. Place hammer cushion or cap block between ram and the pile cap or drive cap. Hammer cushion or cap block must have consistent elastic properties, minimize energy absorption, and transmit hammer energy uniformly and consistently during the entire driving period. In accordance with paragraph "Submittals," submit the following information for each impact hammer proposed:

a. Make and model.

b. Ram weight (pounds).

c. Anvil weight (pounds).

d. Rated stroke (inches).

e. Rated energy range (foot-pounds).

f. Rated speed (blows per minute).

g. Steam or air pressure, hammer, and boiler or compressor (psi).

h. Rated bounce chamber pressure curves or charts, including pressure correction chart for type and length of hose used with pressure gage (pounds per square inch).

i. Pile driving cap, make, and weight (pounds).

j. Cushion block dimensions and material type.

k. Power pack description.

3.2.1.2 Vibratory Hammers

The size or capacity of hammers must be as recommended by the hammer manufacturer for the total pile weight and the character of the soil formation to be penetrated. The hammer must provide for maintaining a rigid connection between the hammer and the pile. In accordance with paragraph "Submittals," submit the following information for each vibratory hammer proposed:

a. Make and model.

b. Eccentric moment (inch-pounds).

c. Dynamic force (tons).

d. Steady state frequency or frequency range (cycles per minute).

e. Vibrating weight (pounds).

f. Amplitude (inches).

g. Maximum pull capacity (tons).

h. Non-vibrating weight (pounds).

i. Power pack description.

3.2.2 Pile Driving Leads

Support and guide hammers with fixed extended leads or fixed underhung leads. Provide at least two intermediate supports for the pile in the leads to reduce the unbraced length of the pile during driving and pulling.

3.2.3 Pile Extractors

Pile extractors may be vibratory and/or impact pile driving hammers. Impact hammers are required for pulling piles not extractable with vibratory hammers.

3.3 INSTALLATION

Inspect piles when delivered and when in the leads immediately before driving. Handle piles so as to protect pile coatings. Repair damage or defects in pile coatings as specified. Cut piles at cutoff grade by an approved method. Where cutoff is below existing ground or mudline elevation, complete excavation, sheeting, and dewatering before driving pile to cutoff elevation.

3.3.1 Lengths of Job Piles

The minimum length of piles shall be determined by Contractor based on design tip and cutoff elevations shown in design drawings. Provide additional length as required for handling and cut off.

3.3.2 Pile Driving Records

Develop a form for compiling pile driving records, which must be approved, for recording pile driving data.

Compile and submit accurate records of the pile driving operations on the approved form in accordance with paragraph "Submittals." Include in driving records for each pile date driven, pile identification number, cross section shape and pile dimensions, location, deviations from design location, original length, ground elevation, top elevation, tip elevation, description of hammer used, number of blows required for each foot of penetration throughout the entire length of the pile and for each inch of penetration in the last foot of penetration, total driving time in minutes and seconds, and any other pertinent information as required or requested such as unusual driving conditions, interruptions or delays during driving, damage to pile resulting from driving, heave in adjacent piles, redriving, weaving, obstructions, predrilling, and depth and description of voids formed adjacent to the pile.

Additional data required to be recorded for impact hammers includes the rate of hammer operation, make, size, and the length of the bounce hose. Additional data required to be recorded for vibratory hammers includes hammer power pack description, make, size, horsepower applied to pile, and hammer operating frequency.

3.3.3 Pile Placement and Tolerances in Driving

Develop and submit a pile placement plan which shows the installation sequence and the methods proposed for controlling the location and alignment of piles. Accurately place piles in the correct location and alignments, both laterally and longitudinally, and to the vertical lines indicated. Establish a permanent base line to provide for inspection of pile placement by the Contracting Officer during pile driving operations prior to driving job piles and maintain during the installation of the job piles.

A final lateral deviation from the correct location at the cutoff elevation of not more than 2 inches will be permitted for vertical piles. Manipulation to move piles into position will be permitted only within the aforementioned tolerance to return the pile to the design location, however, do not manipulate piles more than 1.5 percent of the exposed length above the mudline surface. A variation of not more than 0.25 inch per foot of pile length from the vertical for vertical piles will be permitted. In addition to complying with the tolerances stated herein, the clear distance between the heads of piles and the edges of caps must be not less than 6 inches. With prior approval of the Contracting Officer, the Contractor may provide additional concrete and reinforcement to maintain the required minimum clear distance. Redesign of pile caps or additional work required due to improper location of piles is the responsibility of the Contractor. A vertical deviation of not more than 1 inch from the correct cutoff elevations shown is permitted. Inspect piles for heave. Redrive heaved piles to the required tip elevation. Maintain the correct relative position of all piles by the use of templates or by other approved means. Piles damaged or not located properly or exceeding the maximum limits for rotation, lateral and vertical deviation, or variation in alignment must be pulled and new piles redriven, or provide additional piles, at a location directed at no additional cost to the Government.

3.3.3.1 Survey Data

After the driving of each pile group is complete and before superimposed concrete is placed, provide the Contracting Officer with an as-driven survey showing actual location and top elevation of each pile. Do not proceed with placing concrete until the Contracting Officer has reviewed

the survey and verified the safe load for the pile group driven. Present a survey in such form that it gives deviation from plan location in two perpendicular directions and elevations of each pile to nearest half inch. Survey must be prepared and certified by a licensed land surveyor.

3.3.4 Pile Penetration Criteria

The controlling tip elevation for job piles will be determined by the Contracting Officer. The required tip depth is as shown on the drawings.

3.3.5 Pile Driving

Notify the Contracting Officer 30 days prior to the date pile driving is to begin. Do not drive piles within 100 feet of concrete less than 7 days old. Drive job piles with hammers of the same model and manufacturer, same energy and efficiency, and using the same driving system. Operate hammers at all times at the speed and under the conditions recommended by the manufacturer. Prior to driving and with the pile head seated in the hammer, check each pile to ensure that it has been aligned correctly and that the orientation of the web about the centerline is as shown. Once pile driving has begun, keep conditions such as alignment constant.. Drive each pile continuously and without interruption until the required tip elevation has been attained. Deviation from this procedure will be permitted only when driving is stopped by causes that reasonably could not have been anticipated. A pile that can not be driven to the required depth because of an obstruction, as indicated by a sudden unexplained change in blow count and drifting, must be pulled and redriven or cut off and abandoned, whichever is directed. After piles are driven, cutoff square as required at the indicated cutoff elevation. Backfill any voids around piles or abandoned holes for pulled piles with sand and compact to the same density as the surrounding soil. If, in driving, it is found that pile is not of sufficient length to give the capacity specified, notify the Contracting Officer, who will determine the procedure to be followed.

3.3.5.1 Pulled Piles

Pull and replace piles damaged or impaired for use during driving with new piles, or cut off and abandon and drive new piles as directed without additional cost to the Government. The Contracting Officer may require that any pile be pulled for inspection. Redrive piles pulled as directed and found to be in suitable condition at another location as directed. Replace piles pulled as directed and found to be damaged with new piles at the Contractor's expense.

3.3.5.2 Long Piles

Handle and drive piles of a high slenderness ratio carefully to prevent overstress. Provide pile driving rig with rigid supports so that leads remain accurately aligned. Where a high degree of accuracy is required, erect templates or guide frames at or close to the ground or water surface.

3.3.5.3 Welding

AWS D1.1/D1.1M.

3.4 INSPECTION OF DRIVEN PILING

Perform continuous inspection during pile driving. Inspect all piles for compliance with tolerance requirements. Bring any unusual problems which may occur to the attention of the Contracting Officer. Inspect the interlocked joints of driven pilings extending above ground. Use divers to inspect underwater interlocked joints of piling. Pilings found to be out of interlock shall be removed and replaced at the Contractor's expense.

-- End of Section --

SECTION 32 01 19

FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 509	(2006) Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM D5893/D5893M	(2010) Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

1.2 SYSTEM DESCRIPTION

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started maintained in satisfactory condition at all times.

1.2.1 Joint Cleaning Equipment

1.2.1.1 Tractor-Mounted Routing Tool

Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used to clean and enlarge random cracks.

1.2.1.2 Concrete Saw

Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

1.2.1.3 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. The maximum nozzle opening should not exceed 1/4 inch. The air compressor shall be portable and capable of furnishing not less than 150 cfm and maintaining a line pressure of not less than 90 psi at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an

adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to secure satisfactory results.

1.2.1.4 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in psi at which the equipment is operating.

1.2.1.5 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

1.2.2 Sealing Equipment

1.2.2.1 Cold-Applied, Single-Component Sealing Equipment

The equipment for installing ASTM D5893/D5893M single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturer's Recommendations; G.

Printed copies of manufacturer's recommendations, 21 days prior to use on the project, where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

Equipment.

List of proposed equipment to be used in performance of construction work including descriptive data, 21 days prior to use

on the project.

SD-06 Test Reports

Certified copies of the test reports; G.

1.4 QUALITY ASSURANCE

1.4.1 Safety

Do not place joint sealant within 25 feet of any liquid oxygen (LOX) equipment, LOX storage, or LOX piping. Thoroughly clean joints in this area and leave them unsealed.

1.4.2 Test Requirements

Test the joint sealant and backup or separating material for conformance with the referenced applicable material specification. Perform testing of the materials in an approved independent laboratory and submit certified copies of the test reports for approval 21 days prior to the use of the materials at the job site. Samples will be retained by the Government for possible future testing should the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based on the performance of the in-place materials.

1.4.3 Trial Joint Sealant Installation

Prior to the cleaning and sealing of the joints for the entire project, prepare a test section at least 100 feet long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the test section and before any other joint is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. If it is determined that the materials or installation do not meet the requirements, remove the materials, and reclean and reseal the joints at no cost to the Government. When the test section meets the requirements, it may be incorporated into the permanent work and paid for at the contract unit price per linear foot for sealing items scheduled. Prepare and seal all other joints in the manner approved for sealing the test section.

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects, unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site for maintaining materials at the temperatures and conditions recommended by the manufacturer.

1.6 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint wall shall be a minimum of 50 degrees F and rising at the time of application of the materials. Do not apply sealant if moisture is observed in the joint.

PART 2 PRODUCTS

2.1 SEALANTS

Materials for sealing cracks in the various paved areas indicated on the drawings shall be as follows:

Area	Sealing Material
All Concrete Pavement Areas	ASTM D 5893 and COE CRD-C 525

2.2 PRIMERS

When primers are recommended by the manufacturer of the sealant, use them in accordance with the recommendation of the manufacturer.

2.3 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have a water absorption of not more than 5 percent of the sample weight when tested in accordance with ASTM C 509. The backup material shall be 25 plus or minus 5 percent larger in diameter than the nominal width of the crack.

PART 3 EXECUTION

3.1 PREPARATION OF JOINTS

Immediately before the installation of the sealant, thoroughly clean the joints to remove all laitance, curing compound, filler, protrusions of hardened concrete, and old sealant from the sides and upper edges of the joint space to be sealed.

3.1.1 Existing Sealant Removal

Cut loose the in-place sealant from both joint faces and to the depth shown on the drawings, using the waterblaster as specified in paragraph EQUIPMENT. Depth shall be sufficient to accommodate any separating or backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all loose old sealant remaining in the joint opening by blowing with compressed air. Hand tools may be required to remove sealant from random cracks. Chipping, spalling, or otherwise damaging the concrete will not be allowed.

3.1.2 Sawing

3.1.2.1 Refacing of Joints

Accomplish facing of joints using a concrete saw as specified in paragraph EQUIPMENT to remove all residual old sealant and a minimum of concrete from the joint face to provide exposure of newly cleaned concrete, and, if required, to enlarge the joint opening to the width and depth shown on the drawings. Stiffen the blade with a sufficient number of suitable dummy (used) blades or washers. Thoroughly clean, immediately following the sawing operation, the joint opening using a water jet to remove all saw cuttings and debris.

3.1.3 Sandblasting

The newly exposed concrete joint faces and the pavement surfaces extending a minimum of 1/2 inch from the joint edges shall be waterblasted clean. use a multiple-pass technique until the surfaces are free of dust, dirt, curing compound, filler, old sealant residue, or any foreign debris that might prevent the bonding of the sealant to the concrete. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water.

3.1.4 Back-Up Material

When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

3.1.5 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, which include sandblasting, air pressure cleaning and placing of the back-up material to only that lineal footage that can be sealed during the same day.

3.2 PREPARATION OF SEALANT

3.2.1 Type M Sealants

Inspect the FS SS-S-200 Type M sealant components and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection. Prior to transfer of the components from the shipping containers to the appropriate reservoir of the application equipment, thoroughly mix the materials to ensure homogeneity of the components and incorporation of all constituents at the time of transfer. When necessary for remixing prior to transfer to the application equipment reservoirs, warm the components to a temperature not to exceed 90 degrees F by placing the components in heated storage or by other approved methods but in no case shall the components be heated by direct flame, or in a single walled kettle, or a kettle without an oil bath.

3.2.2 Type H Sealants

Mix the FS SS-S-200 Type H sealant components either in the container furnished by the manufacturer or a cylindrical metal container of volume approximately 50 percent greater than the package volume. Thoroughly mix the base material in accordance with the manufacturer's instructions. The cure component shall then be slowly added during continued mixing until a uniform consistency is obtained.

3.2.3 Single-Component, Cold-Applied Sealants

Inspect the ASTM D5893/D5893M sealant and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be

cause for rejection.

3.3 INSTALLATION OF SEALANT

3.3.1 Time of Application

Seal joints immediately following final cleaning of the joint walls and following the placement of the separating or backup material. Open joints, that cannot be sealed under the conditions specified, or when rain interrupts sealing operations shall be recleaned and allowed to dry prior to installing the sealant.

3.3.2 Sealing Joints

Immediately preceding, but not more than 50 feet ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/4 inch plus or minus 1/16 inch below the pavement surface. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

3.4 INSPECTION

3.4.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Cleaned joints will be approved prior to installation of the separating or back-up material and joint sealant.

3.4.2 Joint Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Evidences of bubbling, improper installation, failure to cure or set will be cause to suspend operations until causes of the deficiencies are determined and corrected.

3.4.3 Joint Sealant

Inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified herein at no additional cost to the Government.

3.5 CLEAN-UP

Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

-- End of Section --

SECTION 32 11 16

BASE COURSE FOR RIGID PAVING
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2015) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2014) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM D1556/D1556M	(2015) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	(2015) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates
ASTM E11	(2015) Wire Cloth and Sieves for Testing Purposes

1.2 DEFINITION

Degree of compaction required is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density, and if applicable, corrected using AASHTO T 180 and AASHTO T 224.

1.3 SYSTEM DESCRIPTION

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Provide equipment which is adequate and has the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment
Waybills and Delivery Tickets

SD-06 Test Reports

Sampling and Testing; G
Field Density Tests; G

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor, to be performed by an approved testing laboratory in accordance with Section 01 45 00.00 20 QUALITY CONTROL. Perform tests at the specified frequency. No work requiring testing will be permitted until the testing laboratory has been inspected and approved. Test the materials to establish

compliance with the specified requirements.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.5.2 Tests

1.5.2.1 Sieve Analysis

Make sieve analysis in conformance with ASTM C117 and ASTM C136/C136M. Complete particle-size analysis of the soils in conformance with ASTM D422. Sieves shall conform to ASTM E11.

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture in accordance with ASTM D1557.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, ASTM D2167, or ASTM D6938. For the method presented in ASTM D1556/D1556M, use the base plate, as shown in the drawing. For the method presented in ASTM D6938, check and adjust the calibration curves, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil and ASTM D6938 will be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph Calibration, in ASTM D6938, on each different type of material to be tested at the beginning of a job and at intervals as directed.

a. Submit certified copies of test results for approval not less than 30 days before material is required for the work.

b. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

c. Submit copies of field test results within 24 hours after the tests are performed.

1.5.2.5 Wear Test

Perform wear tests in conformance with ASTM C131/C131M.

1.5.2.6 Weight of Slag

Determine weight per cubic foot of slag in accordance with ASTM C29/C29M.

1.5.3 Testing Frequency

1.5.3.1 Initial Tests

Perform one of each of the following tests on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements prior to installation.

a. Sieve Analysis
b. Liquid limit and plasticity index
c. Moisture-density relationship
d. Wear

1.5.3.2 In-Place Tests

Perform one of each of the following tests on samples taken from the placed and compacted graded crushed aggregate (GCA). Samples shall be taken and tested at the rates indicated.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square yards, or portion thereof, of completed area.

b. Perform sieve analysis on every lift of material placed and at a frequency of one sieve analysis for every 500 square yards, or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.

d. Measure the thickness of each course at intervals providing at least one measurement for each 500 square yards or part thereof. The thickness measurement shall be made by test holes, at least 3 inches in diameter through the course.

1.5.4 Approval of Material

Select the source of materials 30 days prior to the time the material will be required in the work. Tentative approval will be based on initial test results. Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and compacted course.

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Subbase Course

Provide aggregates consisting of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or

naturally combined. Provide aggregates which are durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Material retained on the No. 4 sieve shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested as specified in ASTM C131/C131M. Aggregate shall be reasonably uniform in density and quality. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 65 pcf.

The portion of any blended component and of the completed course passing the No. 40 sieve shall be either nonplastic or shall have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.1.2 Select-Material Subbase Course

Provide materials consisting of selected soil or other materials from field excavation, stockpiles, or other sources and free from lumps and balls of clay and from organic and other objectionable matter. Not more than 25 percent by weight shall pass the No. 200 sieve. The portion of material passing the No. 40 sieve shall have a liquid limit less than 35 and a plasticity index less than 12. The maximum particle size shall not exceed 3 inches.

2.1.3 Rigid Pavement Base Course

Provide aggregates consisting of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Provide aggregates which are durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Material retained on the No. 4 sieve shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested as specified in ASTM C131/C131M. At least 50 percent by weight retained on each sieve shall have one freshly fractured face with the area at least equal to 75 percent of the smallest midsectional area of the piece. Aggregate shall be reasonably uniform in density and quality. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 65 pcf. Aggregates shall have a maximum size of 2 inches and shall be within the limits specified as follows:

Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve	
Sieve Designation	Rigid Pavement Base Course
No. 10	85
No. 200	8

The portion of any blended component and of the completed course passing the No. 40 sieve shall be either nonplastic or shall have a liquid limit not greater than 25 and a plasticity index not greater than 5. The Contractor is responsible for any additional stability required to provide a working platform for construction equipment. If the Contractor can demonstrate with a test section that a material has adequate stability to support construction equipment, the fractured face requirement can be deleted, subject to the approval of the Contracting Officer.

