

SECTION TABLE OF CONTENTS

DIVISION 03 - CONCRETE

SECTION 03702

SOIL CEMENT

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 GOVERNMENT TESTING
 - 1.2.1 Preconstruction Testing by the Government
 - 1.2.2 Testing During Construction by the Government
 - 1.2.2.1 General
 - 1.2.2.2 Aggregates Testing
 - 1.2.2.3 Cementitious Materials
 - 1.2.2.4 Cement Sources
 - 1.2.2.5 Pozzolan Sources
- 1.3 SUBMITTALS
- 1.4 MATERIAL DELIVERY, STORAGE, AND HANDLING
 - 1.4.1 Cementitious Materials
 - 1.4.1.1 Transportation
 - 1.4.1.2 Storage

PART 2 PRODUCTS

- 2.1 MATERIALS
 - 2.1.1 Cementitious Materials
 - 2.1.1.1 Portland Cement
 - 2.1.1.2 Pozzolan
 - 2.1.1.3 Temperature of Cementitious Materials
 - 2.1.2 Water
 - 2.1.3 Aggregates
 - 2.1.3.1 Aggregate Sources
 - 2.1.3.2 Gradation
 - 2.1.4 CURING MATERIALS
 - 2.1.4.1 Burlap
 - 2.1.4.2 Sheeting
 - 2.1.4.3 Membrane Curing Compound
- 2.2 MIXTURE PROPORTIONING
 - 2.2.1 Composition
 - 2.2.2 Proportioning Methodology
 - 2.2.3 Proportioning Responsibility
 - 2.2.4 Consistency of Soil Cement
- 2.3 MIX DESIGN
 - 2.3.1 Materials for Laboratory Testing
 - 2.3.2 Stockpile Sampling Procedure
 - 2.3.3 Determination of Aggregate Gradation
 - 2.3.4 Determination of Moisture-Density
 - 2.3.5 Determination of Compressive Strength
- 2.4 STOCKPILING OF AGGREGATE
 - 2.4.1 Testing Requirements
 - 2.4.2 Evaluation and Acceptance of Stockpile

- 2.5 BEDDING MORTAR
 - 2.5.1 Bedding Mortar Mix Design

PART 3 EXECUTION

- 3.1 EQUIPMENT
 - 3.1.1 Capacity
 - 3.1.2 Mixing Plant
 - 3.1.2.1 Location
 - 3.1.2.2 Bins and Silos
 - 3.1.2.3 Batch Plant
 - 3.1.2.4 Continuous Mixing Plant
 - 3.1.3 Mixers
 - 3.1.3.1 Pugmill Mixers
 - 3.1.4 Transporting Equipment
 - 3.1.5 Spreading Equipment
 - 3.1.6 Compaction Equipment
 - 3.1.6.1 Primary Rollers
 - 3.1.6.2 Secondary Rollers
 - 3.1.6.3 Small Vibratory Rollers
 - 3.1.6.4 Tampers (Rammers)
 - 3.1.7 Other Motorized Equipment
 - 3.1.8 Nuclear Density Gauge
 - 3.1.9 Calibration
- 3.2 SUBGRADE PREPARATION
- 3.3 PREPARATION FOR PLACING
 - 3.3.1 Placing Schedule
 - 3.3.2 Aggregate Production Schedule
 - 3.3.3 Soil Cement Test Section
 - 3.3.3.1 General
 - 3.3.3.2 Test Section Requirements
 - 3.3.3.3 Evaluation of Test Section
 - 3.3.4 Weather
 - 3.3.4.1 Cold-Weather Placement
 - 3.3.4.2 Placing During Rain
 - 3.3.4.3 Hot-Weather Placement
 - 3.3.5 Surface Preparation
- 3.4 PLACING
 - 3.4.1 Procedures
 - 3.4.2 Bedding Mortar
 - 3.4.3 Lift Thickness
 - 3.4.4 Depositing and Spreading
 - 3.4.5 Compaction
 - 3.4.6 Joints
 - 3.4.6.1 Lift Joint
 - 3.4.6.2 Construction Joints
- 3.5 CURING AND PROTECTION
 - 3.5.1 Curing
 - 3.5.1.1 Moist Curing
 - 3.5.1.2 Truck Applications
 - 3.5.1.3 Sprinkler System
 - 3.5.1.4 Burlap
 - 3.5.1.5 Impervious Sheet Curing
 - 3.5.1.6 Curing Compound
 - 3.5.2 Protection from Rain or Water Flow
- 3.6 FINISHING
- 3.7 DISPOSAL OF UNSATISFACTORY MATERIALS
- 3.8 TESTS AND INSPECTIONS
 - 3.8.1 General

- 3.8.2 Testing and Inspection Requirements
 - 3.8.2.1 Calibration of Mixing Plant
 - 3.8.2.2 Stockpiled Aggregate
 - 3.8.2.3 Batched Aggregate
 - 3.8.2.4 Scales
 - 3.8.2.5 Mixing Plant Control
 - 3.8.2.6 Field Density
 - 3.8.2.7 Inspection Before Placing
 - 3.8.2.8 Placing Inspection
 - 3.8.2.9 Compressive Strength Tests
 - 3.8.2.10 Curing Inspection
 - 3.8.2.11 Cold-Weather and Hot-Weather Protection
 - 3.8.2.12 Cold-Weather and Hot-Weather Protection Corrective Action
- 3.8.3 Reports

-- End of Section Table of Contents --

SECTION 03702

SOIL CEMENT

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 SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 33	(2001a) Standard Specification for Concrete Aggregates
ASTM C 117	(1995) Materials Finer than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	(2002) Standard Specification for Portland Cement
ASTM C 171	(1997a) Sheet Materials for Curing Concrete
ASTM C 309	(1998a) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 618	(2001) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 1040	(1993; R2000) Density of Unhardened and Hardened Concrete in Place by Nuclear Methods
ASTM C 1064	(1999) Temperature of Freshly Mixed Portland Cement Concrete
ASTM D 558	(1982; R 1990) Moisture-Density Relations of Soil Cement Mixtures
ASTM D 1557	(2000) Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³ (2,700 kN-m/m ³))
ASTM D 1633	(1984; R 1990) Compressive Strength of Molded Soil Cement Cylinders
ASTM D 4318	(2000) Standard Test Methods for Liquid

Limit, Plastic Limit, and Plasticity Index
of Soils

ASTM E 329 (2000b) Standard Specification for
Agencies Engaged in the Testing and/or
Inspection of Materials Used in
Construction

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 400 (1963) Requirements for Water for Use in
Mixing or Curing Concrete

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS CCC-C-467 (Rev C) Cloth, Burlap, Jute (or Kenaf)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44 (1997) NIST Handbook 44: Specifications,
Tolerances, and Other Technical
Requirements for Weighing and Measuring
Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100 (1996) Concrete Plant Standards

1.2 GOVERNMENT TESTING

1.2.1 Preconstruction Testing by the Government

At least 45 days in advance of the time when construction of the test section is expected to occur, the Contractor shall notify the Contracting Officer of the source, brand name, type, and quantity of all materials (other than aggregates) to be used in the manufacture and curing of the soil cement. The Contractor shall assist the Contracting Officer in obtaining samples of each material. Sampling and testing as determined appropriate will be performed by and at the expense of the Government. If cement or fly ashes are to be obtained from more than one source, the notification shall state the estimated amount of cement or fly ash to be obtained from each source and the proposed schedule of shipments. When pozzolan other than fly ash is used, it shall be from one source.