PART 3 EXECUTION

3.1 OPERATION OF AGGREGATE SOURCES

Clearing, stripping and excavating are the responsibility of the Contractor. Operate the aggregate sources to produce the quantity and quality of materials meeting the specified requirements in the specified time limit. Aggregate sources on private lands shall be conditioned in agreement with local laws and authorities.

3.2 STOCKPILING MATERIAL

Prior to stockpiling of material, clear and level storage sites. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Contracting Officer to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.3 PREPARATION OF UNDERLYING MATERIAL

Prior to constructing the rigid pavement base course, clean the underlying course or subgrade of all foreign substances. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. Correct ruts, or soft yielding spots, in the underlying courses, subgrade areas having inadequate compaction, and deviations of the surface from the specified requirements, by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in ASTM D2487, the surface shall be stabilized prior to placement of the overlying course. Accomplish stabilization by mixing the overlying course material into the underlying course, and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements for the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the overlying course is placed.

3.4 GRADE CONTROL

The finished and completed course shall conform to the lines, grades, and cross sections shown. The lines, grades, and cross sections shown shall be maintained by means of line and grade stakes placed by the Contractor at the work site.

3.5 MIXING AND PLACING MATERIALS

Mix and place the materials to obtain uniformity of the material at the water content specified. Make such adjustments in mixing or placing procedures or in equipment as may be directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to insure a satisfactory subbase course.

3.6 LAYER THICKNESS

The compacted thickness of the completed course shall be as indicated. When a compacted layer of 6 inches is specified, the material may be placed in a single layer; when a compacted thickness of more than 6 inches is

required, no layer shall be thicker than 6 inches nor be thinner than 3 inches when compacted.

3.7 COMPACTION

Compact each layer of the material, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus or minus 2 percent of optimum water content, as determined from laboratory tests, as specified in paragraph SAMPLING AND TESTING. In all places not accessible to the rollers, compact the mixture with hand-operated power tampers. Compaction of the rigid base course shall continue until each layer is compacted through the full depth to at least 95 percent of laboratory maximum density. Make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory subbase course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.8 PROOF ROLLING

Areas designated on the drawings to be proof rolled shall receive an application of coverages with a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi. A coverage is defined as the application of one tire print over the designated area. In the areas designated, apply proof rolling to the top layer of the subbase course. Maintain water content of the top layer of the subbase course such that the water content is within plus or minus 2 percent of optimum water content, as determined from laboratory tests, as specified in paragraph SAMPLING AND TESTING. Any material in the subbase courses or underlying materials indicated to be unsatisfactory by the proof rolling shall be removed, dried, and recompacted, or removed and replaced with satisfactory materials.

3.9 EDGES

Place approved material along the edges of the subbase and select-material subbase course in such quantity as will compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, at least a 1 foot width of the shoulder shall be rolled and compacted simultaneously with the rolling and compacting of each layer of the subbase course, as directed.

3.10 SMOOTHNESS TEST

The surface of the top layer shall show no deviations in excess of 3/8 inch when tested with a 12 foot straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 50 foot intervals. Correct deviations exceeding this amount by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.11 THICKNESS CONTROL

The completed thickness of the course(s) shall be in accordance with the thickness and grade indicated . The completed course shall not be more than 1/2 inch deficient in thickness nor more than 1/2 inch above or below the

established grade. Where any of these tolerances are exceeded, correct such areas by scarifying, adding new material of proper gradation or removing material, and compacting, as directed. Where the measured thickness is 1/2 inch or more thicker than shown, the course will be considered as conforming with the specified thickness requirements plus 1/2 inch. The average job thickness is the average of the job measurements as specified above but within 1/4 inch of the thickness shown.

3.12 MAINTENANCE

Maintain the completed course in a satisfactory condition until accepted.

-- End of Section --

SECTION 32 13 11

CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS
11/15

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2012) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 305R	(2010) Guide to Hot Weather Concreting

ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M	(2006; E2011) Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A615/A615M	(2015a) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b; R2014) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A996/A996M	(2015) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C172/C172M	(2014a) Standard Practice for Sampling Freshly Mixed Concrete

ASTM C192/C192M	(2015) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C39/C39M	(2015a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C78/C78M	(2015a) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2011) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 55	(1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 662	(2009) Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)

1.2 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of concrete pavement. However, where the construction covered herein interfaces with other sections, the construction at each interface shall conform to the requirements of both this section and the other section, including tolerances for both.

1.2.1 Surface Smoothness

Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 200 feet, and at the ends of the paving limits for the project. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.),

finish the surface to meet the approval of the Contracting Officer. Detailed notes shall be kept of the results of the testing and a copy furnished to the Government after each day's testing.

a. Straightedge Testing: The finished surfaces of the pavements shall have no abrupt change of 1/4 inch or more, and all pavements shall be within the limits specified when checked with an approved 12 foot straightedge. Roads, streets, tank hardstands, vehicular parking areas, and open storage areas shall have a variation from the specified straight edge not greater than 1/4 inch in either the longitudinal or transverse direction.

1.2.2 Plan Grade

Within 5 days after paving of each lot, the finished surface of the pavement area shall be tested, by running lines of levels at intervals corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. The results of this survey shall be recorded and a copy given to the Government at the completion of the survey of each lot. The finished surfaces of pavements shall vary not more than 1/2 inch above or below the plan grade line or elevation indicated. The above deviations from the approved grade line and elevation will not be permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenant structures. The finished surfaces of new abutting pavements shall coincide at their juncture.

1.2.3 Flexural Strength

Each lot of pavement will be evaluated for acceptance in accordance with the following procedures.

a. Sampling and Testing: For acceptance, one composite sample of concrete from each sublot shall be obtained in accordance with ASTM C172/C172M from one batch or truckload. Two test cylinders per sublot (8 per lot) shall be tested at 14 days.

b. Computations: Average the eight 14-day strength tests for the lot. The average strength shall be used in accordance with paragraph "Concrete Strength for Final Acceptance" in PART 2.

1.2.4 Thickness

Each lot of pavement will be evaluated for acceptance and payment adjustment in accordance with the following procedure. Two cores, between 4 and 6 inches in diameter, shall be drilled from the pavement, per sublot (8 per lot). The Contractor is responsible for drilling the cores within 3 days after lot placement, filling the core holes with an approved non-shrink concrete, respraying the cored areas with curing compound, and for measuring the cores. Each core shall be inspected for voids, thickness of paste on the surface, and depth of reinforcement (if required). Provide the results with the thickness measurement data. Eight measurements of thickness shall be made around the circumference of each core and one in the center, in accordance with ASTM C 174/C 174M, using calibrated calipers for specimens longer than 10 inches. The pavement thickness from the 8 cores for the lot shall be averaged and shall be evaluated.

1.2.5 Diamond Grinding of PCC Surfaces

In areas not meeting the specified limits for surface smoothness and plan grade, high areas shall be reduced to attain the required smoothness and grade, except as depth is limited below. High areas shall be reduced by grinding the hardened concrete with an approved diamond grinding machine after the concrete is 14 days or more old. Grinding shall be accomplished by sawing with an industrial diamond abrasive which is impregnated in the saw blades. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the concrete pavement or joint faces. The saw blades shall be 1/8-inch wide and there shall be a minimum of 55 to 60 blades per 12 inches of cutting head width depending on the hardness of the aggregate. Each machine shall be capable of cutting a path 3 to 4 ft 3 to 4 ft wide. Grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The area corrected by grinding the surface of the hardened concrete shall not exceed 10 percent of the total area of any sublot. The depth of diamond grinding shall not exceed 1/4 inch. All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above, shall be removed and replaced in conformance with paragraph REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. All areas in which diamond grinding has been performed will be subject to the thickness tolerances specified in paragraph: Thickness, above.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment

a. Details and data on the batching and mixing plant prior to plant assembly including manufacturer's literature showing that the equipment meets all requirements specified herein.

b. A certified copy of the NRMCA QC Manual Section 3 Concrete Plant Certification Checklist and Calibration documentation on all measuring and weighing devices, submitted prior to uniformity testing.

c. A description of the equipment proposed for transporting concrete mixture from the central mixing plant to the paving equipment.

d. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture. Manufacturer's literature on the paver and finisher, together with the manufacturer's written instructions on adjustments and operating procedures necessary to assure a tight, smooth surface on the concrete pavement. The literature shall show that the equipment meets all details of these specifications.

Proposed Techniques; G

Placing and protection methods; paving sequence; jointing pattern; data on curing equipment; demolition of existing pavements; as specified. Pavement diamond grinding equipment and procedures.

SD-05 Design Data

Proportioning Studies; G

The results of the mixture proportioning studies signed and stamped by the registered professional engineer having technical responsibility for the mix design study, and submitted at least 30 days prior to commencing concrete placing operations. The results shall include a statement giving the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition. The recommended mixture proportions shall be accompanied by test results demonstrating that the proportions selected will produce concrete of the qualities indicated.

SD-06 Test Reports

Sampling and Testing; G

Certified copies of laboratory test reports and sources for cement, supplementary cementitious materials (SCM), aggregates, admixtures, curing compound, epoxy, and proprietary patching materials proposed for use on this project. All aggregate tests shall have been performed no earlier than 6 months prior to contract award.

SD-07 Certificates

Contractor Quality Control Staff; G

American Concrete Institute certification for Contractor Quality Control staff. Qualifications and resumes for petrographer, surveyor and concrete batch plant operator.

Laboratory Accreditation; G

Accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM C 1077, including all applicable test procedures.

1.4 QUALITY ASSURANCE

1.4.1 Contractor Quality Control Staff

All Contractor Quality Control personnel assigned to concrete construction shall be American Concrete Institute (ACI) certified in the following grade (or shall have written evidence acceptable to the Contracting Officer's representative of having completed similar qualification programs):

a. CQC personnel responsible for inspection of concrete paving operations: ACI Concrete Transportation Inspector.

b. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews: ACI Concrete Flatwork Technician/Finisher.

c. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

d. Laboratory Testing Technicians: ACI Concrete Strength Testing Technician and Laboratory Testing Technician, Grade I or II.

1.4.2 Other Staff

Submit for approval, the qualifications and resumes for the following staff:

a. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C 294 and ASTM C 295 and trained in identification of the specific deleterious materials and tests identified in this specification. Resume shall detail the education, training and experience related to the project-specific test methods and deleterious materials and shall be submitted at least 20 days before petrographic and deleterious materials examination is to commence.

b. Licensed Surveyor: All survey work shall be performed under the supervision of a Licensed Surveyor.

c. Concrete Batch Plant Operator: National Ready Mix Concrete Association (NRMCA) Plant Manager certification at the Plant Manager level.

1.4.3 Laboratory Accreditation

Laboratory and testing facilities shall be provided by and at the expense of the Contractor. The laboratories performing the tests shall be accredited in accordance with ASTM C 1077, including ASTM C78/C78M and ASTM C 1260. The accreditation shall be current and shall include the required and optional test methods, as specified throughout this Section. Onsite temperature-controlled concrete curing facilities shall be provided.

a. Aggregate Testing and Mix Proportioning: Aggregate testing and mixture proportioning studies shall be performed by a commercial laboratory.

b. Acceptance Testing: Furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the site and in the laboratory. Steel molds shall be used for molding the beam specimens. Furnish and maintain boxes or other facilities suitable for storing and curing the specimens at the site while in the mold within the temperature range stipulated by ASTM C 31/C 31M. Flexural loading equipment shall be in accordance with ASTM C78/C78M.

c. Contractor Quality Control: All sampling and testing shall be performed by an approved, onsite, independent, commercial laboratory, or for cementitious materials and admixtures, the manufacturer's laboratory.

d. Laboratory Inspection: The Government will inspect the laboratory equipment and test procedures prior to the start of concreting operations for conformance to ASTM C 1077. The laboratory shall maintain this certification for the duration of the project.

1.4.4 Preconstruction Testing of Materials

All sampling and testing shall be performed by, and at the expense of, the Contractor. Use an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. No material shall be used until notice of acceptance has been given. The Contractor will not be entitled to any additional payment or extension of time due to failure of any material to meet project requirements, or for any additional sampling or testing required. Additional tests may be performed by the Government at the discretion of the Contracting Officer; such Government testing will not relieve the Contractor of any testing responsibilities.

1.4.4.1 Aggregates

Aggregates shall be sampled in the presence of a Government Representative. Samples shall be obtained in accordance with ASTM D 75/D 75M and shall be representative of the materials to be used for the project. Test results shall be submitted 7 days before commencing mixture proportioning studies.

1.4.4.2 Chemical Admixtures, Curing Compounds and Epoxies

At least 30 days before the material is used, submit certified copies of test results for the specific lots or batches to be used on the project. Test results shall be not more than 6 months old prior to use in the work. Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing will be retested at the expense of the Contractor and will be rejected if test results are not satisfactory.

1.4.4.3 Cementitious Materials

Cement will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the specification under which it is furnished. Mill test reports shall be no more than 1 month old, prior to use in the work. No cementitious material shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious material may be subjected to check testing by the Government from samples obtained at the mill, at transfer points, or at the project site. If tests prove that a cementitious material that has been delivered is unsatisfactory, it shall be promptly removed from the site of the work. Cementitious material that has not been used within 6 months after testing shall be retested at the Contractor's expense and shall be rejected if test results are not satisfactory.

1.4.5 Testing During Construction

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials, and concrete as specified herein. The Government will sample and test concrete and ingredient materials as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Testing by the Government will in no way relieve the Contractor of the specified testing requirements.

1.4.6 Test Section

At least 10 days, but not more than 60 days, prior to construction of the concrete pavement, construct a test section near the job site, but not as part of the production pavement area. Use the test section to develop and demonstrate to the satisfaction of the Contracting Officer the proposed techniques of mixing, hauling, placing, consolidating, finishing, curing, initial saw cutting, start-up procedures, testing methods, plant operations, and the preparation of the construction joints. Variations in mixture proportions, other than water, shall be made if directed. Vary the water content, as necessary, to arrive at the appropriate content. The mixing plant shall be operated and calibrated prior to start of placing the test section. Use the same equipment, materials, and construction techniques on the test section as will be used in all subsequent work. Base course preparation, concrete production, placing, consolidating, curing, construction of joints, and all testing shall be in accordance with applicable provisions of this specification. Three days after completion of the test section, provide eight cores at least 6 inch diameter by full depth cut from points selected in the test section by the Government. The cores will be evaluated for homogeneity, consolidation and segregation. Construct the test section meeting all specification requirements and being acceptable to the Contracting Officer in all aspects, including surface texture. Failure to construct an acceptable test section will necessitate construction of additional test sections at no additional cost to the Government. Test sections allowed to be constructed as part of the production paving which do not meet specification requirements shall be removed at the Contractor's expense. Production paving shall not commence until the results on aggregates and concrete, including evaluation of the cores, and all pavement measurements for edge slump, joint face deformation, actual plan grade, surface smoothness and thickness have been submitted and approved by the Contracting Officer. Pavement accepted as a production lot will be evaluated and paid in accordance with Paragraph: ACCEPTABILITY OF WORK below.

1.4.7 Acceptability of Work

The materials and the pavement itself will be accepted on the basis of tests made by the Contractor. The Government may make check tests to validate the results of the Contractor's testing. If the results of the Contractor tests vary by less than 2.0 percent of the Government's test results, the results of the Contractor's tests will be used. If the results of the Government and Contractor tests vary by 2.0 percent, but less than 4.0 percent, the average of the two will be considered the value to be used. If these vary by 4.0 percent or more, each sampling and testing procedure shall be carefully evaluated and both the Government and the Contractor shall take another series of tests on duplicate samples of material. If these vary by 4.0 percent or more, the results of the tests made by the Government shall be used and the Government will continue check testing of this item on a continuous basis until the two sets of tests agree within less than 4.0 percent on a regular basis. Testing performed by the Government will in no way at any time relieve the Contractor from the specified testing requirements.

1.4.8 Acceptance Requirements

1.4.8.1 Pavement Lots

A lot will be that quantity of construction that will be evaluated for acceptance with specification requirements. A lot will be equal to one

shift of production not to exceed 500 cubic yards. In order to evaluate thickness, each lot will be divided into four equal sublots. Grade determinations will be made on the lot as a whole. Surface smoothness determinations will be made on every 0.1 mile segment in each lot. Location of all samples shall be selected on a random basis in accordance with ASTM D 3665. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, the following procedure shall be used to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they shall constitute a lot. Where one or two sublots have been completed, they shall be incorporated into the next lot (except for the last lot), and the total number of sublots shall be used and acceptance criteria adjusted accordingly.

1.4.8.2 Evaluation

Provide all sampling and testing required for acceptance and payment adjustment at the Contractor's expense. Individuals performing sampling, testing and inspection duties shall meet the required Qualifications. The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. Testing in these areas will be in addition to the sublot or lot testing, and the requirements for these areas will be the same as those for a sublot or lot. Provide facilities for and, where directed, personnel to assist in obtaining samples for any Government testing.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Bulk Cementitious Materials

Furnish all cementitious material in bulk. The temperature of the cementitious material, as delivered to storage at the site, shall not exceed 150 degrees F. Sufficient cementitious materials shall be in storage to sustain continuous operation of the concrete mixing plant while the pavement is being placed. Provide separate facilities to prevent any intermixing during unloading, transporting, storing, and handling of each type of cementitious material.

1.5.2 Aggregate Materials

Store aggregate at the site of the batching and mixing plant avoiding breakage, segregation, intermixing or contamination by foreign materials. Each size of aggregate from each source shall be stored separately in free-draining stockpiles. Aggregate stored on ground shall have a minimum 24 inch thick sacrificial layer left undisturbed. Fine aggregate and the smallest size coarse aggregate shall remain in free-draining storage for at least 24 hours immediately prior to use. Sufficient aggregate shall be maintained at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time concrete pavement is being placed. Tracked equipment shall not be allowed on coarse aggregate stockpiles.

1.5.3 Other Materials

Store reinforcing bars and accessories above the ground on supports. All materials shall be stored avoiding contamination and deterioration.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

Cementitious materials shall be portland cement, or only portland cement in combination with supplementary cementitious materials (SCM), and shall conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.1.1 Portland Cement

Provide portland cement conforming to ASTM C 150/C 150M, Type I, low alkali. Low alkali cement is required if the proposed aggregates are found to have greater than 0.04 percent expansion when tested in accordance with paragraph: Alkali-Silica Reactivity below.

2.1.2 Blended Cements

Blended cement shall conform to ASTM C 595/C 595M, Type IP or IS, including the optional requirement for mortar expansion and sulfate soundness. The pozzolan added to the Type IP blend shall be ASTM C 618 Class F or Class N and shall be interground with the cement clinker. The manufacturer shall state in writing that the amount of pozzolan in the finished cement will not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of mineral admixture used in the blend shall not change from that submitted for the aggregate evaluation and mixture proportioning.

2.1.3 Pozzolan

2.1.3.1 Fly Ash

Fly ash shall conform to ASTM C 618, Class F, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 6 percent. Class F fly ash for use in mitigating Alkali-Silica Reactivity shall have a Calcium Oxide (CaO) content of less than 13 percent and a total equivalent alkali content less than 3 percent.

2.1.3.2 Raw or Calcined Natural Pozzolan

Natural pozzolan shall be raw or calcined and conform to ASTM C 618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 6 percent. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a Calcium Oxide (CaO) content of less than 13 percent and a total equivalent alkali content less than 3 percent.

2.1.3.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) shall conform to ASTM C 618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age shall be at least 95 percent of the control specimens.

b. The average particle size shall not exceed 6 microns.

c. The sum of SiO_2 + Al_2O_3 + Fe_2O_3 shall be greater than 77 percent.

2.1.4 Ground Granulated Blast-Furnace (GGBF) Slag

Ground Granulated Blast-Furnace Slag shall conform to ASTM C 989, Grade 120.

2.1.5 Silica Fume

Silica fume shall conform to ASTM C 1240, including the optional limits on reactivity with cement alkalis. Silica fume may be furnished as a dry, densified material or as a slurry. Provide at the Contractor's expense the services of a manufacturer's technical representative, experienced in mixing, proportioning, placement procedures, and curing of concrete containing silica fume. This representative must be present on the project prior to and during at least the first 4 days of concrete production and placement using silica fume.

2.2 AGGREGATES

2.2.1 Aggregate Sources

2.2.1.1 Durability

Fine and coarse aggregates to be used in all concrete shall be evaluated and tested for durability in accordance with ASTM C 88. Results shall not show more than 18 percent loss when subjected to 5 cycles using Magnesium Sulfate. If Sodium Sulfate is used, results shall not show more than 12 percent loss when subjected to 5 cycles.

2.2.1.2 Alkali-Silica Reactivity

Fine and coarse aggregates to be used in all concrete shall be evaluated and tested for alkali-aggregate reactivity. Both coarse aggregate size groups shall be tested.

a. The fine and coarse aggregates shall be evaluated separately, using ASTM C 1260. Test results of the individual aggregates shall have a measured expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Should the test data indicate an expansion of greater than 0.08 percent, the aggregate(s) shall be rejected or additional testing shall be performed as follows: utilize the Contractor's proposed low alkali portland cement, blended cement, and/or SCM, and/or Lithium Nitrate in combination with each individual aggregate. If only SCMs are being evaluated, the testing shall be in accordance with ASTM C 1567. If Lithium Nitrate is being evaluated, with or without SCMs, the testing shall be in accordance with COE CRD-C 662. Determine the quantity that will meet all the requirements of these specifications and that will lower the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Mixture proportioning shall be based on the highest percentage of SCM required to mitigate ASR-reactivity

b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing to the Contracting Officer for evaluation and acceptance.

2.2.1.3 Combined Aggregate Gradation

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, the combined aggregate grading shall meet the following requirements:

a. The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point thus determined shall fall within the parallelogram described therein.

b. The Coarseness Factor (CF) shall be determined from the following equation:

CF = (cumulative percent retained on the 3/8 in. sieve)(100)/(cumulative percent retained on the No. 8 sieve)

c. The Workability Factor WF is defined as the percent passing the No. 8 sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 94 pounds of cementitious material per cubic yard greater than 564 pounds per cubic yard.

d. A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary.)

2.2.2 Coarse Aggregate

2.2.2.1 Material Composition

Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, crushed adequately seasoned air-cooled iron blast-furnace slag; steel furnace slag will not be permitted, or a combination thereof. Aggregates, as delivered to the mixers, shall consist of clean, hard, uncoated particles meeting the requirements of ASTM C 33/C 33M except as specified herein. Coarse aggregate shall be washed. Washing shall be sufficient to remove dust and other coatings. Coarse aggregate shall not show more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 12 percent, or the magnesium sulfate soundness loss shall not exceed 18 percent after five cycles when tested in accordance with ASTM C 88.

2.2.2.2 Particle Shape Characteristics

Particles of the coarse aggregate shall be generally spherical or cubical in shape. The quantity of flat and elongated particles in any size group coarser than the3/8 inch sieve shall not exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle Test of ASTM D 4791. A flat particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.

2.2.2.3 Size and Grading

The nominal maximum size of the coarse aggregate shall be 1.5 inch. The individual aggregates shall be graded and furnished in size groups to meet the coarseness and workability factor criteria for the contractor-proposed combined gradation.

2.2.2.4 Deleterious Material - Road Pavements

The amount of deleterious material in each size group of coarse aggregate shall not exceed the limits in the following table when tested as indicated.

LIMITS OF DELETERIOUS MATERIALS IN COARSE
AGGREGATE FOR ROAD PAVEMENTS
Percentage by Mass

Clay lumps and friable particles (ASTM C142/C142M)	2.0
Material finer than 0.075 mm (No. 200 sieve) (ASTM C 117)	1.0
Lightweight particles (ASTM C 123)	1.0
Other soft particles (COE CRD-C 130)	2.0
Total of all deleterious substances, exclusive of material finer than No. 200 sieve	5.0

The limit for material finer than the No. 200 sieve will be increased to 1.5 percent for crushed aggregates consisting of crusher dust that is essentially free from clay or shale. The separation medium for lightweight particles shall have a density of Sp. Gr. 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

2.2.3 Fine Aggregate

2.2.3.1 Composition

Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles meeting the requirements of ASTM C 33/C 33M. Each type of fine aggregate shall be stockpiled and batched separately. Particles of the fine aggregate shall be generally spherical or cubical in shape.

2.2.3.2 Grading

Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C 33/C 33M and shall have a fineness modulus of not less than 2.50 nor more than 3.00.

2.2.3.3 Deleterious Material

The amount of deleterious material in the fine aggregate shall not exceed

the following limits by mass:

Material	Percentage by Mass
Clay lumps and friable particles ASTM C142/C142M	1.0
Material finer than 0.075 mm (No. 200 sieve) ASTM C 117	3.0
Lightweight particles ASTM C 123 using a medium with a density of 2.0 Mg/cubic meter (Sp. Gr. of 2.0))	0.5
Total of all above	3.0

2.3 CHEMICAL ADMIXTURES

2.3.1 General Requirements

Chemical admixtures may only be used when the specific admixture type and manufacturer is the same material used in the mixture proportioning studies. The air-entraining admixture shall conform to ASTM C260/C260M. An accelerator conforming to ASTM C 494/C 494M, Type C, may be used only when specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES below and shall not be used to reduce the amount of cementitious material used. Calcium chloride and admixtures containing calcium chloride shall not be used. Retarding or water-reducing admixture shall meet the requirements of ASTM C 494/C 494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived. ASTM C 494/C 494M, Type F and G high range water reducing admixtures and ASTM C 1017/C 1017M flowable admixtures shall not be used.

2.3.2 Lithium Nitrate

The lithium admixture shall be a nominal 30 percent aqueous solution of Lithium Nitrate, with a density of 10 pounds/gallon, and shall have the approximate chemical form as shown below:

Constituent	Limit (Percent by Mass)
$LiNo_3$ (Lithium Nitrate)	30 +/- 0.5
SO_4^{-2} (Sulfate Ion)	0.1 (max)
Cl^- (Chloride Ion)	0.2 (max)
Na^+ (Sodium Ion)	0.1 (max)
K^+ (Potassium Ion)	0.1 (max)

The Lithium Nitrate manufacturer shall provide a trained representative to supervise the lithium nitrate admixture dispensing and mixing operations.

2.4 MEMBRANE FORMING CURING COMPOUND

Membrane forming curing compound shall conform to ASTM C 309, white-pigmented Type 2, Class B.

2.5 WATER

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C 1602/C 1602M.

2.6 JOINT MATERIALS

2.6.1 Expansion Joint Material

Expansion joint filler shall be a preformed material conforming to ASTM D 1751 Expansion joint filler shall be 3/4 inch thick, unless otherwise indicated, and shall be furnished in a single full depth piece.

2.7 REINFORCING

All reinforcement shall be free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties shall not be used.

2.7.1 Reinforcing Bars and Bar Mats

Reinforcing bars shall conform to ASTM A615/A615M, billet-steel, Grade 60. Bar mats shall conform to ASTM A184/A184M. The bar members may be billet rail or axle steel.

2.7.2 Welded Wire Reinforcement

Welded Wire Reinforcement shall be deformed or smooth, conforming to ASTM A185/A185M, and shall be furnished in flat sheets.

2.8 DOWELS AND TIE BARS

2.8.1 Dowels

Dowels shall be single piece bars fabricated or cut to length at the shop or mill before delivery to the site. Dowels shall be free of loose, flaky rust and loose scale and shall be clean and straight. Dowels may be sheared to length provided that the deformation from true shape caused by shearing does not exceed 0.04 inch on the diameter of the dowel and does not extend more than 0.04 inch from the end of the dowel. Dowels shall be plain (non-deformed) steel bars conforming to ASTM A615/A615M, Grade 40 or 60; ASTM A996/A996M, Grade 50 or 60. Dowel bars shall be epoxy coated in conformance with ASTM A775/A775M. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the epoxy hardens. Dowel sleeves or inserts are not permitted.

2.8.2 Dowel Bar Assemblies

Dowel bar assemblies shall consist of a framework of metal bars or wires arranged to provide rigid support for the dowels throughout the paving operation, with a minimum of four continuous bars or wires extending along the joint line. The dowels shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from rising, sliding out, or becoming distorted during paving operations.

2.8.3 Tie Bars

Tie bars shall be deformed steel bars conforming to ASTM A615/A615M, or ASTM A996/A996M, Grade 60, and of the sizes and dimensions indicated. Deformed rail steel bars and high-strength billet or axle steel bars, Grade 50 or higher, shall not be used for bars that are bent and straightened

during construction.

2.9 EPOXY RESIN

All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C 881/C 881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials shall meet the following requirements:

a. Material for use for embedding dowels and anchor bolts shall be Type IV, Grade 3.

b. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar shall be Type III, Grade as approved.

c. Material for use for injecting cracks shall be Type IV, Grade 1.

d. Material for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete shall be Type V, Grade as approved.

2.10 EQUIPMENT

All plant, equipment, tools, and machines used in the work shall be maintained in satisfactory working conditions at all times.

2.10.1 Batching and Mixing Plant

a. Location: The batching and mixing plant shall be located off Government premises no more than 15 minutes haul time from the placing site. There shall be operable telephonic or radio communication between the plant and the placing site at all times concreting is taking place.

b. Type and Capacity: The batching and mixing plant shall be a stationary-type central mix plant, including permanent installations or portable/relocatable plants installed on stable foundations. The plant shall be designed and operated to produce concrete within the specified tolerances, and shall have a capacity of at least 250 cubic yards per hour. The batching and mixing plant shall conform to the requirements of NRMCA QC 3 including provisions addressing:

1. Material Storage and Handling
2. Batching Equipment
3. Central Mixer
4. Ticketing System
5. Delivery System

c. Tolerances: The following tolerances shall apply.

Materials	Percentage of Required Mass
Cementitious Materials	plus or minus 1
Aggregate	plus or minus 2
Water	plus or minus 1
Admixture	plus or minus 3

For volumetric batching equipment for water and admixtures, the above numeric tolerances shall apply to the required volume of material being batched. Concentrated admixtures shall be uniformly diluted, if necessary, to provide sufficient volume per batch to ensure that the batchers will consistently operate within the above tolerance.

d. Moisture Control: The plant shall be capable of ready adjustment to compensate for the varying moisture contents of the aggregates and to change the quantities of the materials being batched.

2.10.2 Concrete Mixers

a. General: Mixers shall be stationary or truck mixers. Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades or paddles.

b. Stationary: Stationary mixers shall be drum or pan mixers. Mixers shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed.

c. Mixing Time and Uniformity for Stationary Mixers: For stationary mixers, before uniformity data are available, the mixing time for each batch after all solid materials are in the mixer, provided that all of the mixing water is introduced before one-fourth of the mixing time has elapsed, shall be 1 minute for mixers having a capacity of 1 cubic yard. For mixers of greater capacity, this minimum time shall be increased 20 seconds for each additional 1.33 cubic yard or fraction thereof. After results of uniformity tests are available, the mixing time may be reduced to the minimum time required to meet uniformity requirements; but if uniformity requirements are not being met, the mixing time shall be increased as directed. The mixing time for full batch production shall be a minimum of 75 seconds. Mixer performance tests at new mixing times shall be performed immediately after any change in mixing time. The Regular Test sequence shall be conducted for initial determination of the mixing time or as directed. When regular testing is performed, the concrete shall meet the limits of any five of the six uniformity requirements listed in Table 1 below.

d. The Abbreviated Test sequence shall be conducted for production concrete verification at the frequency specified in Table 6. When abbreviated testing is performed, the concrete shall meet only those requirements listed for abbreviated testing. The concrete proportions used for uniformity tests shall be as used on the project. Regular testing shall consist of performing all six tests on three batches of concrete. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the three required tests on a single batch of concrete. The range for abbreviated testing shall be the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, etc., the results of tests on one of the mixers shall apply to the others, subject to the approval of the Contracting Officer. All mixer performance

(uniformity) testing shall be performed in accordance with COE CRD-C 55 and with paragraph titled TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3.

TABLE 1
UNIFORMITY REQUIREMENTS--STATIONARY MIXERS

Parameter	Regular Tests Allowable Maximum Range for Average of 3 Batches	Abbreviated Tests Allowable Maximum Range for 1 Batch
Unit weight of air-free mortar	2.0 lbs/cubic ft	2.0 lbs/cubic ft
Air content	1.0 percent	--
Slump	1.0 inch	1.0 inch
Coarse aggregate	6.0 percent	6.0 percent
Compressive strength at 7 days,	10.0 percent	10.0 percent
Water content	1.5 percent	

e. Truck: The only truck mixers used for mixing or transporting paving concrete shall be those designed with extra large blading and rear opening specifically for low-slump paving concrete. Truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof shall conform to the requirements of ASTM C 94/C 94M. The number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete shall be determined by uniformity tests as specified in ASTM C 94/C 94M and in requirements for mixer performance stated in paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3. If requirements for the uniformity of concrete are not met with 100 revolutions of mixing after all ingredients including water are in the truck mixer drum, the mixer shall not be used until the condition is corrected. Water shall not be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Water shall be injected into the head of the mixer (end opposite the discharge opening) drum under pressure, and the drum or blades shall be turned a minimum of 30 additional revolutions at mixing speed. Water shall not be added to the batch at any later time. Mixer performance (uniformity) tests for truck mixers shall be made in accordance with ASTM C 94/C 94M.

2.10.3 Transporting Equipment

Fixed form concrete shall be transported in approved truck mixers designed with extra large blading and rear opening specifically for low slump concrete. All transporting equipment shall be designed and operated to deliver and discharge the required concrete mixture completely without segregation.

2.10.4 Transfer and Spreading Equipment

Equipment for transferring concrete from the transporting equipment to the paving lane in front of the paver shall be specially manufactured, self-propelled transfer equipment which will accept the concrete outside the paving lane and will transfer and spread it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

2.10.5 Paver-Finisher

a. General: The paver-finisher shall be a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement. The paver-finisher shall weigh at least 2200 lb/foot of lane width, and shall be powered by an engine having at least 6.0 horsepower/foot of lane width. The paver-finisher shall spread, consolidate, and shape the plastic concrete to the desired cross section in one pass. The mechanisms for forming the pavement shall be easily adjustable in width and thickness and for required crown. In addition to other spreaders required by paragraph above, the paver-finisher shall be equipped with a full width knock-down auger or paddle mechanism, capable of operating in both directions, which will evenly spread the fresh concrete in front of the screed or extrusion plate.

b. Vibrators: Immersion vibrators shall be gang mounted at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete, as required. The vibrators shall be automatically controlled so that they will be immediately stopped as forward motion of the paver ceases. The spacing of the immersion vibrators across the paving lane shall be as necessary to properly consolidate the concrete, but the clear distance between vibrators shall not exceed 30 inches. The outside vibrators shall not be more than 12 inches from the lane edge. Spud vibrators shall operate at a frequency of not less than 8000 impulses/minute and an amplitude of not less than 0.03 inch, as determined by COE CRD-C 521.

c. Screed or Extrusion Plate: The paver-finisher shall be equipped with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface and shall so finish the surface that no significant amount of hand finishing, except use of cutting straightedges, is required. The screed or extrusion plate shall be constructed to provide adjustment for crown in the pavement. The entire machine shall provide adjustment for variation in lane width or thickness and to prevent more than 8 inches of the screed or extrusion plate extending over previously placed concrete on either end when paving fill-in lanes. Machines that cause displacement of properly installed forms or cause ruts or indentations in the prepared underlying materials and machines that cause frequent delays due to mechanical failures shall be replaced as directed.

d. Fixed Forms: The paver-finisher shall be equipped with wheels designed to ride the forms, keep it aligned with the forms, and spread the load so as to prevent deformation of the forms. Paver-finishers traveling on guide rails located outside the paving lane shall be equipped with wheels when traveling on new or existing concrete to remain.

e. Longitudinal Mechanical Float: A longitudinal mechanical float shall be specially designed and manufactured to smooth and finish the pavement surface without working excess paste to the surface. It shall be rigidly attached to the rear of the paver-finisher or to a separate self-propelled frame spanning the paving lane. The float plate shall be at least 5 feet long by 8 inches wide and shall automatically be oscillated in the longitudinal direction while slowly moving from edge to edge of the paving lane, with the float plate in contact with the surface at all times.

f. Nonrotating Pipe Float: A pipe float if used, shall be a nonrotating pipe 6 to 10 inches in diameter and sufficiently long to span the full paving width when oriented at an angle of approximately 60 degrees with the centerline. The pipe float shall be mounted on a self-propelled frame that spans the paving lane. No means of applying water to the surface shall be incorporated in the pipe float.

g. Other Types of Finishing Equipment: Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to the Contracting Officer's approval. Bridge deck finishers shall have a minimum operating weight of 7500 pounds and shall have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

2.10.6 Curing Equipment

Equipment for applying membrane-forming curing compound shall be mounted on a self-propelled frame that spans the paving lane. The reservoir for curing compound shall be constantly mechanically (not air) agitated during operation and shall contain means for completely draining the reservoir. The spraying system shall consist of a mechanically powered pump which will maintain constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to give uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a speed correlated with the forward movement of the overall frame. All spray nozzles shall be protected with wind screens. Calibrate the spraying system in accordance with ASTM D 2995, Method A, for the rate of application required in paragraph: Membrane Curing. Any hand-operated sprayers allowed by that paragraph shall be compressed air supplied by a mechanical air compressor. If the curing equipment fails to apply an even coating of compound at the specified rate, it shall immediately be replaced.