1.2.2 Testing During Construction by the Government

1.2.2.1 General

The Government will sample and test cementitious materials, stockpiled aggregates, and soil cement during construction as considered appropriate to determine compliance with the specifications. The Contractor shall provide equipment and labor as may be necessary for procurement of representative test samples. Compression test specimens of soil cement will be made and tested by the Government. The Government as considered appropriate will check density of the compacted soil cement.

1.2.2.2 Aggregates Testing

Testing performed by the Government will not relieve the Contractor of his

responsibility for testing under paragraph TESTS AND INSPECTIONS. During construction, aggregates will be sampled for acceptance testing for each specified aggregate stockpile, to determine compliance with specification provisions. The Contractor shall provide necessary equipment and labor for the ready procurement of representative samples under Government supervision. The Government will test such samples at its expense using the specified COE CRD-C and ASTM methods.

1.2.2.3 Cementitious Materials

The Government will sample cement and pozzolan at the mill, shipping point, or site of the work. Sampling and testing as determined appropriate will be performed by and at the expense of the Government. If tests prove that a material, which has been delivered, is unsatisfactory, it shall be promptly removed from the site of the work. Cementitious materials that have not been used within 6 months after being tested will be retested by the Government at the expense of the Contractor when directed by the Contracting Officer. Samples of representative materials shall be delivered to the laboratory listed below by the Contractor at his expense.

U.S. Army Engineer Waterways Experiment Station
Concrete and Materials Branch
3909 Halls Ferry Road, Bldg 6000
Vicksburg, MS 39180-6199

1.2.2.4 Cement Sources

The Contracting Officer (on an as-desired basis) for testing at the expense of the Government will take samples of cement for quality-assurance testing at the project site or cement-producing plant. A copy of the mill tests from the cement manufacturer shall be furnished for each lot. Cement that has not been used within 6 months after testing will be retested at the expense of the Contractor, and will be rejected if test results are not satisfactory. No cement shall be used until the Contracting Officer has given notice that test results are satisfactory. In the event of failure, the cement may be resampled and tested at the request of the Contractor and at the Contractor's expense. The cost of testing cement excess to project requirements will also be at the Contractor's expense and will be deducted from payments due the Contractor at a rate of \$1750 per test.

1.2.2.5 Pozzolan Sources

The Contracting Officer (as needed) will take samples of pozzolan for check testing at the project site for testing at the expense of the Government. A copy of the test results from the pozzolan manufacturer shall be furnished for each lot. Pozzolan that has not been used within 6 months after testing will be retested at the expense of the Contractor, and will be rejected if test results are not satisfactory. No pozzolan shall be used until the Contracting Officer has given notice that test results are satisfactory. In the event of failure, the pozzolan may be resampled and tested at the Contractor's expense. The cost of testing excess pozzolan in excess of project requirements will be at the Contractor's expense at a rate of \$1650 per test. The amount will be deducted from payment to the Contractor.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as

otherwise designated. 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 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Aggregate; G, ED

Proposed source(s) to be used in the production of soil cement shall be submitted 60 days prior to construction of the test section.

Aggregate Stockpiles; G, ED

Proposed size and number of soil cement aggregate stockpiles shall be submitted 60 days prior to construction of the test section.

Test Report Forms; G, ED
Mixture Proportioning; G, ED

Soil cement test reports including sieve analysis, atterberg limit, moisture-density curves, and compressive strengths, showing that the soil cement meets all specified requirements, shall be submitted 10 days prior to construction of the test section and shall be reported in an approved report form.

Bedding Mortar Mixture; G, ED

Bedding mortar test reports including sieve analysis, and mix design shall be submitted 10 days prior to construction of the test section.

Mixers; G, ED

Details and data on the soil cement mixing plant including manufacturer's literature on the cementitious material and aggregate feed equipment, water controls, and pug mill mixers, showing that the equipment meets all specified requirements, shall be submitted 30 days prior to plant assembly for review and approval by the Contracting Officer for conformance with the requirements of paragraph MIXERS.

Transporting Equipment;
Spreading Equipment;
Compaction Equipment; G, ED

A listing of the equipment, including manufacturer's literature, proposed for transporting, handling, depositing, spreading, and compacting the soil cement shall be submitted for review and approval by the Contracting Officer 30 days prior to construction of the test section.

Nuclear Density Gauge;

A description of the nuclear density gauge apparatus proposed for use including manufacturer's literature and the latest manufacturer's calibration results of the nuclear density gauge

shall be submitted for review by the Contracting Officer 30 days prior to use.

SD-07 Certificates

Nuclear Density Gauge Operators; G, ED

Copies of permits and licenses for gauge operation; the Contracting Officer shall submit copies of certification of training for all operators for review and approval.

Cementitious Materials; G, ED

Cementitious materials including cement and pozzolan, will be accepted on the basis of the manufacturer's certification of compliance, accompanied by mill test reports that materials meet the requirements of the specification under which they are furnished. No cementitious materials shall be used until the Contracting Officer has given notice of acceptance.

Waybills and Delivery Tickets; G, ED

Copies of waybills or delivery tickets for cementitious material during the progress of the work shall be submitted for review and approval. Before the final payment is allowed, waybills and certified delivery tickets shall be furnished for all cementitious material used in the construction.

SD-08 Manufacturer's Instructions

Soil Cement Production; G, ED

Descriptions and details for all methods and operations proposed for soil cement operation including daily and weekly production rates, shall be submitted for review and approval for conformance with specifications.

Curing; G, ED

The curing media and methods to be used to keep soil cement surfaces continually moist until subsequent layers of soil cement are placed shall be submitted for review and approval to the Contracting Officer 5 days before soil cement placement begins for conformance with paragraph CURING AND PROTECTION.

Cold-Weather Placement;

When soil cement is to be placed under cold-weather conditions, a description of the materials and methods proposed for protection of the concrete meeting the requirements of paragraph COLD-WEATHER PLACEMENT, shall be furnished to the Contracting Officer for review 5 days in advance of anticipated need date.

Hot-Weather Placement;

When soil cement is to be placed under hot-weather conditions, a description of the materials and methods proposed for protection of the concrete meeting the requirements of paragraph HOT-WEATHER PLACEMENT, shall be furnished to the Contracting Officer for

review 5 days in advance of anticipated need date.