2.10.7 Texturing Equipment

a. General: Texturing equipment shall be as specified below. Before use, the texturing equipment shall be demonstrated on a test section, and the equipment shall be modified as necessary to produce the texture directed.

b. Burlap Drag: A burlap drag shall be securely attached to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Length of the material shall provide 24 to 36 inches dragging flat on the pavement surface. Width shall be at least equal to the width of the slab. The material shall be clean,

reasonably new burlap, completely saturated with water before attachment to the frame, always resaturated before start of use, and kept clean and saturated during use. Burlap shall conform to AASHTO M 182, Class 3 or 4.

c. Broom: Surface texture shall be applied using an approved mechanical stiff bristle broom drag of a type that will uniformly score the surface transverse to the pavement center line. The broom shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. The scores shall be uniform in appearance and approximately 1/16 inch in depth but not more than 1/8 inch in depth.

2.10.8 Sawing Equipment

Equipment for sawing joints and for other similar sawing of concrete shall be standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Blades shall be diamond tipped. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to maintain the required sawing rate. Wheel saws used in the removal of concrete shall be saws with large diameter tungsten carbide tipped blades mounted on a heavy-duty chassis which will produce a saw kerf at least 1-1/2 inch wide. All saws shall be capable of sawing to the full depth required. Early-entry saws may be used, subject to demonstration and approval of the Contracting Officer. No change to the initial sawcut depth shall be permitted.

2.10.9 Straightedge

Furnish and maintain at the job site, in good condition, one 12 foot straightedge for each paving train for testing the hardened portland cement concrete surfaces. These straightedges shall be constructed of aluminum or magnesium alloy and shall have blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Straightedges shall have handles for operation on the pavement.

2.11 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

2.11.1 Specified Flexural Strength

Specified flexural strength, R, for concrete is 650 psi at 28 days,, Maximum allowable water-cementitious material ratio is 0.45. The water-cementitious material ratio will be the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus SCM by the mass equivalency method described in ACI 211.1. The concrete shall be air-entrained with a total air content of 4 plus or minus 1.5 percentage points, at the point of placement. Air content shall be determined in accordance with ASTM C231/C231M. The maximum allowable slump of the concrete at the point of placement shall be 2 inches for pavement constructed with fixed forms. The selected slump shall be applicable to both pilot and fill-in lanes.

2.11.2 Concrete Temperature

The temperature of the concrete as delivered shall conform to the requirements of paragraphs, Paving in Hot Weather and Paving in Cold Weather, in PART 3. Temperature of concrete shall be determined in accordance with ASTM C 1064/C 1064M.

2.11.3 Concrete Strength for Final Acceptance

The strength of the concrete will be considered acceptable when the average equivalent 28-day flexural strengths for each lot are above the 'Specified Flexural Strength' as determined by correlation with 14-day compressive strength tests specified in paragraph: "Mixture Proportioning for Flexural Strength" below, The strength of the concrete will be considered acceptable when the equivalent 28-day flexural strengths for each lot are above the'Specified Flexural Strength' as determined by correlation with 14-day flexural strength tests specified in paragraph: "Mixture Proportioning for Flexural Strength" below, and no individual set (2 specimens per sublot) in the lot are 25 psi or more below the equivalent 'Specified Flexural Strength'. If any lot or sublot, respectively, fails to meet the above criteria, the lot or sublot shall be removed and replaced at no additional cost to the Government. This is in addition to and does not replace the average strength required for day-to-day CQC operations as specified in paragraph: Average CQC Flexural Strength Required for Mixtures, below.

2.12 MIXTURE PROPORTIONS

2.12.1 Composition

Concrete shall be composed of cementitious material, water, fine and coarse aggregates, and admixtures. Supplementary Cementitious Materials (SCM) choice and usage shall be in accordance with paragraph: Supplementary Cementitious Materials (SCM) Content. The total cementitious material content shall be at least 470 lb./cu. yd.. Admixtures shall consist of air entraining admixture and may also include, as approved, water-reducing admixture.

2.12.2 Proportioning Studies

Trial design batches, mixture proportioning studies, and testing requirements are the responsibility of the Contractor. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in ACI 211.1, modified as necessary to accommodate flexural strength. Submit test results including:

a. Coarse and fine aggregate gradations and plots.
b. Combined aggregate gradation plots.
c. Coarse aggregate quality test results, include deleterious materials.
d. Fine aggregate quality test results.
e. Mill certificates for cement and supplemental cementitious materials.
f. Certified test results for air entraining, water reducing, retarding, non-chloride accelerating admixtures.
g. Specified flexural strength, slump, and air content.
h. Documentation of required average CQC flexural strength, Ra.
i. Recommended proportions/volumes for proposed mixture and each of three trial water-cementitious materials ratios.
j. Individual beam and cylinder breaks.
k. Flexural strength summaries and plots.
l. Correlation ratios for acceptance testing and CQC testing.
m. Historical record of test results, documenting production standard deviation (if available).

2.12.2.1 Water-Cement Ratio

At least three different water-cement ratios, which will produce a range of strength encompassing that required on the project, shall be used. The

maximum allowable water-cement ratio required in paragraph: Specified Flexural Strength, above will be the equivalent water-cement ratio. Laboratory trial mixtures shall be proportioned for maximum permitted slump and air content.

2.12.2.2 Trial Mixture Studies

Separate sets of trial mixture studies shall be made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for each placing method (slip form, fixed form, or hand placement) proposed. The temperature of concrete in each trial batch shall be reported. Each mixture shall be designed to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

2.12.2.3 Mixture Proportioning for Flexural Strength

The following step by step procedure shall be followed:

a. Fabricate all beams and cylinders for each mixture from the same batch or blend of batches. Fabricate and cure all beams and cylinders in accordance with ASTM C192/C192M, using 6 x 6 inches steel beam forms and 6 x 12 inches single-use cylinder forms.

b. Cure test beams from each mixture for 3, 7, 14 and 28-day flexural tests; 6 beams to be tested per age.

c. Cure test cylinders from each mixture for 3, 7, 14 and 28-day compressive strength tests; 6 cylinders to be tested per age.

d. Test beams in accordance with ASTM C78/C78M, cylinders in accordance with ASTM C39/C39M.

e. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:
    3-day flexural strength
    7-day flexural strength
    14-day flexural strength
    28-day flexural strength

    3-day compressive strength
    7-day compressive strength
    14-day compressive strength
    28-day compressive strength

f. From these graphs select a w/c that produces a mixture giving a 28 -day flexural strength equal to the required strength determined in accordance with the next paragraph.

g. Using the above selected w/c, select from the graphs the expected 3, 7, 14, 28-day flexural strengths and the expected 3, 7, 14, 28-day compressive strengths for the mixture.

h. From the above expected strengths for the selected mixture determine the following Correlation Ratios:

(1) Ratio of the 14-day compressive strength of the selected mixture to the 28-day flexural strength of the mixture (for acceptance).

(2) Ratio of the 7-day compressive strength of the selected mixture to the 28-day flexural strength of the mixture (for CQC control).

i. If there is a change in materials, perform additional mixture design studies using the new materials and new Correlation Ratios determined.

j. No concrete pavement placement is allowed until the mixture proportions are approved. The approved water-cementitious materials ratio is restricted to the maximum value specified in the next paragraph and not be increased without written approval.

2.12.3 Average CQC Flexural Strength Required for Mixtures

In order to ensure meeting the strength requirements specified in paragraph: SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES above, during production, the mixture proportions selected during mixture proportioning studies and used during construction shall produce a required average CQC flexural strength exceeding the specified strength, R, by the amount indicated below. This required average CQC flexural strength, Ra, will be used only for CQC operations as specified in paragraph: TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL in PART 3 and as specified in the previous paragraph. During production, the required Ra shall be adjusted, as appropriate and as approved, based on the standard deviation of -day strengths being attained during paving.

a. From Previous Test Records: Where a concrete production facility has previous test records current to within 18 months, a standard deviation shall be established in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified flexural strength or strengths within 150 psi of the 90-day flexural strength specified for the proposed work, and shall consist of at least 30 consecutive tests. Perform verification testing, as directed by the Contracting Officer, to document the current strength. A strength test shall be the average of the strengths of two specimens made from the same sample of concrete and tested at 90 days. Required average CQC flexural strength, Ra, used as the basis for selection of concrete proportions shall be the value from the equation that follows, using the standard deviation as determined above:

$$Ra = R + 1.34S$$

Where: S = standard deviation
R = specified flexural strength
Ra = required average flexural strength

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

b. Without Previous Test Records: When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength, Ra, shall be determined by adding 15 percent to the specified flexural strength, R.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Before commencing paving, perform the following. If used, forms shall be in place, cleaned, coated, and adequately supported. Any reinforcing steel needed shall be at the paving site. All transporting and transfer equipment shall be ready for use, clean, and free of hardened concrete and foreign material. Equipment for spreading, consolidating, screeding, finishing, and texturing concrete shall be at the paving site, clean and in proper working order. All equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the paving site, in proper working condition, and in sufficient amount for the entire placement.

3.1.1 Weather Prevention

When windy conditions during paving appear probable, equipment and material shall be at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.2 Proposed Techniques

Submit for approval the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints; transverse and longitudinal dowel bar spacing; and identifying pilot lanes and hand placement areas. No deviation from the jointing pattern shown on the drawings shall be made without written approval of the design engineer.

c. Plan and equipment proposed to control alignment of sawn joints within the specified tolerances.

d. Pavement demolition work plan, presenting the proposed methods and equipment to remove existing pavement and protect pavement to remain in place.

3.2 CONDITIONING OF UNDERLYING MATERIAL

3.2.1 General Procedures

Underlying material, upon which concrete is to be placed shall be clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, the underlying material shall be well drained and shall have been satisfactorily graded by string-line controlled, automated, trimmer/fine grader and uniformly compacted in accordance with the applicable Section of these specifications. The surface of the underlying material shall be tested as to crown, elevation, and density in advance of setting forms or of concrete placement using slip-form techniques. High areas shall be trimmed to proper elevation. Low areas shall be filled and compacted to a condition similar to that of surrounding grade, or filled with concrete monolithically with the pavement. Low areas filled with concrete shall not be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Any underlying material disturbed by construction operations shall be reworked and recompacted to specified density immediately in front of the paver.

3.2.2 Traffic on Underlying Material

After the underlying material has been prepared for concrete placement, no equipment shall be permitted thereon. Subject to specific approval, crossing of the prepared underlying material at specified intervals for construction purposes may be permitted, provided rutting or indentations do not occur. The surface shall be reworked and reprepared to the satisfaction of the Contracting Officer before concrete is placed. Equipment shall be allowed to operate on the underlying material only if approved by the Contracting Officer and only if no damage is done to the underlying material and its degree of compaction. Any disturbance to the underlying material that does occur shall be corrected, as approved, before the paver-finisher or the deposited concrete reaches the location of the disturbance and the equipment shall be replaced or procedures changed to prevent any future damage.

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. All unhardened concrete shall be immediately covered and protected from the rain or other damaging weather. Any slab damaged by rain or other weather shall be completely removed full depth, by full slab width, to the nearest original joint, and replaced at the Contractor's expense as specified in paragraph: REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS below.

3.3.2 Paving in Hot Weather

When the ambient temperature during paving is expected to exceed 90 degrees F, the concrete shall be properly placed and finished in accordance with

procedures previously submitted, approved, and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C 1064/C 1064M. Cooling of the mixing water or aggregates or placing in the cooler part of the day may be required to obtain an adequate placing temperature. Steel forms and reinforcing shall be cooled as needed to maintain steel temperatures below 120 degrees F. Transporting and placing equipment shall be cooled or protected if necessary to maintain proper concrete placing temperature. The finished surfaces of the newly laid pavement shall be kept damp by applying a fog spray (mist) with approved spraying equipment until the pavement is covered by the curing medium.

Maximum Allowable Concrete Placing Temperature

Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature in Degrees F
Greater than 60	90
40-60	85
Less than 40	80

3.3.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 2.1.5 of ACI 305R. In addition to the protective measures specified in the previous paragraph, the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. When such water treatment is stopped, curing procedures shall be immediately commenced. Plastic shrinkage cracks that occur shall be repaired in accordance with paragraph: REPAIR, REMOVAL, REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Plastic shrinkage cracks shall never be troweled over or filled with slurry.

3.4 CONCRETE PRODUCTION

Batching, mixing, and transporting equipment shall have a capacity sufficient to maintain a continuous, uniform forward movement of the paver of not less than 2.5 feet per minute. Concrete transported in non-agitating equipment shall be deposited in front of the paver within 45 minutes from the time cement has been charged into the mixing drum, except that if the ambient temperature is above 90 degrees F, the time shall be reduced to 30 minutes. Concrete transported in truck mixers shall be deposited in front of the paver within 90 minutes from the time cement has been charged into the mixer drum of the plant or truck mixer. If the ambient temperature is above 90 degrees F, the time shall be reduced to 60 minutes. Every load of concrete delivered to the paving site shall be accompanied by a batch ticket from the operator of the batching plant. Tickets shall be on approved forms and shall show at least the mass, or volume, of all ingredients in each batch delivered, and the time of day. Tickets shall be delivered to the placing foreman who shall keep them on file and deliver them to the Government weekly, or as directed by the Contracting Officer.

3.4.1 Batching and Mixing Concrete

Scale pivots and bearings shall be kept clean and free of rust. Any equipment which fails to perform as specified shall immediately be removed from use until properly repaired and adjusted, or replaced.

3.4.2 Transporting and Transfer - Spreading Operations

Non-agitating equipment shall be used only on smooth roads and for haul time less than 15 minutes. Concrete shall be deposited as close as possible to its final position in the paving lane. All equipment shall be operated to discharge and transfer concrete without segregation. In no case shall dumping of concrete in discrete piles be permitted. No transfer or spreading operation which requires the use of front-end loaders, dozers, or similar equipment to distribute the concrete will be permitted.

3.5 PAVING

3.5.1 General Requirements

Pavement shall be constructed with paving and finishing equipment utilizing rigid fixed forms. Paving and finishing equipment and procedures shall be capable of constructing paving lanes of the required width at a rate of at least 50 feet of paving lane per hour on a routine basis. Paving equipment and its operation shall be controlled, and coordinated with all other operations, such that the paver-finisher has a continuous forward movement, at a reasonably uniform speed, from beginning to end of each paving lane, except for inadvertent equipment breakdown. Failure to achieve this shall require the Contractor to halt operations, regroup, and modify operations to achieve this requirement. Workmen with foreign material on their footwear or construction equipment that might deposit foreign material shall not be permitted to walk or operate in the plastic concrete. Where an open-graded granular base is required under the concrete, select paving equipment and procedures which will operate properly on the base course without causing displacement or other damage.

3.5.2 Consolidation

Concrete shall be consolidated with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than 2 inches. Excessive vibration shall not be permitted. If the vibrators cause visible tracking in the paving lane, the paving operation shall be stopped and equipment and operations modified to prevent it. Concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment shall be vibrated with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Vibrators shall not be used to transport or spread the concrete. Hand-operated vibrators shall not be operated in the concrete at one location for more than 20 seconds. Insertion locations for hand-operated vibrators shall be between 6 to 15 inches on centers. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) shall require the immediate stopping of the paving operation and approved adjustment of the equipment or procedures.

3.5.3 Operation

When the paver approaches a header at the end of a paving lane, a sufficient amount of concrete shall be maintained ahead of the paver to provide a roll of concrete which will spill over the header. The amount of extra concrete shall be sufficient to prevent any slurry that is formed and carried along ahead of the paver from being deposited adjacent to the header. The spud vibrators in front of the paver shall be brought as close to the header as possible before they are lifted. Additional consolidation shall be provided adjacent to the headers by hand-manipulated vibrators. When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement. Screeds or extrusion plates shall be electronically controlled from the previously placed pavement so as to prevent them from applying pressure to the existing pavement and to prevent abrasion of the pavement surface. The overlapping area of existing pavement surface shall at all times be kept completely free of any loose or bonded foreign material as the paver-finisher operates across it. When the paver travels on existing pavement, approved provisions shall be made to prevent damage to the existing pavement. Pavers using transversely oscillating screeds shall not be used to form fill-in lanes that have widths less than a full width for which the paver was designed or adjusted.

3.5.4 Required Results

The paver-finisher, and its gang-mounted vibrators, together with its operating procedures shall be adjusted and operated and coordinated with the concrete mixture being used to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. The paver-finisher shall make only one pass across the pavement; multiple passes will not be permitted. The equipment and its operation shall produce a finished surface requiring no hand finishing other than the use of cutting straightedges, except in very infrequent instances. If any equipment or operation fails to produce the above results, the paving shall be stopped, the equipment shall be replaced or properly adjusted, the operation shall be appropriately modified, or the mixture proportions modified, in order to produce the required results before recommencing paving. No water, other than fog sprays (mist) as specified in paragraph: Prevention of Plastic Shrinkage Cracking above, shall be applied to the concrete or the concrete surface during paving and finishing.

3.5.5 Fixed Form Paving

Paving equipment for fixed-form paving and the operation thereof shall conform to the requirements of paragraph EQUIPMENT, and all requirements specified herein.