1.4 MATERIAL DELIVERY, STORAGE, AND HANDLING

1.4.1 Cementitious Materials

1.4.1.1 Transportation

When bulk cement or pozzolan is not unloaded from primary carriers directly into weather-tight hoppers at the batching plant, transportation from the railhead, mill, or intermediate storage to the batching plant shall be accomplished in adequately designed weather-tight trucks, conveyors, or other means that will protect the material from exposure to moisture.

1.4.1.2 Storage

Cementitious materials shall be furnished in bulk. Immediately upon receipt at the site of the work, all cementitious materials shall be stored in a dry, weather-tight, and properly ventilated structure. All storage facilities shall permit easy access for inspection and identification. Sufficient materials shall be in storage to sustain continuous operation of the mixing plant while the soil cement is being placed. In order that cement may not become unduly aged after delivery, the Contractor shall use any cement that has been stored at the site for 60 days or more before using cement of lesser age.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

2.1.1.1 Portland Cement

Portland cement shall conform to ASTM C 150, Type II, low alkali. Portland cement shall be furnished in bulk.

2.1.1.2 Pozzolan

Pozzolan shall conform to ASTM C 618, Class F, with loss on ignition limited to 6 percent. Pozzolan shall be furnished in bulk.

2.1.1.3 Temperature of Cementitious Materials

The temperature of the cementitious materials as delivered to the site shall not exceed 150 degrees F.

2.1.2 Water

Water for mixing and curing soil cement shall be free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances and shall comply with COE CRD-C 400.

2.1.3 Aggregates

The soil used in the soil cement mixture shall not contain any material retained on a 2-inch sieve, nor any deleterious material. Soil aggregates shall be obtained from sources specified herein. Prior to using the aggregate, it shall be stockpiled, sampled, and shall be approved by the

Contracting Officer in accordance with the requirements of paragraphs STOCKPILING OF AGGREGATE and MIX DESIGN.

2.1.3.1 Aggregate Sources

Soil cement aggregates may be furnished from any source capable of meeting the grading requirements stated in paragraph GRADATION. Aggregates may be obtained from commercial sources or processed from the required excavation.

It is the responsibility of the Contractor to blend and/or process aggregates, or to import suitable materials from other sources approved by the Contracting Officer so that soil aggregate used in construction of soil cement conforms to the gradation requirement. The Contractor shall make all arrangements and secure all necessary permits for the procurement, furnishing, and transporting the soil cement aggregate.

2.1.3.2 Gradation

Soil aggregate for use in soil cement construction, when tested in accordance with ASTM C 136 and ASTM C 117, shall conform to the following gradation and be free of any deleterious material.

<u>Standard Sieve Size</u>	<u>Percent Passing by Weight</u> ^{1, 2}
1 1/2"	98-100
No. 4	60-90
No. 200	5-12

NOTE:

¹ The maximum plasticity index shall be limited to 3 when determined in accordance with ASTM D 4318.

² Clay and silt lumps larger than 1/2 inch shall be unacceptable, and screening will be required whenever this type of material is encountered.

2.1.4 CURING MATERIALS

2.1.4.1 Burlap

Burlap shall conform to FS CCC-C-467.

2.1.4.2 Sheeting

Waterproof sheeting shall be white waterproof paper or white opaque polyethylene film conforming to ASTM C 171.

2.1.4.3 Membrane Curing Compound

Curing compound shall conform to ASTM C 309, Type 1-D.

2.2 MIXTURE PROPORTIONING

2.2.1 Composition

Soil cement shall be composed of cementitious materials, water, and aggregates. The cementitious material shall be portland cement, or portland cement in combination with pozzolan. The Government will use a pozzolan in the soil cement, it shall be proportioned to a maximum of fifteen (15) percent, by weight, of the total weight of cement.

2.2.2 Proportioning Methodology

The mixture of the aggregate, cement, pozzolan (if used), and water shall be analyzed by laboratory tests by the Contractor to determine physical properties of soil cement. Testing of the mixture shall be in accordance with this specification as described in paragraph MIX DESIGN. Upon completion of the testing, the Contractor shall submit the results on an approved form to the Contracting Officer. Following the evaluation of the results, the Contracting Officer will provide the Contractor the job-mix design for the soil cement. A new mix design will be required any time the Contractor requests a change in aggregate source, or constructs a new stockpile.

2.2.3 Proportioning Responsibility

The Government will change the proportions as necessary. Adjustments will be made to the batch weights, including cement, pozzolan, and water, to maintain the necessary consistency to prevent segregation within the soil cement and allow full compaction as determined. Frequent changes to the batch weights shall be considered usual and can be expected to occur frequently during the course of each day's placement depending on such variables as humidity, wind velocity, temperature, and cloud cover. Such changes will be as directed. The Contractor will be responsible for adjusting the added water to compensate for changes in aggregate moisture content.

2.2.4 Consistency of Soil Cement

The Contracting Officer will determine at the placement site on a continuing basis the proper consistency necessary for adequate hauling, spreading, and compacting and will direct all necessary changes to achieve the proper soil cement consistency. Changes will be directed based on visual examination of the soil cement during the spreading and compaction process.

2.3 MIX DESIGN

The design requirements for the soil cement protection shall be such that it has a compressive strength of 750 psi at the end of seven (7) days plus 2% additional cement added for erosion resistance.

2.3.1 Materials for Laboratory Testing

At least 45 days in advance of the time when construction of the test section is expected to occur, samples of representative materials proposed for this project and meeting all the requirements of this specification shall be obtained and tested by the Contractor. Sampling and testing shall be at the Contractor's expense. Samples of aggregates shall be taken on the materials stockpiled and shall be in accordance with STOCKPILE SAMPLING PROCEDURE. Samples of materials other than aggregates shall be representative of those proposed for the project.

2.3.2 Stockpile Sampling Procedure

Samples will be taken from six different locations of the specified stockpile. Samples will be obtained by making a complete cut of the entire height of the stockpile. The six samples will be combined into a composite mixture to prepare moisture density and compressive strength specimens.

2.3.3 Determination of Aggregate Gradation

Prior to determining the moisture-density relationship, a gradation test, in accordance with ASTM C 136, shall be conducted on the composite sample obtained, as described above. The Contractor shall submit the gradation results to the Contracting Officer. Based on the gradation, the Contracting Officer will provide the cement contents needed for the Contractor to perform trial batches.

2.3.4 Determination of Moisture-Density

The Contractor shall perform optimum moisture-maximum density relationships for four (4) different cement contents, in accordance with ASTM D 558, Method B. The moisture-density relationships will be determined for the cement contents directed by the Contracting Officer.

2.3.5 Determination of Compressive Strength

Following the determination of optimum moisture and maximum density, the Contractor shall prepare two (2) compressive strength test specimens for each of the cement contents specified at age of 1, 7, and 28 days. Specimens shall be tested in accordance with ASTM D 1633, Method A. The compression test specimens prepared for each of the cement percentages shall have approximately the following moisture contents: 4 percent below optimum, 2 percent below optimum, optimum moisture, and 2 percent above optimum.

2.4 STOCKPILING OF AGGREGATE

Whether obtained from the streambed or from off-site sources, aggregates shall not be transported directly to the mixing plant. The aggregates shall be stockpiled on firm ground drained and leveled, free of debris, trash, organic materials, and other objectionable or deleterious material. Stockpiles shall be constructed in layers not exceeding 3 feet in thickness. Ramps formed for the construction of stockpiles shall be of the same material as that being stockpiled, and will be considered a part of the stockpile. Stockpiled material shall be thoroughly mixed throughout its depth, width, and length before utilization. The material shall be homogenous and uniform in color, gradation, and moisture throughout.

2.4.1 Testing Requirements

Tests including sieve analyses, atterberg limits, and a mix design shall be conducted and submitted for each stockpile. Stockpile(s) for use in soil cement production shall not exceed 15,000 cubic yards. When the total quantity of material required to complete all soil cement exceeds the specified limit, the same testing requirements shall be conducted for each 10,000-cubic yard aggregate stockpile or fraction thereof.

2.4.2 Evaluation and Acceptance of Stockpile

During the determination of the job mix proportions of the soil cement for each stockpile as specified in paragraph MIX DESIGN, no material shall be used nor be added to the stockpile being evaluated. Following the submittal of the soil cement test results (sieve analysis, atterberg limit, moisture-density relationships, compressive strengths), the Contractor shall allow the Contracting Officer at least ten (10) days to evaluate test results. After the evaluation period, the Government shall then provide the soil cement mix proportions to the Contractor.

2.5 BEDDING MORTAR

Bedding mortar is to be used for achieving bond between soil cement lifts as indicated in paragraph JOINTS. No surfaces to receive a bedding mortar shall be covered with soil cement until the prepared surface has been approved and that acceptance has been recorded on an approved checkout form. In no case will the bedding mortar be allowed to dry from the sun and wind.

2.5.1 Bedding Mortar Mix Design

The bedding mortar mix design will be developed by the Contractor and will conform to the following general requirements. Aggregate for bedding mortar shall conform to the requirements of ASTM C 33, for washed concrete sand.

Parameter	Values
Slump	8 - 10 inches
Cement Content	650 pounds/cubic yard
Minimum Compressive Strength	2500 p.s.i. (28 days)

PART 3 EXECUTION

3.1 EQUIPMENT

3.1.1 Capacity

The mixing plant, placing, compaction, and cleanup systems shall have a capacity of at least 100 cubic yards per hour.

3.1.2 Mixing Plant

The mixing plant shall be a weigh-batch type or continuous type.

3.1.2.1 Location

The mixing plant shall be located at the site of the work, subject to the approval of the Contracting Officer.

3.1.2.2 Bins and Silos

Separate bins, compartments, or silos shall be provided for each of the cementitious materials. The compartments shall be of ample size and so constructed that the various materials will be maintained separately under all working conditions. All compartments containing bulk cement or pozzolan shall be separated from each other by a free-draining air space. The cement and pozzolan bins shall be equipped with filters which allow air passage but preclude the venting of cement or pozzolan into the atmosphere.

All filling ports shall be clearly marked with a permanent sign stating the contents.

3.1.2.3 Batch Plant

The batch plant requirements shall meet the following requirements.

a. Batchers - Aggregate shall be weighed on a separate scale in a separate weigh batcher. Bulk cement and other cementitious materials shall each be weighed on a separate scale in a separate weigh batcher. Water shall be measured by weight or by volume. It shall not be weighed or measured cumulatively with another ingredient.

b. Water Batcher - A suitable water-measuring and batching device shall be provided that will be capable of measuring and batching the mixing water within the specified tolerances for each batch. The mechanism for delivering water to the mixers shall be free from leakage when the valves are closed. The filling and discharge valves for the water batcher shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. When a water meter is used, a suitable strainer shall be provided ahead of the metering device.

c. Moisture Control - The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the masses of the materials being batched.

d. Scales - Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering the soil cement. The weighing equipment and controls shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be within 0.2 percent of the scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Tests shall be made at the frequency required in paragraph TESTS AND INSPECTIONS and in the presence of a Government inspector. Each weighing unit shall include a visible indicator that shall indicate the scale load at all stages of the weighing operation and shall show the scale in balance at zero load. The weighing equipment shall be arranged so that the concrete plant operator can conveniently observe the indicators.

e. Operation and Accuracy - The weighing operation of each material shall begin automatically when actuated by one or more starter switches and shall end when the designated amount of each material has been reached. These requirements can be met by providing a semiautomatic or automatic batching system as defined by the NRMCA CPMB 100. The weigh batchers shall be so constructed and arranged that the sequence and timing of batcher discharge gates can be controlled to produce a ribboning and mixing of the aggregates, water, and cementitious materials as the materials pass through the charging hopper into the mixer. The plant shall include provisions to facilitate the inspection of all operations at all times. Delivery of materials from the batching equipment shall be within the following limits of accuracy:

<u>MATERIAL</u>	<u>PERCENT OF REQUIRED MASS</u>
Cementitious materials	0 to +2
Water	±1
Soil Aggregate.....	±2

When water is measured by volume, it shall meet the same tolerance percent as stated in the chart.

f. Interlocks - Batchers and mixers shall be interlocked so that:

(1) The charging device of each batcher cannot be actuated until all scales have returned to zero balance within plus or minus 0.2 percent of the scale capacity and each volumetric device has reset to start or has signaled empty.

(2) The charging device of each batcher cannot be actuated if the discharge device is open.

(3) The discharge device of each batcher cannot be actuated if the charging device is open.

(4) The discharge device of each batcher cannot be actuated until the indicated material is within the allowable tolerances.

(5) The mixers cannot be discharged until the required mixing time has elapsed.

g. Recorder - An accurate recorder or recorders shall be provided and shall conform to the following detailed requirements:

(1) The recorder shall produce a graphical or digital record on a single visible chart or tape of the weight or volume of each material in the batchers at the conclusion of the batching cycle. The record shall be produced prior to delivery of the materials to the mixer. After the batchers have been discharged, the recorder shall show the return to empty condition.

(2) A graphical recording or digital printout unit shall be completely housed in a single cabinet that shall be capable of being locked.

(3) The chart or tape shall show time of day at intervals of not more than 15 minutes.

(4) The recorder chart or tape shall become the property of the Government.