3.5.5.1 Forms for Fixed-Form Paving

a. Straight forms shall be made of steel and shall be furnished in sections not less than 10 feet in length. Flexible or curved forms of proper radius shall be used for curves of 100-foot radius or less. Wood forms for curves and fillets shall be made of well-seasoned, surfaced plank or plywood, straight, and free from warp or bend. Wood forms shall be adequate in strength and rigidly braced. Forms shall have a depth equal to the pavement thickness at the edge. Where the

project requires several different slab thicknesses, forms may be built up by bolting or welding a tubular metal section or by bolting wood planks to the bottom of the form to completely cover the underside of the base of the form and provide an increase in depth of not more than 25 percent. The base width of the one-piece or built-up form shall be not less than eight-tenths of the vertical height of the form, except than forms 8 inches or less in vertical height shall have a base width not less than the vertical height of the form. Maximum vertical deviation of top of any side form, including joints, shall not vary from a true plane more than 1/8 inch in 10 feet, and the upstanding leg shall not vary more than 1/4 inch.

b. Form sections shall be tightly locked and shall be free from play or movement in any direction. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.

c. Set forms for full bearing on foundation for entire length and width and in alignment with edge of finished pavement. Support forms during entire operation of placing, compaction, and finishing so that forms will not deviate vertically more than 0.01 foot from required grade and elevations indicated. Conformity to the alignment and grade elevations shown on the drawings shall be checked and necessary corrections shall be made immediately prior to placing the concrete. The forms shall be cleaned and oiled each time before concrete is placed. No concrete shall be placed until setting of forms has been checked and approved by the CQC team.

d. Do not anchor guide rails for fixed form pavers into new concrete or existing concrete to remain.

3.5.5.2 Form Removal

Keep forms in place at least 12 hours after the concrete has been placed. When conditions are such that the early strength gain of the concrete is delayed, leave the forms in place for a longer time, as directed. Remove forms by procedures that do not injure the concrete. Bars or heavy metal tools shall not be used directly against the concrete in removing the forms. Any concrete found to be defective after form removal shall be repaired promptly, using procedures specified or as directed.

3.5.6 Placing Reinforcing Steel

The type and amount of steel reinforcement shall be as shown on the drawings.

3.5.6.1 Pavement Thickness Less Than 12 Inches

For pavements less than 12 inches thick, the reinforcement shall be positioned on suitable chairs or continuous mesh support devices securely fastened to the subgrade prior to concrete placement. Concrete shall be vibrated after the steel has been placed. Regardless of placement procedure, the reinforcing steel shall be free from coatings which could impair bond between the steel and concrete, and laps in the reinforcement shall be as indicated. Regardless of the equipment or procedures used for installing reinforcement, ensure that the entire depth of concrete is adequately consolidated.

3.5.7 Placing Dowels and Tie Bars

The method used in installing and holding dowels in position shall ensure that the error in alignment of any dowel from its required horizontal and vertical alignment after the pavement has been completed will not be greater than 1/8 in. per ft. Except as otherwise specified below, horizontal spacing of dowels shall be within a tolerance of plus or minus 5/8 inch. The vertical location on the face of the slab shall be within a tolerance of plus or minus 1/2 inch). The vertical alignment of the dowels shall be measured parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The horizontal alignment shall be checked with a framing square. Dowels and tie bars shall not be placed closer than 0.6 times the dowel bar length to the planned joint line. If the last regularly spaced dowel is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar length, but not closer than 6 inches to its nearest neighbor. Dowel (tie bar) interference at a transverse joint-longitudinal joint intersection shall be resolved by deleting the closest transverse dowel (tie bar). Dowels shall be installed as specified in the following subparagraphs.

3.5.7.1 Contraction Joints

Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. The basket assemblies shall be held securely in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires. At the Contractor's option, in lieu of the above, dowels and tie bars in contraction joints shall be installed near the front of the paver by insertion into the plastic concrete using approved equipment and procedures. Approval will be based on the results of a preconstruction demonstration, showing that the dowels and tie bars are installed within specified tolerances.

3.5.7.2 Construction Joints-Fixed Form Paving

Installation of dowels and tie bars shall be by the bonded-in-place method. Installation by removing and replacing in preformed holes will not be permitted. Dowels and tie bars shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. The spacing of dowels and tie bars in construction joints shall be as indicated, except that, where the planned spacing cannot be maintained because of form length or interference with form braces, closer spacing with additional dowels or tie bars shall be used.

3.5.7.3 Dowels Installed in Hardened Concrete

Install dowels in hardened concrete by bonding the dowels into holes drilled into the hardened concrete. The concrete shall have cured for 7 days or reached a minimum before drilling commences. Holes 1/8 inch greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur to the concrete joint face. Continuing damage shall require modification of the equipment and

operation. Depth of dowel hole shall be within a tolerance of plus/minus 1/2 inch of the dimension shown on the drawings. Upon completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Dowels required to be installed in any joints between new and existing concrete shall be grouted in holes drilled in the existing concrete, all as specified above.

3.5.7.4 Lubricating Dowel Bars

The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed.

3.6 FINISHING

Finishing operations shall be a continuing part of placing operations starting immediately behind the strike-off of the paver. Initial finishing shall be provided by the transverse screed or extrusion plate. The sequence of operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Finishing shall be by the machine method. The hand method shall be used only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing, shall be immediately stopped and proper adjustments made or the equipment replaced. Any operations which produce more than 1/8 inch of mortar-rich surface (defined as deficient in plusU.S. No. 4 sieve size aggregate) shall be halted immediately and the equipment, mixture, or procedures modified as necessary. Compensation shall be made for surging behind the screeds or extrusion plate and settlement during hardening and care shall be taken to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) will be at the required line and grade. Finishing equipment and tools shall be maintained clean and in an approved condition. At no time shall water be added to the surface of the slab with the finishing equipment or tools, or in any other way, except for fog (mist) sprays specified to prevent plastic shrinkage cracking.

3.6.1 Machine Finishing With Fixed Forms

The machine shall be designed to ride the forms and shall be operated to screed and consolidate the concrete. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

3.6.2 Surface Correction and Testing

After all other finishing is completed but while the concrete is still plastic, minor irregularities and score marks in the pavement surface shall be eliminated by means of cutting straightedges. Such straightedges shall be 12 feet in length and shall be operated from the sides of the pavement and from bridges. A straightedge operated from the side of the pavement shall be equipped with a handle 3 feet longer than one-half the width of the pavement. The surface shall then be tested for trueness with a straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages of not more than one-half the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated with an internal vibrator, and refinished. Projections above the required elevation shall also be struck off and refinished. The straightedge testing and finishing shall continue until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in paragraph: ACCEPTABILITY OF WORK in PART 1. This straightedging shall not be used as a replacement for the straightedge testing of paragraph: Surface Smoothness in PART 1. Long-handled, flat bull floats shall be used very sparingly and only as necessary to correct minor, scattered surface defects. If frequent use of bull floats is necessary, the paving operation shall be stopped and the equipment, mixture or procedures adjusted to eliminate the surface defects. Finishing with hand floats and trowels shall be held to the absolute minimum necessary. Extreme care shall be taken to prevent overfinishing joints and edges. The surface finish of the pavement shall be produced essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations shall be subject to approval and shall be modified when directed.

3.6.3 Hand Finishing

Use hand finishing operations only as specified below.

3.6.3.1 Equipment and Template

In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping template and a longitudinal float for hand finishing. The template shall be at least 1 foot longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, and shall be constructed of metal or other suitable material shod with metal. The longitudinal float shall be at least 10 feet long, of approved design, and rigid and substantially braced, and shall maintain a plane surface on the bottom. Grate tampers (jitterbugs) shall not be used.

3.6.3.2 Finishing and Floating

As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at the required elevation. In addition to previously specified complete coverage with handheld immersion vibrators, the entire surface shall be tamped with the strike-off and tamping template, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, the pavement shall be floated longitudinally from bridges

resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed, consolidated and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces.

3.6.4 Texturing

Before the surface sheen has disappeared and before the concrete hardens or curing compound is applied, the surface of the pavement shall be given a texture as described herein. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris.

3.6.4.1 Burlap Drag Surface

Surface texture shall be applied by dragging the surface of the pavement, in the direction of the concrete placement, with an approved burlap drag. The drag shall be operated with the fabric moist, and the fabric shall be cleaned or changed as required to keep clean. The dragging shall be done so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.4.2 Broom Texturing

Brooming should be completed before the concrete has hardened to the point where the surface will be unduly torn or roughened, but after hardening has progressed enough so that the mortar will not flow and reduce the sharpness of the scores. Successive passes of the broom shall be overlapped the minimum necessary to obtain a uniformly textured surface. Brooms shall be washed thoroughly at frequent intervals during use. Worn or damaged brooms shall be removed from the job site. Hand brooming will be permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted. For hand brooming, the brooms shall have handles longer than half the width of slab to be finished. The hand brooms shall be drawn transversely across the surface from the center line to each edge with slight overlapping strokes.

3.6.5 Edging

After texturing has been completed, the edge of the slabs along the forms and at the joints shall be carefully finished with an edging tool to form a smooth rounded surface of 1/8 inch radius. Tool marks shall be eliminated, and the edges shall be smooth and true to line. No water shall be added to the surface during edging. Extreme care shall be taken to prevent overworking the concrete.

3.6.6 Outlets in Pavement

Recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement shall be constructed to conform to the details and dimensions shown. The concrete in these areas shall be carefully finished to provide a surface of the same texture as the surrounding area that will be within the requirements for plan grade and surface smoothness.

3.7 CURING

3.7.1 Protection of Concrete

Concrete shall be continuously protected against loss of moisture and rapid

temperature changes for at least 7 days from the completion of finishing operations. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. If any selected method of curing does not afford the proper curing and protection against concrete cracking, the damaged pavement shall be removed and replaced, and another method of curing shall be employed as directed. Curing shall be accomplished by one of the following methods.

3.7.2 Membrane Curing

A uniform coating of white-pigmented, membrane-forming, curing compound shall be applied to the entire exposed surface of the concrete as soon as the free water has disappeared from the surface after finishing. Along the formed edge faces, it shall be applied immediately after the forms are removed. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water, and the curing compound applied as soon as the free water disappears. The curing compound shall be applied to the finished surfaces by means of an approved automatic spraying machine. The curing compound shall be applied with a single overlapping application that will give a uniform coverage of 150 square feet per gallon. The application of curing compound by hand-operated, mechanical powered pressure sprayers will be permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, a second coat shall be applied in a direction approximately at right angles to the direction of the first coat. If pinholes, abrasions, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be immediately resprayed. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.8 JOINTS

3.8.1 General Requirements for Joints

Joints shall conform to the locations and details indicated and shall be perpendicular to the finished grade of the pavement. All joints shall be straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 1/2 inch. Where any joint fails to meet these tolerances, the slabs adjacent to the joint shall be removed and replaced at no additional cost to the Government. No change from the jointing pattern shown on the drawings shall be made without written approval of the Contracting Officer. Joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS.

3.8.2 Longitudinal Construction Joints

Dowels shall be installed in the longitudinal construction joints, or the

edges shall be thickened as indicated. Dowels shall be installed as specified above. After the end of the curing period, longitudinal construction joints shall be sawed to provide a groove at the top for sealant conforming to the details and dimensions indicated.

3.8.3 Transverse Construction Joints

Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for 30 minutes or longer. The transverse construction joint shall be installed at a planned transverse joint. Transverse construction joints shall be constructed by utilizing headers or by paving through the joint, then full-depth sawcutting the excess concrete. Pavement shall be constructed with the paver as close to the header as possible, and the paver shall be run out completely past the header. Transverse construction joints installed at a planned transverse joint shall be constructed as shown or, if not shown otherwise, shall be dowelled in accordance with paragraph: Dowels Installed in Hardened Concrete, or paragraph: Fixed Form Paving above.

3.8.4 Expansion Joints

Expansion joints shall be formed where indicated, and about any structures and features that project through or into the pavement, using joint filler of the type, thickness, and width indicated, and shall be installed to form a complete, uniform separation between the structure and the pavement. The filler shall be attached to the original concrete placement with adhesive or other fasteners and shall extend the full slab depth. Adjacent sections of filler shall be fitted tightly together, and the filler shall extend across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Edges of the concrete at the joint face shall be finished with an edger with a radius of 1/8 inch. The joint filler strips shall be installed 3/4 inch below the pavement surface with a slightly tapered, dressed-and-oiled wood strip or other approved material temporarily secured to the top of the filler to form a recess to be filled with joint sealant.

3.8.5 Contraction Joints

Construct transverse and longitudinal contraction joints by sawing an initial groove in the concrete with a 1/8 inch blade to the indicated depth. During sawing of joints, and again 24 hours later, the CQC team shall inspect all exposed lane edges for development of cracks below the saw cut, and shall immediately report results to the Contracting Officer. If the Contracting Officer determines that there are more uncracked joints than desired, the Contractor will be directed to saw succeeding joints 25 percent deeper than originally indicated at no additional cost to the Government. The time of initial sawing shall vary depending on existing and anticipated weather conditions and shall be such as to prevent uncontrolled cracking of the pavement. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The sawed faces of joints will be inspected for undercutting or washing of the concrete due to the early sawing, and sawing shall be delayed if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. The sawing operation shall be carried on as required during both day and night regardless of weather conditions. The joints shall be sawed at the required spacing consecutively in the sequence of the concrete placement. Adequate lighting shall be provided for night work. Illumination using

vehicle headlights will not be permitted. A chalk line or other suitable guide shall be used to mark the alignment of the joint. Before sawing a joint, the concrete shall be examined closely for cracks, and the joint shall not be sawed if a crack has occurred near the planned joint location. Sawing shall be discontinued when a crack develops ahead of the saw cut. Immediately after the joint is sawed, the saw cut and adjacent concrete surface shall be thoroughly flushed with water and vacuumed until all waste from sawing is removed from the joint and adjacent concrete surface. The surface shall be resprayed with curing compound as soon as free water disappears. Necessary precautions shall be taken to insure that the concrete is properly protected from damage and cured at sawed joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed with cord backer rod before the concrete in the region of the joint is resprayed with curing compound, and shall be maintained until removed immediately before sawing the joint sealant reservoir. The exposed saw cuts on the faces of pilot lanes shall be sealed with bituminous mastic or masking tape. After expiration of the curing period, the upper portion of the groove shall be widened by sawing with ganged diamond saw blades to the width and depth indicated for the joint sealer. The reservoir shall be centered over the initial sawcut.

3.8.6 Thickened Edge Joints

Construct thickened edge joints as indicated on the drawings. Underlying material in the transition area shall be graded as shown and shall meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.9 REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

New pavement slabs that are broken, have spalled edges, or contain cracks shall be removed and replaced or repaired, as specified at no cost to the Government. Removal of partial slabs is not permitted. Not more than 15.0 percent of each slab's longitudinal joint edge shall be spalled. Prior to fill-in lane placement, pilot lane slabs with spalls exceeding this quantity, regardless of spall size, shall be sawn full depth to remove the spalled face. All other slabs shall be removed, as directed. The Contracting Officer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be at least 6 inch diameter, and shall be drilled and backfilled with an approved non-shrink concrete. Perform drilling of cores and refilling holes at no expense to the Government.

3.9.2 Slabs with Cracks

Cracks that do not exceed 25 percent of the design thickness in depth shall be cleaned and then pressure injected full depth with epoxy resin, Type IV, Grade 1. Slabs containing cracks deeper than 25 percent of the design thickness shall be removed.

3.9.3 Removal and Replacement of Full Slabs

Where it is necessary to remove full slabs, removal shall be in accordance with paragraph: Removal of Existing Pavement Slab below. Removal and replacement shall be full depth, by full width of the slab, and the limit of removal shall be normal to the paving lane and extend to each original joint. Dowels of the size and spacing as specified for other joints in

similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified in paragraph: Placing Dowels and Tie Bars, above. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All four edges of the new slab shall thus contain dowels. Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material shall be recompacted and shaped as specified in the appropriate section of these specifications, and the surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

3.9.4 Repairing Spalls Along Joints

Where directed, spalls along joints of new slabs, along edges of adjacent existing concrete, and along parallel cracks shall be repaired by first making a vertical saw cut at least 1 inch outside the spalled area and to a depth of at least 2 inches. Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and into at least 1/2 inch of visually sound concrete. Spalls along joints to be sealed with compression seals shall be sawn, chipped out, and repaired to a depth to restore the full joint-face support. The cavity thus formed shall be thoroughly cleaned with high pressure water jets supplemented with oil-free compressed air to remove all loose material. Immediately before filling the cavity, a prime coat shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Prime coat for portland cement repairs shall be a neat cement grout and for epoxy resin repairs shall be epoxy resin, Type III, Grade 1. The prepared cavity shall be filled with: Portland cement concrete or latex modified mortar for larger cavities, those more than 1/3 cu. ft. in size after removal operations; Portland cement mortar for cavities between 0.03 cu. ft. and 1/3 cu. ft.; and epoxy resin mortar or epoxy resin or latex modified mortar for those cavities less than 0.03 cu. ft. in size. Portland cement concretes and mortars shall be very low slump mixtures, 1/2 inch slump or less, proportioned, mixed, placed, consolidated by tamping, and cured, all as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Contracting Officer. Proprietary patching materials may be used, subject to approval by the Contracting Officer. The epoxy resin materials shall be placed in the cavity in layers not over 2 inches thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140 degrees F at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints. The reservoir shall be thoroughly cleaned and then sealed with the sealer specified for the joints.

3.9.5 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Slabs containing weak surfaces less than 1/4 inch (6 mm) thick shall be diamond ground to remove the weak surface. Diamond grinding shall be in accordance with paragraph: Diamond Grinding of PCC Surfaces in PART 1. All ground areas shall meet the thickness, smoothness and grade criteria of paragraph: Acceptance Requirements in PART 1. Slabs containing weak surfaces greater than 1/4 inch thick shall be removed and replaced.

3.9.6 Repair of Pilot Lane Vertical Faces

Excessive edge slump and joint face deformation shall be repaired in accordance with paragraph: Edge Slump and Joint Face Deformation in PART 1. Inadequate consolidation (honeycombing or air voids) shall be repaired by saw cutting the face full depth along the entire lane length with a diamond blade. Obtain cores, as directed, to determine the depth of removal.

3.10 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

Existing concrete pavement shall be removed at locations indicated on the drawings. Prior to commencing pavement removal operations, inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain. After pavement removal, the remaining edge shall again be surveyed to quantify any damage caused by Contractor's removal operations. Perform both surveys in the presence of the Contracting Officer. Repairs shall be made as indicated and as specified herein. All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface, forming rectangular areas.