(5) The recorded weights or volumes when compared to the weights or volumes actually batched shall be accurate within plus or minus 2 percent.

h. Batch Counters - The plant shall include devices for automatically counting the total number of batches of all concrete batched and the number of batches of each preset mixture.

i. Batch Plant Trial Operation - Not less than 7 days prior to commencement of placing the test section, a test of the batching and mixing plant shall be made in the presence of a representative of the Contracting Officer to check operational adequacy. The number of full-scale soil cement batches required to be produced in trial runs shall be as directed, will not exceed 20, and shall be proportioned as directed by the Contracting Officer. All soil cement produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected to the satisfaction of the Contracting Officer prior to the start of soil cement placing operations. No separate payment will be made to the Contractor for labor or materials required by provisions of this paragraph. Mixer uniformity testing, in accordance with paragraph TESTS AND INSPECTION, will be performed by the government near the end of this trial operation period. The Contractor shall notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

j. Protection - The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

3.1.2.4 Continuous Mixing Plant

A continuous mixing plant shall be capable of producing soil cement of the same quality and uniformity as would be produced in a conventional batch plant and shall be capable of producing a uniform continuous product (at both maximum and minimum production rates) that is mixed so that complete intermingling of all ingredients occurs without balling, segregation, and wet or dry portions.

a. Operation and Accuracy - An electronic control system shall be provided. The control system shall have the capability of changing mixtures instantaneously, producing any of the mixtures at a variable rate, and tracking a mixture change to a hopper or a conveyor system. The control panel shall display for each ingredient the designed formula values and the instantaneous percentage values and shall record the instantaneous values at a preset time interval or on demand with a multiple copy printer/recorder. The recorder shall note formula changes and shall print total quantities of each ingredient and total amounts produced on command. There shall be weighing devices (belt scale or other) for continuous weighing of individual ingredients and total ingredients. The plant control shall not require manual devices to adjust the material flow. The plant shall be capable of total manual control operation for a single product at a limited production for short-time durations in the event of loss of electronic control. The electronic control system shall incorporate modular replaceable components to reduce down time in the event of control system malfunction. An inventory shall be maintained of such replaceable components. The accuracy of the plant dispensing systems shall be within the following limits:

Pozzolan	0 to +2 percent
Cement	0 to +2 percent
Water	± 1 percent
Soil Aggregate.....	± 1 percent

The continuous feeders for each of the ingredients shall be calibrated as per the manufacturer's specifications. Devices and tools shall be maintained at the plant location to check the feeder's calibration at the Contracting Officer's request. A technician shall be provided that is skilled in calibration of the feed devices and the maintenance and repair of the plant control system. The technician shall be available within 30 minutes notice during all scheduled plant operations. The technician could be one or more of the Contractor's personnel.

b. Cement, Pozzolan, and Aggregate Feed - Cement, pozzolan, and aggregate shall be uniformly, continuously, and simultaneously fed (at the proper ratios and quantity for the mixture required) into the mixer by belt, auger, vane feeder, or other acceptable method. The feed bins or silos for each ingredient shall be kept sufficiently full and shall be of sufficient size to ensure a uniform flow at a constant rate for a specific mixture. The feed bins shall have a low-level indicator that both warns the operator and can shut the plant down if insufficient material is available for a uniform and continuous flow.

c. Water Dispenser - The liquid-dispensing device shall be capable of metering and dispensing within the specified requirements. The liquid valves shall be free from leakage in the closed position. The dispensers shall have attachments and/or be installed in such a manner that will permit convenient checking of their accuracy. Plumbing shall be leak-free and properly valved to prevent backflow and siphoning. The dispenser shall

be interlocked with the electronic plant control and shall warn the operator and shut down the plant if insufficient liquid is available.

d. Continuous Mixer - The continuous mixer shall have proper introduction of ingredients as specified by the manufacturer and shall not be charged in excess of the manufacturer's recommended capacity. Mixer shall be capable of combining the materials into a uniform homogeneous mixture and of discharging this mixture without segregation. The mixer shall operate at the blade speed designated by the manufacturer and shall be capable of changing retention time of the ingredients in the mixer. This should be accomplished by manually resetting the mixer blade angles. Mixing time (ingredient retention time in the mixer) shall be predicated upon the uniformity, homogeneity, and consistency of the resultant mixture. The mixer shall be maintained in satisfactory operating condition and mixer blades shall be kept free of hardened soil cement. Should mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired. Suitable facilities shall be provided for obtaining representative samples of soil cement for testing. All necessary platforms, shelters, tools, labor, and equipment shall be provided for obtaining samples.

e. Segregation - A means shall be used to reduce and minimize segregation and waste which would otherwise result from the continuous stream of soil cement being fed into the batch haul devices (dump trucks, etc.). The equipment shall retain the soil cement between tracks or other means of transport to prevent the need for stopping the mixer. These devices could include, but not be limited to, small-volume conveyor discharge hopper with a large gate that is automatically opened on a timed interval, thereby dumping a series of small batches into larger batch hoppers, trucks, or truck beds.

f. Discharge Hopper - The continuous mixer shall be equipped with a discharge hopper having a capacity of at least 20 tons. The hopper shall be equipped with dump gates to assure rapid and complete discharge without segregation.

g. Trial operation - Not less than 7 days prior to commencement of placing the test section, a test of the plant shall be made in the presence of a representative of the Contracting Officer to check operational adequacy. The number of cubic yards required to be produced in trial runs shall be as directed, but will not exceed 100 cubic yards and shall be proportioned as directed by the Contracting Officer. All soil cement produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected to the satisfaction of the Contracting Officer prior to the start of soil cement placing operations. No separate payment will be made to the Contractor for labor or materials required by provisions of this paragraph. The Contractor shall notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

h. Protection - The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

3.1.3 Mixers

Mixers shall be stationary mixers or pugmill mixers. Mixers may be batch or continuous mixing. Each mixer shall combine the materials into a

uniform mixture and discharge this mixture without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer on the nameplate. Excessive overmixing requiring additions of water will not be permitted. The mixers shall be maintained in satisfactory operating condition. 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. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired or replaced.

3.1.3.1 Pugmill Mixers

A batch or continuous mixing twin-shaft pugmill mixer shall be capable of producing soil cement of the same quality and uniformity as would be produced in a conventional plant that meets all the requirements of these specification. All pugmill mixers shall meet the requirements of paragraph CONTINUOUS MIXING PLANT.

3.1.4 Transporting Equipment

The concrete mixtures (soil cement, and bedding mortar) shall be transported from the plant mixer(s) to placement as rapidly and as continuously as practical by methods, which limit segregation, contamination, and surface drying. The soil cement shall be hauled from the mixing plant to the placing site in dump trucks equipped with protective covers.