3.10.1 Removal of Existing Pavement Slab

When existing concrete pavement is to be removed and adjacent concrete is to be left in place, the joint between the removal area and adjoining pavement to stay in place shall first be cut full depth with a standard diamond-type concrete saw. Next, a full depth saw cut shall be made parallel to the joint at least 24 inches from the joint and at least 6 inches from the end of any dowels. This saw cut shall be made with a wheel saw as specified in paragraph: Sawing Equipment. All pavement to be removed beyond this last saw cut shall be removed in accordance with the approved demolition work plan. All pavement between this last saw cut and the joint line shall be removed by carefully pulling pieces and blocks away from the joint face with suitable equipment and then picking them up for removal. In lieu of this method, this strip of concrete may be carefully broken up and removed using hand-held jackhammers, 30 lb or less, or other approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. In lieu of the above specified removal method, the slab may be sawcut full depth to divide it into several pieces and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and safe lifting devices used for attachment to the slab.

3.10.2 Edge Repair

The edge of existing concrete pavement against which new pavement abuts

shall be protected from damage at all times. Slabs which are damaged during construction shall be removed and replaced as directed by the Contracting Officer at no cost to the Government. Repair of previously existing damage areas will be considered a subsidiary part of concrete pavement construction. All exposed keyways shall be sawn off full depth.

3.10.2.1 Spall Repair

All slabs with spalls shall be repaired as directed by the Contracting Officer.

3.10.2.2 Underbreak and Underlying Material

All underbreak shall be repaired by removal and replacement of the damaged slabs in accordance with paragraph: Removal and Replacement of Full Slabs above. The underlying material adjacent to the edge of and under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient underlying material shall be kept in place outside the joint line to completely prevent disturbance of material under the pavement which is to remain in place. Any material under the portion of the concrete pavement to remain in place which is disturbed or loses its compaction shall be carefully removed and replaced with concrete.

3.11 PAVEMENT PROTECTION

Protect the pavement against all damage prior to final acceptance of the work by the Government. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or for a longer period if so directed. As a construction expedient in paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected, the concrete has attained a minimum field cured flexural strength of 550 psi. and approved means are furnished to prevent damage to the slab edge. All new and existing pavement carrying construction traffic or equipment shall be continuously kept completely clean, and spillage of concrete or other materials shall be cleaned up immediately upon occurrence. Power broom existing pavements at least daily when traffic operates. For fill-in lanes, equipment shall be used that will not damage or spall the edges or joints of the previously constructed pavement.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

3.12.1 Testing and Inspection by Contractor

During construction, the Contractor is responsible for sampling and testing aggregates, cementitious materials (cement, GGBF and pozzolan), and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary for procurement of representative test samples. Furnish sampling platforms and belt templates to obtain representative samples of aggregates from charging belts at the concrete plant. Samples of concrete shall be obtained at the point of delivery to the paver. Testing by the Government will in no way relieve the Contractor of the specified testing requirements. Perform the inspection and tests described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. This testing

shall be performed regardless of any other testing performed by the Government, either for pay adjustment purposes or for any other reason.

3.12.2 Testing and Inspection Requirements

Contractor CQC sampling, testing, inspection and reporting shall be in accordance with the following Table.

TABLE 6
CONTRACTOR TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit/Corrective Action
	Fine Aggregate Gradation and Fineness Modulus	
2 per lot	ASTM C 136 sample at belt	9 of 10 tests vary <0.15 from average Outside limits on any sieve-retest 2nd failure-stop, repair, retest
	Coarse Aggregate Gradation	
2 per lot	ASTM C 136 sample at belt	Outside limits on any sieve-retest 2nd failure-report to COR, correct 2 consecutive avgs of 5 tests out- report to COR, stop ops, repair, retest
	Workability Factor and Coarseness Factor Computation	
Same as C.A. & F.A.	see paragraph: Aggregates	Use individual C.A. and F.A. gradations Combine using batch ticket percentages Tolerances: +/- 3 points on WF +/- 5 points on CF from approved mix design values Check batching tolerances, recalibrate scales
	Aggregate Deleterious, Quality, and ASR Tests	
Every 30 days	see paragraph: AGGREGATES	Stop production, retest, replace aggregate Increase testing interval to 90 days if previous 2 tests pass
	Plant - Scales, Weighing Accuracy	
Monthly	NRMCA QC 3	Stop plant ops, repair, recalibrate
	Plant - Batching and Recording Accuracy	
Weekly	Record/Report	Record required/recorded/actual batch mass Stop plant ops, repair, recalibrate
	Plant - Batch Plant Control	
Every lot	Record/Report	Record type/amt of each material per lot
	Plant - Mixer Uniformity - Stationary Mixers	
Every 4 months during paving	COE CRD-C 55	After initial approval, use abbreviated method. Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest
	Plant - Mixer Uniformity - Truck Mixers	
Every 4 months during paving	ASTM C 94/C 94M	Random selection of truck. Increase mixing time, change batching sequence, reduce batch size to bring into compliance. Retest.

Frequency	Test Method	Control Limit/Corrective Action
		Concrete Mixture - Air Content
When test specimens prepared + 2 random	ASTM C231/C231M sample at paving site	Individual test control chart: Warning +/-1.0 - adjust AEA, retest Action +/-1.5 - halt ops, repair, retest Range between 2 consecutive tests: Warning +2.0 - recalibrate AEA dispenser Action +3.0 - halt ops, repair, retest
		Concrete Mixture - Unit Weight and Yield
Same as Air content	ASTM C 138/C 138M sample at paving site	Individual test basis: Warning Yield -0/+1% - check batching tol. Action Yield -0/+5% - halt ops, recalibrate
		Concrete Mixture - Slump
When test specimens prepared + 4 random	ASTM C 143/C 143M sample at paving site	Individual test control chart: Upper Warning - 1/2 inch below max-adjust batch masses within max W/C ratio Upper Action - maximum allowable slump stop operations, adjust, retest Range between each consecutive test: 1-1/2 inches stop operations, repair, retest
		Concrete Mixture - Temperature
When test specimens prepared	ASTM C 1064/C 1064M sample at paving site	See paragraph: WEATHER LIMITATIONS
		Concrete Mixture - Strength
8 per lot	ASTM C 31/C 31M sample at paving site	See Paragraph: Concrete Strength Testing for CQC
		Paving - Inspection Before Paving
Prior to each paving operation	Report	Inspect underlying materials, construction joint faces, forms, reinforcing, dowels, and embedded items
		Paving - Inspection During Paving
During each paving operation		Monitor and control paving operation, including placement, consolidation, finishing, texturing, curing, and joint sawing.
		Paving - Vibrators
Weekly, during paving	COE CRD-C 521	Test frequency (in concrete), and amplitude (in air), measure at tip/head and average. Repair or replace defective vibrators.
		Moist Curing
2 per lot, min 4 per day	Visual	Repair defects, extend curing by 1 day
		Membrane Compound Curing
Daily	Visual	Calculate coverage based on quantity/area Respray areas where coverage defective

Frequency	Test Method	Control Limit/Corrective Action
		Recalibrate equipment
		Cold Weather Protection
Once per	Visual	Repair defects, report conditions to COR

3.12.3 Concrete Strength Testing for Contractor CQC

3.12.4 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, make daily reports of pertinent temperatures. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all Contractor quality control records.

-- End of Section --

SECTION 33 11 00

WATER DISTRIBUTION
02/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2008; Errata 2010) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2011) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C153/A21.53	(2011) Ductile-Iron Compact Fittings for Water Service
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C500	(2009) Metal-Seated Gate Valves for Water Supply Service
AWWA C502	(2005) Dry-Barrel Fire Hydrants
AWWA C508	(2009; Addenda A 2011) Swing-Check Valves for Waterworks Service, 2 In. (50 mm) Through 24 In. (600 mm) NPS
AWWA C509	(2009) Resilient-Seated Gate Valves for Water Supply Service
AWWA C600	(2010) Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C651	(2005; Errata 2005) Standard for Disinfecting Water Mains
AWWA C900	(2007; Errata 2008) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated

	Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Distribution
AWWA C901	(2008) Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13mm) Through 3 In. (76 mm), for Water Service

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B18.2.2	(2010) Standard for Square and Hex Nuts
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts

ASTM INTERNATIONAL (ASTM)

ASTM A307	(2010) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A536	(1984; R 2009) Standard Specification for Ductile Iron Castings
ASTM A563	(2007a) Standard Specification for Carbon and Alloy Steel Nuts
ASTM D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM F402	(2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 704	(2012) Standard System for the Identification of the Hazards of Materials for Emergency Response

UNDERWRITERS LABORATORIES (UL)

UL 246	(2011; Reprint Aug 2011) Hydrants for Fire-Protection Service
UL 262	(2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service
UL 312	(2010) Check Valves for Fire-Protection Service

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-3	(1992) Recommended Practice for the Installation of Polyvinyl Chloride (PVC) Pressure Pipe (Nominal Diameters 4-36 Inches)

1.2 DESIGN REQUIREMENTS

1.2.1 Water Service Lines

Provide water service lines indicated as 6 inch lines from existing water the points indicated. Water service lines shall be polyvinyl chloride (PVC) plastic pipe or ductile-iron or steel pipe. Provide water service line appurtenances as specified and where indicated. Submit design calculations of water piping.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Piping Materials

Water distribution main piping, fittings, joints, valves, and coupling

Water service line piping, fittings, joints, valves, and coupling

Hydrants

Valve boxes

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.

SD-05 Design Data

Design calculations of water piping

SD-06 Test Reports

Bacteriological Disinfection.

Test results from commercial laboratory verifying disinfection

SD-07 Certificates

Water distribution main piping, fittings, joints, valves, and coupling

Water service line piping, fittings, joints, valves, and coupling

Lining

Fire hydrants

Certificates shall attest that tests set forth in each applicable referenced publication have been performed, whether specified in that publication to be mandatory or otherwise and that production control tests have been performed at the intervals or frequency specified in the publication. Other tests shall have been performed within 3 years of the date of submittal of certificates on the same type, class, grade, and size of material as is being provided for the project.

SD-08 Manufacturer's Instructions

Delivery, storage, and handling

Installation procedures for water piping

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, valves and hydrants free of dirt and debris.

1.4.2 Handling

Handle pipe, fittings, valves, hydrants, and other accessories in a manner to ensure delivery to the trench in sound undamaged condition. Take special care to avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place any other material or pipe inside a pipe or fitting after the coating has been applied. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. The interior of pipe and accessories shall be thoroughly cleaned of foreign matter before being lowered into the trench and shall be kept clean during laying operations by plugging or other approved method. Before installation, the pipe shall be inspected for defects. Material found to be defective before or after laying shall be replaced with sound material without additional expense to the Government. Store rubber gaskets that are not to be installed immediately, under cover out of direct sunlight.

1.4.2.1 Coated and Wrapped Steel Pipe

Handle steel pipe with coal-tar epoxy coating in accordance with the provisions of AWWA C203.

1.4.2.2 Polyethylene (PE) Pipe, Fittings, and Accessories

Handle PE pipe, fittings, and accessories in accordance with AWWA C901.

1.4.2.3 Miscellaneous Plastic Pipe and Fittings

Handle Polyvinyl Chloride (PVC) pipe and fittings in accordance with the manufacturer's recommendations. Store plastic piping and jointing materials that are not to be installed immediately under cover out of direct sunlight.

Storage facilities shall be classified and marked in accordance with NFPA 704 with classification as indicated in NFPA 704.

PART 2 PRODUCTS

2.1 WATER DISTRIBUTION MAIN MATERIALS

2.1.1 Piping Materials

2.1.1.1 Ductile-Iron Piping

a. Pipe and Fittings: Pipe, except flanged pipe, AWWA C151/A21.51, Pressure Class 350. Flanged pipe, AWWA C115/A21.15. Fittings, AWWA C110/A21.10 or AWWA C153/A21.53; fittings with push-on joint ends conforming to the same requirements as fittings with mechanical-joint ends, except that the bell design shall be modified, as approved, for push-on joint. Fittings shall have pressure rating at least equivalent to that of the pipe. Ends of pipe and fittings shall be suitable for the specified joints. Pipe and fittings shall have cement-mortar lining, AWWA C104/A21.4, twice the standard thickness.

b. Joints and Jointing Material:

(1) Joints: Joints for pipe and fittings shall be push-on joints or mechanical joints unless otherwise indicated. Provide mechanical joints where indicated. Joints made with sleeve-type mechanical coupling may be used in lieu of push-on joint, subject to the limitations specified in paragraph entitled "Sleeve-Type Mechanical Couplings."

(2) Push-On Joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly, AWWA C111/A21.11.

(3) Mechanical Joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets, AWWA C111/A21.11.

(4) Flanged Joints: Bolts, nuts, and gaskets for flanged connections as recommended in the Appendix to AWWA C115/A21.15. Flange for setscrewed flanges shall be of ductile iron, ASTM A536, Grade 65-45-12, and conform to the applicable requirements of ASME B16.1, Class 250. Setscrews for setscrewed flanges shall be 190,000 psi tensile strength, heat treated and zinc-coated steel. Gasket and lubricants for setscrewed flanges, in accordance with applicable

requirements for mechanical-joint gaskets specified in AWWA C111/A21.11. Design of setscrewed gasket shall provide for confinement and compression of gasket when joint to adjoining flange is made.

(5) Insulating Joints: Designed to effectively prevent metal-to-metal contact at the joint between adjacent sections of piping. Joint shall be of the flanged type with insulating gasket, insulating bolt sleeves, and insulating washers. Gasket shall be of the dielectric type, full face, and in other respects as recommended in the Appendix to AWWA C115/A21.15. Bolts and nuts, as recommended in the Appendix to AWWA C115/A21.15.

(6) Sleeve-Type Mechanical Coupled Joints: As specified in paragraph entitled "Sleeve-Type Mechanical Couplings."

2.1.1.2 Polyvinyl Chloride (PVC) Plastic Piping

a. Pipe and Fittings: Pipe, AWWA C900, shall be plain end or gasket bell end, Pressure Class 150 (DR 18) with cast-iron-pipe-equivalent OD.

b. Fittings for PVC pipe: Fittings shall be gray iron or ductile iron, AWWA C110/A21.10 or AWWA C153/A21.53, and have cement-mortar lining, AWWA C104/A21.4, standard thickness. Fittings with push-on joint ends shall conform to the same requirements as fittings with mechanical-joint ends, except that bell design shall be modified, as approved, for push-on joint suitable for use with PVC plastic pipe specified in this paragraph. Iron fittings and specials shall be cement-mortar lined in accordance with AWWA C104/A21.4.

c. Joints and Jointing Material: Joints for pipe shall be push-on joints, ASTM D3139. Joints between pipe and metal fittings, valves, and other accessories shall be push-on joints ASTM D3139, or compression-type joints/mechanical joints, ASTM D3139 and AWWA C111/A21.11. Provide each joint connection with an elastomeric gasket suitable for the bell or coupling with which it is to be used. Gaskets for push-on joints for pipe, ASTM F477. Gaskets for push-on joints and compression-type joints/mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories, AWWA C111/A21.11, respectively, for push-on joints and mechanical joints. Mechanically coupled joints using a sleeve-type mechanical coupling, as specified in paragraph entitled "Sleeve-Type Mechanical Couplings," may be used as an optional jointing method in lieu of push-on joints on plain-end PVC plastic pipe, subject to the limitations specified for mechanically coupled joints using a sleeve-type mechanical coupling and to the use of internal stiffeners as specified for compression-type joints in ASTM D3139.

2.1.2 Valves, Hydrants, and Other Water Main Accessories

2.1.2.1 Gate Valves on Buried Piping

AWWA C500, AWWA C509, or UL 262. Unless otherwise specified, valves conforming to: (1) AWWA C500 shall be nonrising stem type with double-disc gates and mechanical-joint ends or push-on joint ends as appropriate for the adjoining pipe, (2) AWWA C509 shall be nonrising stem type with mechanical-joint ends or resilient-seated gate valves 3 to 12 inches in size, and (3) UL 262 shall be inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working

pressure of 250 psi, and shall have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined. Materials for UL 262 valves shall conform to the reference standards specified in AWWA C500. Valves shall open by counterclockwise rotation of the valve stem. Stuffing boxes shall have 0-ring stem seals. Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair. In lieu of mechanical-joint ends and push-on joint ends, valves may have special ends for connection to sleeve-type mechanical coupling. Valve ends and gaskets for connection to sleeve-type mechanical coupling shall conform to the applicable requirements specified for the joint or coupling. Valves shall be of one manufacturer.

2.1.2.2 Gate Valves in Valve Pit(s) and Aboveground Location

AWWA C500, AWWA C509, or UL 262. Unless otherwise specified, valves conforming to: (1) AWWA C500 shall be nonrising stem type with solid-wedge gates and flanged ends, (2) AWWA C509 shall be nonrising stem type with flanged ends, and (3) UL 262 shall be inside-screw type, shall have solid or one-piece type gate and flanged ends, and shall be designed for a hydraulic working pressure of 250 psi. Materials for UL 262 valves shall conform to the reference standards specified in AWWA C500. Valves 2-1/2 inch size shall be nonrising stem type or inside-screw type. Valves 2-1/2 inch size shall shall have solid-wedge gates or solid or one-piece type gates. Provide valves with handwheels that open by counterclockwise rotation of the valve stem. Stuffing boxes shall be bolted and constructed so as to permit easy removal of parts for repair. Valves shall be of one manufacturer.

2.1.2.3 Check Valves

Swing-check type, AWWA C508 or UL 312. Valves conforming to: (1) AWWA C508 shall have stainless steel body and cover and flanged ends, and (2) UL 312 shall have stainless steel body and cover, flanged ends, and designed for a working pressure of 150 psi. Materials for UL 312 valves shall conform to the reference standards specified in AWWA C508. Valves shall have clear port opening. Valves shall be spring-loaded.

2.1.2.4 Fire Hydrants

Dry-barrel type. Paint hydrants with at least one coat of primer and two coats of yellow enamel paint, except use red enamel paint for tops of hydrants in non-potable water systems. Stencil hydrant number and main size on the hydrant barrel using black stencil paint.

a. Dry-Barrel Type Fire Hydrants: Dry-barrel type hydrants, AWWA C502 or UL 246, "Base Valve" design, shall have 6 inch inlet, 5 1/4 inch valve opening, one 4 1/2 inch pumper connection, and two 2 1/2 inch hose connections. Inlet shall have mechanical-joint end only; end shall conform to the applicable requirements as specified for the joint. Size and shape of operating nut, cap nuts, and threads on hose and pumper connections shall be as specified in AWWA C502.

2.1.2.5 Valve Boxes

Provide a valve box for each gate valve on buried piping. Valve boxes shall be of cast iron of a size suitable for the valve on which it is to be used and shall be adjustable. Cast-iron boxes shall have a minimum cover and wall thickness of 3/16 inch. Provide a round head. Cast the word "WATER" on the lid. The least diameter of the shaft of the box shall be

5-1/4 inches. Cast-iron box shall have a heavy coat of bituminous paint.

2.1.2.6 Valve Pits

Valve pits shall be constructed at locations indicated or as required above and in accordance with the details shown.

2.1.2.7 Sleeve-Type Mechanical Couplings

Couplings shall be designed to couple plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. The coupling shall consist of one middle ring flared or beveled at each end to provide a gasket seat; two follower rings; two resilient tapered rubber gaskets; and bolts and nuts to draw the follower rings toward each other to compress the gaskets. The middle ring and the follower rings shall be true circular sections free from irregularities, flat spots, and surface defects; the design shall provide for confinement and compression of the gaskets. For stainless steel pipe, the middle ring shall be of stainless steel. Gaskets shall be designed for resistance to set after installation and shall meet the applicable requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Bolts shall be track-head type, ASTM A307, Grade A, with nuts, ASTM A563, Grade A; or round-head square-neck type bolts, ASME B18.5.2.1M and ASME B18.5.2.2M with hex nuts, ASME B18.2.2. Bolts shall be 5/8 inch in diameter. Bolt holes in follower rings shall be of a shape to hold fast the necks of the bolts used. Mechanically coupled joints using a sleeve-type mechanical coupling shall not be used as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint. Mechanical couplings shall provide a tight flexible joint under all reasonable conditions, such as pipe movements caused by expansion, contraction, slight setting or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Couplings shall be of strength not less than the adjoining pipeline.

2.1.2.8 Tracer Wire for Nonmetallic Piping

Provide bare copper or aluminum wire not less than 0.10 inch in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.

2.2 WATER SERVICE LINE MATERIALS

2.2.1 Piping Materials

2.2.1.1 Plastic Piping

Comply with "Ductile-Iron Piping" subparagraph under paragraph "Water Distribution Main Materials".

2.2.1.2 Stainless Steel Piping

Comply with utility notes in the drawings.

2.2.1.3 Ductile-Iron Piping

Comply with "Ductile-Iron Piping" subparagraph under paragraph "Water Distribution Main Materials."

2.2.1.4 Insulating Joints

Joints between pipe of dissimilar metals shall have a rubber-gasketed or other suitable approved type of insulating joint or dielectric coupling which will effectively prevent metal-to-metal contact between adjacent sections of piping.

2.2.2 Water Service Line Appurtenances

2.2.2.1 Check Valves

Check valves shall be designed for a minimum working pressure of 150 psi or as indicated. Valves shall have a clear waterway equal to the full nominal diameter of the valve. Valves shall open to permit flow when inlet pressure is greater than the discharge pressure, and shall close tightly to prevent return flow when discharge pressure exceeds inlet pressure. The size of the valve, working pressure, manufacturer's name, initials, or trademark shall be cast on the body of each valve. Valves 2 inches and larger shall be outside lever and spring type.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPELINES

3.1.1 General Requirements for Installation of Pipelines

These requirements shall apply to all pipeline installation except where specific exception is made in the "Special Requirements..." paragraphs.

3.1.1.1 Location of Water Lines

Do not lay water lines in the same trench with fuel lines.

a. Water Piping Installation Parallel With Sewer Piping

Normal Conditions: Lay water piping at least 10 feet horizontally from a sewer or sewer manhole whenever possible. Measure the distance edge-to-edge.

Unusual Conditions: When local conditions prevent a horizontal seperation of 10 feet, the water piping may laid closer to a sewer or sewer manhole provided that:

(1) The bottom (invert) of the water piping shall be at least 18 inches above the top (crown) of the sewer piping.

(2) Where this vertical separation cannot be obtained, the sewer piping shall be constructed of AWWA-approved water pipe and pressure tested in place without leakage prior to backfilling. Approved waste water disposal method shall be utilized.

(3) The sewer manhole shall be of watertight construction and tested in place.

b. Installation of Water Piping Crossing Sewer Piping

(1) Normal Conditions: Water piping crossing above sewer piping shall be laid to provide a separation of at least 18 inches between the bottom of the water piping and the top of the sewer

piping.

(2) Unusual Conditions: When local conditions prevent a vertical separation described above, use the following construction:

(a) Sewer piping passing over or under water piping shall be constructed of AWWA-approved ductile iron water piping, pressure tested in place without leakage prior to backfilling.

(b) Water piping passing under sewer piping shall, in addition, be protected by providing a vertical separation of at least 18 inches between the bottom of the sewer piping and the top of the water piping; adequate structural support for the sewer piping to prevent excessive deflection of the joints and the settling on and breaking of the water piping; and that the length, minimum 20 feet, of the water piping be centered at the point of the crossing so that joints shall be equidistant and as far as possible from the sewer piping.

c. Sewer Piping or Sewer Manholes: No water piping shall pass through or come in contact with any part of a sewer manhole.

3.1.1.2 Pipe Laying and Jointing

Remove fins and burrs from pipe and fittings. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition. Provide proper facilities for lowering sections of pipe into trenches. Do not under any circumstances drop or dump pipe, fittings, valves, or any other water line material into trenches. Cut pipe in a neat workmanlike manner accurately to length established at the site and work into place without springing or forcing. Replace by one of the proper length any pipe or fitting that does not allow sufficient space for proper installation of jointing material. Blocking or wedging between bells and spigots will not be permitted. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at proper elevation and grade. Secure firm, uniform support. Wood support blocking will not be permitted. Lay pipe so that the full length of each section of pipe and each fitting will rest solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports where necessary for fastening work into place. Make proper provision for expansion and contraction of pipelines. Keep trenches free of water until joints have been properly made. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Do not lay pipe when conditions of trench or weather prevent installation. Depth of cover over top of pipe shall not be less than 3 feet.

3.1.1.3 Installation of Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.1.1.4 Penetrations

Pipe passing through walls of valve pits and structures shall be provided with ductile-iron or Schedule 40 steel wall sleeves. Annular space between walls and sleeves shall be filled with rich cement mortar. Annular space between pipe and sleeves shall be filled with mastic.

3.1.1.5 Flanged Pipe

Flanged pipe shall only be installed above ground or with the flanges in valve pits.

3.1.2 Special Requirements for Installation of Water Service Piping

3.1.2.1 Installation of Metallic Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" and with the applicable requirements of AWWA C600 for pipe installation, unless otherwise specified.

a. Jointing:

(1) Flanged Joints: Make flanged joints up tight, taking care to avoid undue strain on flanges, valves, fittings, and accessories.

3.1.2.2 Installation of Plastic Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" and with the applicable requirements of ASTM D2774 and ASTM D2855, unless otherwise specified. Handle solvent cements used to join plastic piping in accordance with ASTM F402.

a. Jointing: Make plastic pipe joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.1.2.3 Location of Meters

Vaults shall be installed at the locations shown on the drawings. The meters shall be centered in the vaults to allow for reading and ease of removal or maintenance.

3.1.3 Disinfection

Prior to disinfection, obtain Contracting Officer approval of the proposed method for disposal of waste water from disinfection procedures. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Fill piping systems with solution containing minimum of 50 parts per million of available chlorine and allow solution to stand for minimum of 24 hours. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 and 0.5 parts per million, or the residual chlorine content of domestic water supply. Obtain at least two consecutive satisfactory bacteriological samples from new water piping, analyze by a certified laboratory, and submit the test results prior to the new water piping being placed into service. Disinfection of systems supplying nonpotable water is not required.

3.2 FIELD QUALITY CONTROL

3.2.1 Field Tests and Inspections

Prior to hydrostatic testing, obtain Contracting Officer approval of the proposed method for disposal of waste water from hydrostatic testing. The Contracting Officer will conduct field inspections and witness field tests

specified in this section. The Contractor shall perform field tests, and provide labor, equipment, and incidentals required for testing, except that water and electric power needed for field tests will be furnished by the Contracting Officer. The Contractor shall produce evidence, when required, that any item of work has been constructed in accordance with the drawings and specifications. Do not begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least 5 days after placing of the concrete.

3.2.2 Testing Procedure

Test water mains and water service lines in accordance with the applicable specified standard, except for the special testing requirements given in paragraph entitled "Special Testing Requirements." Test ductile-iron water mains and water service lines in accordance with the requirements of AWWA C600 for hydrostatic testing. The amount of leakage on ductile-iron pipelines with mechanical-joints or push-on joints shall not exceed the amounts given in AWWA C600; no leakage will be allowed at joints made by any other method. Test PVC plastic water mains and water service lines made with PVC plastic water main pipe in accordance with the requirements of UBPPA UNI-B-3 for pressure and leakage tests. The amount of leakage on pipelines made of PVC plastic water main pipe shall not exceed the amounts given in UBPPA UNI-B-3, except that at joints made with sleeve-type mechanical couplings, no leakage will be allowed. Test steel water mains in accordance with applicable requirements of AWWA C600 for hydrostatic testing. The amount of leakage on steel pipelines with rubber-gasketed bell-and-spigot joints shall not exceed 20 gallons per 24 hours per inch of pipe diameter per mile of pipeline; no leakage will be allowed at joints made by any other method. Repair of welded joints to stop leakage shall be done by welding only. Test water service lines in accordance with applicable requirements of AWWA C600 for hydrostatic testing. No leakage will be allowed at plastic pipe joints or flanged joints.

3.2.3 Special Testing Requirements

For pressure test, use a hydrostatic pressure 50 psi greater than the maximum working pressure of the system, except that for those portions of the system having pipe size larger than 2 inches in diameter, hydrostatic test pressure shall be not less than 200 psi. Hold this pressure for not less than 2 hours. Prior to the pressure test, fill that portion of the pipeline being tested with water for a soaking period of not less than 24 hours. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

3.3 CLEANUP

Upon completion of the installation of water lines, and appurtenances, all debris and surplus materials resulting from the work shall be removed.

-- End of Section --

SECTION 33 40 00

STORM DRAINAGE UTILITIES
02/10

PART 1 GENERAL

1.1 MEASUREMENT AND PAYMENT

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A929/A929M	(2001; R 2013) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe
ASTM C1433	(2015) Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers
ASTM C231/C231M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C425	(2004; R 2013) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2011) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	(2015a) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C76	(2015) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and

	Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D3350	(2012) Polyethylene Plastics Pipe and Fittings Materials
ASTM D6938	(2015) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Placing Pipe

Submit printed copies of the manufacturer's recommendations for installation procedures of the material being placed, prior to installation.

SD-07 Certificates

Resin Certification

Pipeline Testing

Determination of Density

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.4.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C76, Class V.

2.1.2 Polyethylene (PE) Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PE used to manufacture the pipe, prior to installation of the pipe. The minimum cell classification for polyethylene plastic shall apply to each of the seven primary properties of the cell classification limits in accordance with ASTM D3350.

2.1.2.1 Smooth Wall PE Pipe

ASTM F714, maximum DR of 21 for pipes 3 to 24 inches in diameter and maximum DR of 26 for pipes 26 to 48 inches in diameter. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.

2.2 DRAINAGE STRUCTURES

2.2.1 Flared End Sections

Sections shall be of a standard design fabricated from zinc coated steel sheets meeting requirements of ASTM A929/A929M.

2.2.2 Precast Reinforced Concrete Box

Manufactured in accordance with and conforming to ASTM C1433.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements of Section 03 31 29 MARINE CONCRETE. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Air content shall be determined in accordance with ASTM C231/C231M. The concrete covering over steel reinforcing shall not be less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 3 inches between steel and ground. Expansion-joint filler material shall conform to ASTM D1751, or ASTM D1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.3.2 Precast Reinforced Concrete Manholes

Conform to ASTM C478. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure.

2.3.3 Frame and Cover for Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.OT6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.3.4 Joints

2.3.4.1 Flexible Watertight Joints

a. Materials: Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for preformed flexible joint sealants shall conform to ASTM C990, and rubber-type gaskets shall conform to ASTM C443. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 54 inches.

b. Test Requirements: Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443. Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

2.4 HYDROSTATIC TEST ON WATERTIGHT JOINTS

2.4.1 Concrete, Clay, PVC, PE, SRPE and PP Pipe

A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to ASTM C990 or ASTM C443. Test requirements for joints in clay pipe shall conform to ASTM C425. Test requirements for joints in PVC, PE, and PP plastic pipe shall conform to ASTM D3212.

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section 31 00 00 EARTHWORK and the requirements specified below.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 12 inches to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe Requirements

When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in granular material minimum 4 inch in depth in trenches with soil foundation. Depth of granular bedding in trenches with rock foundation shall be 1/2 inch in depth per foot of depth of fill, minimum depth of bedding shall be 8 inch up to maximum depth of 24 inches. The middle third of the granular bedding shall be loosely placed. Bell holes and depressions for joints shall be removed and formed so entire barrel of pipe is uniformly supported. The bell hole and depressions for the joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

3.3 PLACING PIPE

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe, excluding SRPE pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall

be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Precast Concrete Pipe	1.5
Plastic (PVC, HDPE, SRPE, and PP)	5

3.3.1 Concrete Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 PE Pipe

Laying shall be with the separate sections joined firmly on a bed shaped to line and grade and shall follow manufacturer's guidelines.

3.4 JOINTING

3.4.1 Concrete Pipe

3.4.1.1 Cement-Mortar Bell-and-Spigot Joint

The first pipe shall be bedded to the established grade line, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the lower portion of the bell filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.

3.4.1.2 Cement-Mortar Oakum Joint for Bell-and-Spigot Pipe

A closely twisted gasket shall be made of jute or oakum of the diameter required to support the spigot end of the pipe at the proper grade and to make the joint concentric. Joint packing shall be in one piece of sufficient length to pass around the pipe and lap at top. This gasket shall be thoroughly saturated with neat cement grout. The bell of the pipe shall be thoroughly cleaned with a wet brush, and the gasket shall be laid in the bell for the lower third of the circumference and covered with mortar. The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted in the bell, and carefully driven home. A small amount of mortar shall be inserted in the annular space for the upper two-thirds of the circumference. The gasket shall be lapped at the top of the pipe and driven home in the annular space with a caulking tool. The remainder of the annular space shall be filled completely with mortar and beveled at an angle of approximately 45 degrees with the outside of the bell. If mortar

is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint thus made shall be wrapped with cheesecloth. Placing of this type of joint shall be kept at least five joints behind laying operations.

3.4.1.3 Cement-Mortar Diaper Joint for Bell-and-Spigot Pipe

The pipe shall be centered so that the annular space is uniform. The annular space shall be caulked with jute or oakum. Before caulking, the inside of the bell and the outside of the spigot shall be cleaned.

a. Diaper Bands: Diaper bands shall consist of heavy cloth fabric to hold grout in place at joints and shall be cut in lengths that extend one-eighth of the circumference of pipe above the spring line on one side of the pipe and up to the spring line on the other side of the pipe. Longitudinal edges of fabric bands shall be rolled and stitched around two pieces of wire. Width of fabric bands shall be such that after fabric has been securely stitched around both edges on wires, the wires will be uniformly spaced not less than 8 inches apart. Wires shall be cut into lengths to pass around pipe with sufficient extra length for the ends to be twisted at top of pipe to hold the band securely in place; bands shall be accurately centered around lower portion of joint.

b. Grout: Grout shall be poured between band and pipe from the high side of band only, until grout rises to the top of band at the spring line of pipe, or as nearly so as possible, on the opposite side of pipe, to ensure a thorough sealing of joint around the portion of pipe covered by the band. Silt, slush, water, or polluted mortar grout forced up on the lower side shall be forced out by pouring, and removed.

c. Remainder of Joint: The remaining unfilled upper portion of the joint shall be filled with mortar and a bead formed around the outside of this upper portion of the joint with a sufficient amount of additional mortar. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind actual laying of pipe. No backfilling around joints shall be done until joints have been fully inspected and approved.

3.4.1.4 Cement-Mortar Tongue-and-Groove Joint

The first pipe shall be bedded carefully to the established grade line with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be thoroughly cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.

3.4.1.5 Cement-Mortar Diaper Joint for Tongue-and-Groove Pipe

The joint shall be of the type described for cement-mortar tongue-and-groove joint in this paragraph, except that the shallow excavation directly beneath the joint shall not be filled with mortar until after a gauze or cheesecloth band dipped in cement mortar has been wrapped

around the outside of the joint. The cement-mortar bead at the joint shall be at least 1/2 inch, thick and the width of the diaper band shall be at least 8 inches. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind the actual laying of the pipe. Backfilling around the joints shall not be done until the joints have been fully inspected and approved.

3.4.1.6 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe

Sealing compounds shall follow the recommendation of the particular manufacturer in regard to special installation requirements. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Sealing compounds shall be inspected before installation of the pipe, and any loose or improperly affixed sealing compound shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. If, while making the joint with mastic-type sealant, a slight protrusion of the material is not visible along the entire inner and outer circumference of the joint when the joint is pulled up, the pipe shall be removed and the joint remade. After the joint is made, all inner protrusions shall be cut off flush with the inner surface of the pipe. If non-mastic-type sealant material is used, the "Squeeze-Out" requirement above will be waived.

3.4.1.7 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

3.5.2 Walls and Headwalls

Construction shall be as indicated.

3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet vertically, and shall be installed to provide at least 6 inches of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of RCP or has reached an elevation of at least 12 inches above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 8 inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.2 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.3 Compaction

3.7.3.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.3.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

a. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the

density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7.4 Determination of Density

Testing is the responsibility of the Contractor and performed at no additional cost to the Government. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.8 PIPELINE TESTING

3.8.1 Post-Installation Inspection

Check each reinforced concrete pipe installation for joint separations, soil migration through the joint, cracks greater than 0.01 inches, settlement and alignment. Check each flexible pipe (HDPE, PVC, CMP, PP) for rips, tears, joint separations, soil migration through the joint, cracks, localized bucking, bulges, settlement and alignment.

a. Replace pipes having cracks greater than 0.1 inches in width or deflection greater than 5 percent deflection. An engineer shall evaluate all pipes with cracks greater than 0.01 inches but less than 0.10 inches to determine if any remediation or repair is required. RCP with crack width less than 0.10 inches and located in a non-corrosive environment (pH 5.5) are generally acceptable. Repair or replace any pipe with crack exhibiting displacement across the crack, exhibiting bulges, creases, tears, spalls, or delamination.

b. Reports: The deflection results and final post installation inspection report shall include: a copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe systems, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage

dents, bulges, creases, tears, holes, etc.).