3.1.5 Spreading Equipment

Spreading of soil cement shall be accomplished by the use of approved motor graders crawler-type equipment, or track dozer, when approved. The equipment shall be maintained in good operating condition. The equipment shall not leak or drip oil, grease, or other visible contaminants onto the soil cement surface. All equipment used for spreading that leaves the surface of the structure for maintenance or repairs or, for any other reason, must be cleaned of all contaminants by an approved method before returning to the structure surface. Under no conditions shall a dozer or other tracked vehicle be operated on other than fresh uncompacted soil cement except to facilitate startup operations for each lift and by approved procedures.

3.1.6 Compaction Equipment

3.1.6.1 Primary Rollers

Self-propelled vibratory rollers shall be used for primary rolling and shall be double-drum. They shall transmit a dynamic impact to the surface through a smooth steel drum by means of revolving weights, eccentric shafts, or other equivalent methods. The compactor shall have a minimum gross mass of 20,000 lbs and shall produce a minimum dynamic force of 4400 lbs/ft of drum width. The operating frequency shall be variable in the approximate range of 1,700 to 3,000 cycles per minute. The amplitude shall be adjustable between .02 inches and .04 inches. The roller shall be capable of full compaction in both forward and reverse directions. The roller shall be operated at speeds not exceeding 2 ft/sec. Within the range of the operating capability of the equipment, the Contracting Officer may direct or approve variations to the frequency, amplitude, and speed of operation, which result in the specified density at the fastest production rate.

3.1.6.2 Secondary Rollers

Self-propelled padded drum vibratory rollers shall be used for secondary rolling of last few passes of each lift in order to provide indentations to promote better bonding conditions between lifts. They shall transmit a dynamic impact to the surface through a padded steel drum by means of revolving weights, eccentric shafts, or other equivalent methods. The compactor shall have a minimum gross mass of 10,000 lbs and shall produce a minimum dynamic force of 3,500 lbs/ft of drum width. The operating frequency shall be variable in the approximate range of 1,500 to 3,000 cycles per minute. The roller shall be capable of full compaction in both forward and reverse directions. The roller shall be operated at speeds not exceeding 2 ft/sec. Within the range of the operating capability of the equipment, the Contracting Officer may direct or approve variations to the frequency, amplitude, and speed of operation, which result in the specified density at the fastest production rate.

3.1.6.3 Small Vibratory Rollers

Small vibratory rollers shall be used to compact the soil cement where the larger vibratory rollers specified above cannot maneuver. The rollers shall compact the soil cement to the required density and shall be so demonstrated during construction of the test section. Small vibratory rollers cannot compact the soil cement to the same density and thickness as the primary rollers; therefore, when small rollers are used, total lift thickness of the soil cement layer or lift shall be not more than 4 inches uncompacted thickness to permit adequate compaction. Rollers shall have independent speed and vibration controls and shall be capable of a wide range of speed adjustments.

3.1.6.4 Tampers (Rammers)

The tampers shall compact the soil cement to the required density and shall be so demonstrated during construction of the test section. Tampers cannot compact the soil cement to the same density and thickness as the primary rollers; therefore, when tampers are used, thickness of each soil cement layer that is to be compacted shall be reduced to not more than 4 inches uncompacted thickness to assure adequate compaction.

3.1.7 Other Motorized Equipment

All other equipment necessary for the successful completion of soil cement production, but not previously discussed within these specifications (or determined to be necessary during the course of the work), shall be approved prior to actual use. Such equipment shall not result in any damage to the soil cement, shall be maintained in good operating condition, and shall be operated by skilled contractor-provided personnel.

3.1.8 Nuclear Density Gauge

Tests to determine the density of the compacted soil cement shall be made by the Contractor using a single-probe nuclear density gauge supplied by the Contractor. The nuclear density gauge shall meet the applicable requirements of ASTM C 1040, Method A. The gauge shall be capable of taking readings along a horizontal path between the probes at 2-inch increments from 2 inches from the surface to the full depth of the compacted lift, minus 1 inch. The gauge and operator shall be made available to the Government until completion of all soil cement production

at no additional cost. The Contractor shall obtain all permits and certifications for the equipment and the operators.

3.1.9 Calibration

Nuclear gauge shall have been factory calibrated within 6 months of soil cement placement. The Contractor shall construct, at no additional cost to the Government, three (3) calibration test blocks using soil cement materials and proportions representative of those to be used during construction. The blocks shall be fabricated before the test section construction begins. The blocks size shall be a minimum of 18 inches by 18 inches by the maximum thickness of one lift, plus 1 inch. The blocks shall be compacted to at least 98 percent of the maximum wet density, which will be determined by the Government in accordance with ASTM D 558. The moisture content of the soil-cement used to fabricate the blocks may be increased just enough to facilitate compaction of the mixture, as long as the proportions of the dry materials remain constant and the required density is achieved. The blocks shall be measured and weighed to determine the actual density (unit weight) and shall be used to check the calibration of the nuclear density gauge. After drilling a hole in the block to accommodate the nuclear density gauge probe, three full depth nuclear density gauge tests shall be performed in the direct transmission mode and the results averaged. This average nuclear density gauge reading shall be compared with the measured unit weight of the blocks and the difference used as a correction factor for all readings taken that day. All measuring and weighing of the test blocks and all calibration checking of the density gauge shall be performed in the presence of a representative of the Contracting Officer. Calibration checks of the density gauge shall be made at the beginning of construction every day. Gauge calibration constants shall be adjusted for performance on these blocks at least 7 days prior to the evaluation of test strips. The Contractor shall remedy any inconsistencies in gauge performance prior to the start of soil cement placement. The blocks shall be used each day before placing begins to calibrate the full-depth readings of the nuclear density gauges used by the Contractor and the Government. The calibration block shall be available for use by the Government as needed.

3.2 SUBGRADE PREPARATION

Previously constructed underlying material shall be conditioned as specified in Section 02300 EARTHWORK. The existing subgrade, other than specified fills, shall be scarified, conditioned to optimum moisture content, and compacted to at least 95 percent of maximum density in accordance with ASTM D 1557 for a depth of least 6 inches. In all cases prior to placing soil cement, deficiencies in the underlying material shall be corrected, and the surface shall be cleaned and moistened, as directed. The Contracting Officer will approve the surface of the underlying material.

3.3 PREPARATION FOR PLACING

3.3.1 Placing Schedule

Before starting soil cement production, a detailed schedule shall be submitted indicating intended daily and weekly production rates that, when followed, will meet the beginning and ending specified soil cement production dates. After initiation of soil cement production, the Contractor's schedule shall be updated and adjusted on a weekly basis for the duration of the soil cement placement. If it becomes apparent for any reason that the Contractor is not pursuing a schedule that will meet the

specified soil cement production dates, actions necessary to increase the production rate shall be taken so that production is once again on schedule, within 5 calendar days after written notice. Also, if not back on schedule by the end of the 5 days calendar period, the Government reserves the right at this time to direct the Contractor, at no additional cost to the Government, to increase the amount and size of crews and equipment.

3.3.2 Aggregate Production Schedule

Aggregate production and stockpiling shall begin and shall be producing acceptable material by not later than 60 days in advance of the time when placement of the soil cement test section is expected to begin. At least 50 percent of the soil aggregates necessary for the completed soil cement construction shall be manufactured and stockpiled prior to start of placement for the permanent soil cement structure.

3.3.3 Soil Cement Test Section

3.3.3.1 General

Prior to placement of any soil cement, the Contractor shall construct a test section. The purpose of the test section is to demonstrate the suitability of the Contractor's equipment, methods, and personnel. The test section shall be at least 3 lifts in height and be at least 50 feet long and 8 feet wide. The site of the test section shall be approved. After evaluation and assessment of the test section by the Contracting Officer, the Contractor shall dispose of the test section in an approved manner. Under no circumstances shall the test section be incorporated into or become a part of the permanent soil cement structure. The test section shall demonstrate sustained plant production rates, and batching, mixing, transporting, spreading, and compaction procedures. The test section will also be used by the Government to evaluate quality control procedures. The date of the test section construction shall be provided at least 7 days in advance.

3.3.3.2 Test Section Requirements

The mixing plant shall be operated and calibrated prior to placing the test section. The Contractor shall use the same equipment, materials, and construction techniques on the test section as will be used in all subsequent work. Sub-grade preparation, soil-cement production, placing, compacting, curing, construction of joints, and all testing shall be in accordance with applicable provisions of this section of the specification. Additionally, three (3) nuclear gauge readings at the last lift of test section shall be provided from points selected by the Government.

3.3.3.3 Evaluation of Test Section

The Contractor shall not begin soil cement operations for the main structure until testing and evaluation by the Government have been completed, and it has been demonstrated to the satisfaction of the Contracting Officer that all specification requirements were met. Following completion of test section construction, 10 calendar days shall be allowed for testing and evaluations. If the Contractor does not meet requirements as specified, an additional test section or sections shall be constructed at no additional cost to the Government. The Contractor shall provide six (6) 6-inch diameter cores to the Government from points selected in the test section by the Government 7 days after completion of

the test section.

3.3.4 Weather

If unusual adverse weather, such as heavy rain, severe cold, high winds, etc., occurs or is forecast to occur during placement, the placement operation shall be suspended until conditions improve.

3.3.4.1 Cold-Weather Placement

In Cold-weather placement the soil cement shall not be placed when the ambient air temperature drops below 32 degrees F. If the ambient air temperature does drop below 32 degrees F, the surface of any recently placed (within the previous 72 hours) and exposed soil cement surface shall not remain exposed for more than 4 hours. Surfaces that will be exposed for longer times shall be protected as specified in paragraph COLD-WEATHER PROTECTION as a measure to maintain soil cement temperatures above 32 degrees F until after the ambient air temperature rises to above 32 degrees F and is expected to remain above 32 degrees F until the end of the curing and protection period, or until covered by another lift.

3.3.4.2 Placing During Rain

Soil cement shall not be placed during rainfall of 0.1 inch/hr or more. During periods of lesser rainfall, placement of soil cement may continue if, in the opinion of the Contracting Officer, no damage to the soil cement is occurring. Work shall commence only after excess free surface water and contaminated paste or soil cement have been removed and the surface has gained sufficient strength (no less than 4 hours after the soil cement placement was suspended) to prevent rutting, pumping, intermixing of rainwater with the soil cement, or other damage to the soil cement. When the soil cement surface has been contaminated or damaged in any manner, the soil cement surface shall be washed to break up and remove laitance and/or mud-like coatings from the surface. All waste shall be removed and disposed of in an approved manner.

3.3.4.3 Hot-Weather Placement

In hot-weather placement the temperature of the soil cement shall be controlled so that it does not exceed 90 degrees F when placed. Placement shall be suspended as soon as the soil cement temperature exceeds 90 degrees F. Measures that can be taken to prevent temperatures exceeding 90 degrees F include, but are not limited to, chilling mixing water, use of a canopy to shade the soil cement placement areas, placing during nighttime and early morning hours, or restricting placements to cloudy days. Use of any of these systems shall not be reason for extension of completion dates specified in these specifications.

3.3.5 Surface Preparation

Lift surfaces shall be cleaned prior to placing any additional soil cement thereon. Surface treatment shall be in accordance with the requirement of paragraph JOINTS. No surfaces to receive bedding mortar shall be covered with soil cement until the prepared surfaces have been accepted in writing and that acceptance has been recorded on an approved checkout form. All surfaces upon which soil cement or any bedding mortar is placed shall be moist (but contain no visible free water). Prior to placing soil cement, all surfaces shall be clean and free of loose, unkeyed, or deteriorated rock; all mud and silt accumulations; vegetation; laitance; puddles or

ponds of free surface water; coatings; and any other detrimental materials.

Suitable equipment, with the approval of the Contracting Officer, shall be at the site to clean all surfaces in conformance with these specifications without disrupting in any way the soil cement production as scheduled.

3.4 PLACING

3.4.1 Procedures

The soil-cement mixture shall be placed and distributed in such a manner as to produce a reasonably smooth, uniform surface in layers of such uncompacted thickness that when compacted each layer shall not be more than 9 inches nor be less than 6 inches in thickness. Soil cement shall be placed in successive horizontal layers. The Contractor is encouraged to place and compact each successive layer as rapidly as possible after the preceding layer is completed and meet the density requirement. The Contractor will be permitted to place the material in sloping layers to accommodate hauling and compacting equipment if such sloping layers are not steeper than 8H:1V. Below grade (toe-down) soil cement placement, the Contractor may place backfill material simultaneously with soil cement. The compacted backfill, however, shall be at least 6 inches lower than the compacted soil cement. Placing of mixture shall be as nearly continuous as possible, with an absolute minimum of stops and starts; speed of placing shall be controlled, to permit proper rolling. Placing shall be discontinued during rain except for light mists, which do not cause intermixing of cement and water slurry on the surface. Placing shall be done in a pattern so that curing water from previous placements will not pose a runoff problem on the fresh surface. The Contractor shall use care to minimize the production of cold joints.

3.4.2 Bedding Mortar

The bedding mortar shall be applied to the existing surface following any required cleanup. The bedding mortar shall be applied not more than 20 minutes ahead of soil cement placement, unless otherwise approved. The bedding mortar shall be used between soil cement lifts where cold joints occur and other horizontal contact surfaces. The bedding mortar shall have an average thickness after application of between 1/8 and 1/4 inches and shall cover 100 percent of the lift area.

3.4.3 Lift Thickness

The total lift thickness after final compaction by the vibratory roller shall be between 6 inches and 9 inches. Each of the last two (top) lifts of any finished structure must have a minimum compacted thickness of 6 inches.

3.4.4 Depositing and Spreading

After the soil cement has been deposited, the soil cement shall be spread by dozers into gently sloping layers, that will, after final compaction of the layers by the vibratory roller, result in the specified lift thickness.