-- End of Section --

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UNDERGROUND ELECTRICAL DISTRIBUTION
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI SP-66	(2004) ACI Detailing Manual

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2001; R 2007) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2001; R 2007) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM C478	(2012a) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C857	(2012a) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM F512	(2012) Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE 400.2	(2004) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)

IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2012; Errata 2012; INT 1 2012; INT 2 2012; INT 3 2012) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-94-649	(2004) Standard for Concentric Neutral Cables Rated 5 Through 46 KV

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI/NEMA WC 71/ICEA S-96-659	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA RN 1	(2005) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2003) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2004) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2003) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658

NEMA WC 74/ICEA S-93-639	(2006) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; Errata 2 2012) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Reprint Oct 2012) Medium-Voltage Power Cables
UL 1242	(2006; Reprint Jul 2012) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 44	(2010) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2003; Reprint Feb 2010) Wire Connectors
UL 510	(2005; Reprint Apr 2008) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2004; Reprint Apr 2010) Metallic Outlet Boxes
UL 514B	(2012) Conduit, Tubing and Cable Fittings
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint Mar 2012) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 83	(2008) Thermoplastic-Insulated Wires and Cables
UL 854	(2004; Reprint Sep 2011) Standard for Service-Entrance Cables

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics

terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Precast underground structures;G, DOR

SD-03 Product Data

Medium voltage cable;G, DOR

Medium voltage cable terminations;G, DOR

Live end caps;G, DOR

Precast concrete structures; G

Sealing Material

Pulling-In Irons

Manhole frames and covers; G

Handhole frames and covers; G

Composite/fiberglass handholes; G

Cable supports (racks, arms and insulators); G

SD-06 Test Reports

Arc-proofing test for cable fireproofing materials; G

Medium voltage cable qualification and production tests;G, DOR

Field Acceptance Checks and Tests; G

Arc-proofing test for cable fireproofing tape; G

Cable Installation Plan and Procedure

Six copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for

each cable pull. Sections shall be separated by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator;G, DOR

Cable Installer Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings in accordance with ACI SP-66

e. Plans and elevations showing opening and pulling-in iron locations and details

1.4.2 Certificate of Competency for Cable Splicer/Terminator

The cable splicer/terminator must have a certification from the National Cable Splicing Certification Board (NCSCB) in the field of splicing and terminating shielded medium voltage (5 kV to 35 kV) power cable using pre-manufactured kits (pre-molded, heat-shrink, cold shrink). Submit "Proof of Certification" for approval, for the individuals that will be performing cable splicer and termination work, 30 days before splices or terminations are to be made.

1.4.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers.

1.4.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 400 volts per mil at 60 Hz, and tensile strength shall be minimum 3500 psi.

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.2.1 Intermediate Metal Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A

durometer, dielectric strength shall be minimum 400 volts per mil at 60 Hz, and tensile strength shall be minimum 3500 psi.

2.1.3 Plastic Conduit for Direct Burial

UL 651,Schedule 40 as indicated, NEMA TC 2, EPC-40-PVC as indicated.

2.1.4 Plastic Duct for Concrete Encasement

NEMA TC 6 & 8 and ASTM F512, UL 651, EPC-40-PVC as indicated.

2.1.5 Innerduct

Provide corrugated polyethylene (PE) or PVC innerducts with pullwire. Size as indicated.

2.1.6 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 35 degrees F, shall neither slump at a temperature of 300 degrees F, nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials. Inflatable bladders may be used as an option.

2.1.7 Fittings

2.1.7.1 Metal Fittings

UL 514B.

2.1.7.2 PVC Conduit Fittings

UL 514B, UL 651, NEMA TC 3.

2.1.7.3 PVC Duct Fittings

NEMA TC 9.

2.1.7.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit shall be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and shall conform to UL 514A.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors shall be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements, or in accordance with NEMA WC 70. Wires and cables manufactured more than 12 months prior to date of delivery to the site shall not be accepted. Service entrance conductors shall conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller shall be solid copper. Conductors No. 8 AWG and larger shall be stranded copper. All conductors shall be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, shall be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44. Copper conductors shall be annealed copper complying with ASTM B3 and ASTM B8. Aluminum conductors shall be Type AA-8000 aluminum conductors complying with ASTM B800 and ASTM B801, and shall be of an aluminum alloy listed or labeled by UL as "component aluminum-wire stock (conductor material). Type EC/1350 is not acceptable. Intermixing of copper and aluminum conductors is not permitted.

2.2.3 Jackets

Multiconductor cables shall have an overall PVC outer jacket.

2.2.4 In Duct

2.2.5 Cable Marking

Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Each cable shall be identified by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag shall contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Conductors shall be color coded. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Conductor identification shall be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Control circuit terminations shall be properly identified. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals shall be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems shall be as follows

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Shall provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

b. For use with aluminum conductors: UL 486A-486B. For connecting aluminum to copper, connectors shall be the circumferentially compressed, metallurgically bonded type.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation shall not require heat or flame, or any additional materials such as covering or adhesive. It shall be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 12 months prior to date of delivery to the site shall not be accepted. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV cable, conforming to NEMA WC 74/ICEA S-93-639 and UL 1072 . Provide cables manufactured for use in duct applications as indicated. Cable shall be rated 5 kV as indicated with 100 percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B compact round conductors. Provide .

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of ANSI/NEMA WC 71/ICEA S-96-659, AEIC CS8 and ICEA S-94-649.

2.5.4 Shielding

Cables rated for 2 kV and above shall have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape or wire shield for each phase.

2.5.5 Neutrals

Neutral conductors of shall be copper , employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.

2.5.6 Jackets

Cables shall be provided with a PVC jacket. Direct buried cables shall be rated for direct burial. Provide PVC jackets with a separator that prevents contact when underlying semiconducting insulating shield.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations shall be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations shall be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator shall be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination shall not require heat or flame for installation. Termination kit shall contain all necessary materials (except for the lugs). Termination shall be designed for installation in low or highly contaminated indoor and outdoor locations and shall resist ultraviolet rays and oxidative decomposition.

2.6.2 Heat Shrinkable Type

Terminator shall consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Termination shall be designed for installation in low or highly contaminated indoor or outdoor locations.

2.6.3 Separable Insulated Connector Type

IEEE 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide connectors of the loadbreak or deadbreak type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points.

a. 200 Ampere loadbreak connector ratings: Voltage: 15 kV, 95 kV BIL. Short time rating: 10,000 rms symmetrical amperes.

b. 600 Ampere deadbreak connector ratings: Voltage: 15 kV, 95 kV BIL. Short time rating: 25,000 rms symmetrical amperes. Connectors shall have 200 ampere bushing interface for surge arresters as indicated.

c. Provide one set of three grounding elbows and one set of three feed-thru inserts. Grounding elbows and feed-thru inserts shall be delivered to the Contracting Officer.

2.7 MEDIUM VOLTAGE CABLE JOINTS

Medium voltage cable joints (splices) are not allowed in manholes, hand holes or junction boxes. All medium voltage cables shall be a continuous conductor from beginning point of connection to ending point of connection (i.e. - transformer, circuit breaker, switch, disconnect, etc.).

2.7.1 Heat-Shrinkable Joint

Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.7.2 Cold-Shrink Rubber-Type Joint

Joint shall be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket shall be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice shall be packaged three splices per kit, including complete installation instructions.

2.8 LIVE END CAPS

Provide live end caps using a "kit" including a heat-shrinkable tube and a high dielectric strength, polymeric plug overlapping the conductor. End cap shall conform to applicable portions of IEEE 48.

2.9 TAPE

2.9.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.9.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.9.3 Fireproofing Tape

Provide tape composed of a flexible conformable unsupported intumescent elastomer. Tape shall be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, and shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.10 PULL ROPE

Shall be plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.11 GROUNDING AND BONDING

2.11.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than in diameter by in length. Sectional type rods may be used for rods 20 feet or longer.

2.11.2 Grounding Conductors

Stranded-bare copper conductors shall conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors shall conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Aluminum is not acceptable.

2.12 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 31 29 MARINE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts shall be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.13 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C857 and ASTM C478. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide

necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable.

2.13.1 Cast-In-Place Concrete Structures

Concrete shall conform to Section 03 31 29 MARINE CONCRETE.

2.13.2 Composite/Fiberglass Handholes and Covers

Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass.

2.14 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms shall be zinc-coated after fabrication.

2.14.1 Cable Racks

The wall bracket shall be 4 inches by approximately 1-1/2 inch by 3/16 inch channel steel, 48 inches long (minimum) in manholes. Slots for mounting cable rack arms shall be spaced at 8 inch intervals.

2.14.2 Rack Arms

Cable rack arms shall be steel or malleable iron or glass reinforced nylon and shall be of the removable type. Rack arm length shall be a minimum of 8 inches and a maximum of 12 inches.

2.14.3 Insulators

Insulators for metal rack arms shall be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.15 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags shall be polyethylene. Do not provide handwritten letters. The first position on the power cable tag shall denote the voltage. The second through sixth positions on the tag shall identify the circuit. The next to last position shall denote the phase of the circuit and shall include the Greek "phi" symbol. The last position shall denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.15.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

2.16 SOURCE QUALITY CONTROL

2.16.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer shall test one sample assembly consisting of a straight lead tube 12 inches long with a 2 1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing material per manufacturer's instructions. The arc and fireproofing tape shall withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode shall be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc shall be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly shall be tested at three unrelated points. Start time for tests shall be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time shall be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape shall indicate that the test has been performed and passed by the manufacturer.

2.16.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 and CALPUC G.O.128 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Prior to installation, each cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

The Contractor shall obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. The Contractor shall then prepare a checklist of significant requirements, perform pulling calculations and prepare a pulling plan which shall be submitted along with the manufacturers instructions in accordance

with SUBMITTALS. Cable shall be installed strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan shall include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.4 CABLE PULLING

Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape or wire shield shall have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.4.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.5 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.5.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice.

Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.6 CONDUCTORS INSTALLED IN PARALLEL

Conductors shall be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

3.7 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes,handholes, or aboveground termination cabinets.

3.8 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.9 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.9.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods shall be as specified elsewhere in this section. Wire shall be trained to the sides of the enclosure to prevent interference with the working area.

3.10 CABLE END CAPS

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.11 LIVE END CAPS

Provide live end caps for single conductor medium voltage cables where indicated.

3.12 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200

volts or more in underground structures.

3.12.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.12.2 Tape-Wrap

Tape-wrap metallic-sheathed or metallic armored cables without a nonmetallic protective covering over the sheath or armor prior to application of fireproofing. Wrap shall be in the form of two tightly applied half-lapped layers of a pressure-sensitive 10 mil thick plastic tape, and shall extend not less than one inch into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

3.13 GROUNDING SYSTEMS

Provide grounding system as indicated, in accordance with NFPA 70 and IEEE C2, and as specified herein.

Noncurrent-carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid earth ground not exceeding the following values:

Pad-mounted transformers without protective fences	5 ohms
Ground in manholes	5 ohms
Grounding other metal enclosures of primary voltage electrical and electrically-operated equipment	5 ohms

3.13.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 12 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, an additional ground rod shall be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.13.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

3.13.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.13.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.13.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

3.14 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 23 00.00 20 EXCAVATION AND FILL, 31 00 00 EARTHWORK.

3.14.1 Reconditioning of Surfaces

3.14.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct . Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.14.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists , restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.15 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 31 29 MARINE CONCRETE.

3.15.1 Concrete Slabs for Equipment

Unless otherwise indicated, the slab shall be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Slab shall be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab shall be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade shall have 1/2 inch chamfer. Slab shall be of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.15.2 Sealing

When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.16 FIELD QUALITY CONTROL

3.16.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.16.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests shall be very low frequency (VLF) alternating voltage withstand tests in accordance with IEEE 400.2. VLF test frequency shall be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages shall be as follows:

CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING	
5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)
25 kV	31kV rms(peak)
35 kV	44kV rms(peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING	
5 kV	7kV rms(peak)
8 kV	10kV rms(peak)
15 kV	16kV rms(peak)
25 kV	23kV rms(peak)
35 kV	33kV rms(peak)

3.16.1.2 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable megohmmeter tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.16.2 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 35 59 13.19

ARCH-TYPE RUBBER MARINE FENDERS
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

ASME B18.21.1	(2009) Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A479/A479M	(2015) Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
ASTM D1171	(1999; R 2007) Rubber Deterioration - Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM D395	(2014) Standard Test Methods for Rubber Property - Compression Set
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D471	(2012a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D573	(2004; R 2010) Standard Test Method for Rubber - Deterioration in an Air Oven
ASTM D575	(1991; R 2012) Rubber Properties in Compression
ASTM D624	(2000; R 2012) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D746	(2014) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM F593	(2013a) Stainless Steel Bolts, Hex Cap Screws, and Studs

ASTM F594 (2009; E 2011) Standard Specification for Stainless Steel Nuts

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-PRF-907 (2004; Rev F) Antiseize Thread Compound, High Temperature

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fender; G

Hardware; G

SD-05 Design Data

Reaction--energy--percent compression curve

Dimension

Fender material specifications

Design calculations

SD-06 Test Reports; G

Minimum Tensile Strength

Shore Hardness (Durometer)

Modulus at 400 Percent Elongation

Maximum Compression Set

Tear Resistance

Minimum Elongation

Ozone Resistance

Low Temperature Impact Resistance

Water Absorption

Heat Resistance

Compression Deflection Resistance

Fender Compression Test

Angular Fender Compression Test

Tests shall have been performed on the specified fender within 5 years of submittal of the reports for approval. Test reports shall be accompanied by notarized certificates from the manufacturer certifying that the tested material is of the same type, quality, manufacture and make as that proposed to be supplied.

SD-08 Manufacturer's Instructions

Installation Instructions

1.3 DELIVERY HANDLING AND STORAGE

Fenders shall be undamaged when delivered and shall be handled and stored so as to prevent damage, such as bending or abrading end fittings, cutting of rubber, or damage to coating of hardware. Protect fenders from exposure to damaging liquids, oils, greases and extended exposure to sunlight. All fenders shall be "broken" fenders with at least 5 full loading-unloading cycles.

PART 2 PRODUCTS

2.1 CONFIGURATION

Fender shall be extruded and shall be continuous in the length indicated. The fenders shall have a truncated "A" cross section shape and be attached to the structure at the base, the widest dimension, of the arch. The connecting hardware shall be fully exposed. No encased hardware or molded fenders shall be allowed. Face of each fender shall be lined with UHMW-PE panel. The fender and hardware shall be designed and factory tested to the loads per linear foot of fender specified in paragraph entitled "PERFORMANCE," for angles of approach of 0 and 15 degrees. Fender anchor bolts and method of anchorage shall be of the size and spacing required by the manufacturer's design and testing; however, the size and spacing of anchor bolts indicated on the drawings shall be construed to be the minimum required, unless exceeded by the requirements of the fender manufacturer's design.

2.2 ELASTOMER

The elastomer shall be the ethylene propylene dimonomer (EPDM), as specified in ASTM D2000, with the following properties:

ELASTOMER PROPERTY REQUIREMENTS	
Minimum Tensile Strength (ASTM D412)	2000 psi
Shore Hardness (Durometer) (ASTM D412)	70 plus 5
Modulus at 400 Percent Elongation (ASTM D412)	900 psi
Maximum Compression Set (ASTM D395 Method B, Maximum Percent 22 Hr. at 158 Degrees F)	25 Percent

ELASTOMER PROPERTY REQUIREMENTS	
Tear Resistance (ASTM D624; DIE B Min. 150 lb/in)	300 lb/in.
Minimum Elongation (ASTM D412)	500 Percent
Ozone Resistance (ASTM D1171 Exposure Method B; 70h Bent Loop at 100 Degrees F; 50pphm)	80 H plus
Low Temperature Impact Resistance (ASTM D746 Procedure B; Non-Brittle at minus 67 Degrees F)	minus 40 Degrees F
Water Absorption (ASTM D471 Method B; 70h 212 Degrees F; Volume Change plus 5 Percent	10.0 Percent
Heat Resistance (ASTM D573; 70h at 212 Degrees F Ch Tensile, Elong. minus 25 Percent, Hardness plus 10	Shall exceed requirements
Compression Deflection Resistance (ASTM D575 Method B; 3 S Dwell at 73 Degrees F	Shall exceed requirements

2.3 HARDWARE

2.3.1 Plates and Angles

ASTM A479/A479M, Type 316L stainless steel for plates, angles, and miscellaneous hardware required to attach the fenders to the structure.

2.3.2 Nuts, Bolts, and Washers

ASTM F593 or ASTM F594, Group 2 (316 alloy) stainless steel for nuts and bolts. ASME B18.21.1 for washers, except fabricate washers of 316 alloy stainless steel.

2.3.3 Antiseize Compound

MIL-PRF-907.

2.4 PERFORMANCE

When vertically compressed by a plate extending the full length and width of a one foot section of the fender, the fender shall absorb 41,100 foot pounds of energy plus 10 percent when 46 percent compressed (i.e., to a dimension of 54 percent of its original height) with a corresponding load of not more than 32,400 pounds plus 10 percent.

2.4.1 FENDER COMPRESSION TEST

Compress fender along its longitudinal axis between two parallel flat plate surfaces to a compressed dimension of 46 percent of its original height. Record load and the corresponding deflection at 1/4 inch increments and plot as a graph of load versus deflection. The Load-Deflection curve shall then be integrated to generate an Energy-Deflection curve for the fender. After compression of the fender to 46 percent of its original height, the fender shall be rebound to 98 percent of its original height within ten minutes after the load is removed.

2.4.2 ANGULAR FENDER COMPRESSION TEST

Compress fender along its longitudinal axis between two flat plate surfaces, at an angle of 15 degrees to each other, to a compressed dimension of 48 percent of its original height. Record load and the corresponding deflection at 1/4 inch increments and plot as a graph of load versus deflection. The Load-Deflection curve shall then be integrated to generate an Energy-Deflection curve for the fender. After compression of the fender to 46 percent of its original height, the fender shall rebound to 98 percent of its original height within 10 minutes after the load is removed.

PART 3 EXECUTION

3.1 INSTALLATION

Install fenders with the fender longitudinal axis vertical. Install the fenders in the position and at the spacing indicated on the drawings. Anchor bolts connecting rubber fenders shall be installed with a torque specified by fender vendor.

3.1.1 Antiseize Compound

Coat threads of bolts prior to applying washers and nuts. Recoat bolt thread projection beyond nut after tightening.

-- End of Section --