In no case shall the soil cement or bedding mortar be allowed to dry. Under no conditions shall a dozer or other tracked vehicle be operated on other than fresh uncompacted soil cement except at the start of each lift placement to facilitate startup operations, and then only by an approved procedure. No soil cement shall be placed on a previous lift, which has not met specification. Unacceptable material shall be removed.

3.4.5 Compaction

Each layer shall be compacted to a density of at least 98 percent maximum density in accordance with ASTM D 558, Method B. The specified moisture content shall be maintained uniformly throughout the layer of material being compacted. At no time shall water be added during compaction operations to the uncompacted soil-cement mixture. If in the opinion of the Contracting Officer, the surface of a layer of soil-cement has been rutted or compacted unduly by hauling equipment so as to reduce the effectiveness of compaction by the specified rollers, the Contractor will be required to scarify such surfaces as directed prior to compacting with the specified rollers. At the start of compaction, the mixture shall be in a uniform, loose condition throughout its full depth. No section shall be left undisturbed for longer than thirty (30) minutes during compaction operations. Compaction of each layer shall be done in such a manner as to produce a dense surface with indentations to promote better bonding conditions with subsequent lift. The surface of the top lift shall be smooth without the indentations.

3.4.6 Joints

3.4.6.1 Lift Joint

The entire soil cement shall be placed with sufficient continuity so that it hardens and acts as one monolithic structure without discontinuous joints or potential planes of separation. All lift joints shall be kept clean, uncontaminated, free from ponded water, and continuously moist until placement of the succeeding soil cement.

a. Lift Placed Within 2 Hours - Regular lift-joint treatment and maintenance applies to subsequent lifts placed within 2 hours of the previous lift and shall include:

(1) Maintaining 100 percent of each compacted lift-joint surface continuously moist by application of water.

(2) If necessary, removing all loose contaminants or deteriorated soil cement by using a power broom and/or jetting the surface with compressed air, and

(3) Exception for Hot Weather Conditions. During periods of hot weather as defined in Paragraph: Hot Weather Placement, the time period for regular lift joint treatment shall be reduced to 1-hour.

b. Subsequent Lift Placed More Than 2 Hours but Less Than 8 Hours - Whenever the Contractor's operation is interrupted such that the subsequent lift cannot be placed within 2 hours, the joint treatment shall include:

(1) Maintaining 100 percent of each compacted lift-joint surface continuously moist by application of water.

(2) If necessary, the top surface of the completed layer (with indentations) shall be swept using a power broom or other method approved by the Contracting Officer to completely free the surface of all loose material. Air jetting may be used in conjunction with power brooming to facilitate surface cleaning.

(3) The top surface of the completed layer, if smooth (without indentations), shall be scarified to a depth of at least 2 inches with a spike-tooth equipment, or by other means approved by the Contracting

Officer, prior to placement of the next lift. The surface, after scarifying, shall be swept using a power broom or other method approved by the Contracting Officer to completely free the surface of all loose material prior to actual placement of the soil cement mixture for the next lift.

(4) Exception for Hot Weather Conditions. During periods of hot weather as defined in Paragraph: Hot Weather Placement, the time period for lift joint treatment shall be reduced to 2-hour.

c. Subsequent Lift Placed More Than 8 Hours - Joint treatment for subsequent lifts placed more than 8 hours shall include:

(1) Maintaining 100 percent of each compacted lift-joint surface continuously moist by application of water.

(2) If necessary, the top surface of the completed layer (with indentations) shall be swept using a power broom or other method approved by the Contracting Officer to completely free the surface of all loose material. Air jetting may be used in conjunction with power brooming to facilitate surface cleaning.

(3) The top surface of the completed layer, if smooth (without indentations), shall be applied with bedding mortar in accordance with paragraph BEDDING MORTAR.

(4) Exception for Hot Weather Conditions. During periods of hot weather as defined in Paragraph: Hot Weather Placement, the time period for lift joint treatment shall be reduced to 4-hour.

3.4.6.2 Construction Joints

At the end of each day's work or whenever construction operations are interrupted for more than 2 hours, a transverse construction joint shall be formed in the last-placed lift by cutting back into the complete lift to form a full-depth vertical face.

3.5 CURING AND PROTECTION

3.5.1 Curing

Temporarily exposed surfaces of soil cement that will be in contact with succeeding layers of soil cement shall be kept continuously moist by moist curing method described hereinafter until placement of the subsequent layer. Curing of permanently exposed surfaces shall begin immediately after compaction and shall continue for at least 14 days. Soil cement shall be cured and protected from premature drying, extremes in temperature, rapid temperature change, freezing, mechanical damage and exposure to rain or flowing water. The Contractor shall have all equipment needed for adequate curing and protection on hand and ready to install before actual placement begins. The Contracting Officer shall approve the curing medium and method, or the combination of mediums and methods used. The soil cement shall be protected from the damaging effects of rain for 12 hours and flowing water for 14 days.

3.5.1.1 Moist Curing

Soil cement will be moist cured by maintaining all surfaces continuously, not periodically, wet for the duration of the entire curing period. Water

for curing shall comply with the requirements of paragraph: WATER. If water is used which stains or discolors soil cement surfaces, which are to be permanently exposed, the surfaces shall be cleaned to the satisfaction of the Contracting Officer. Horizontal surfaces may be cured by covering with a minimum uniform thickness of 6 inches of continuously saturated sand. Temporarily exposed surfaces may not be cured by saturated sand.

3.5.1.2 Truck Applications

Water trucks shall be used, as necessary, to keep surfaces moist at all times until a sprinkler system, wet burlap covering, or final curing method is implemented. The water truck shall be supplemented, as necessary, by mists from hand-held hoses. The truck operator shall be positioned so he is capable of seeing the spray at all times. The spray shall be capable of easy direction, either by attachment to the front of the truck so it can be directed by steering the truck or by other approved means. All spray nozzles both on the trucks and the hand held hoses shall be of a type that produces a true fog spray without any concentrated streams of water. The mist shall not be applied in a channelized or pressurized manner that in any way erodes the surface of the soil cement. It shall also be applied at a rate, which does not cause ponding at the surface. Trucks shall not be allowed to drop visible oil or other contaminants on the surface. If trucks must leave the surface, the tires shall be washed free of dirt or other foreign material before returning to the surface. Water truck wheel loads shall not exceed 4500 pounds and shall be such that no cracking or other damage to the soil cement is caused.

3.5.1.3 Sprinkler System

An approved sprinkler system consisting of pipelines and rotating or other approved type of sprinklers may be used. Sprinklers shall deliver a fine mist of water and shall not cause any erosion to the surface of the soil cement. The sprinkler system shall cover all portions of the soil cement surface, and keep the surface wet at all times.

3.5.1.4 Burlap

Burlap covers, if used, shall consist of two or more layers of burlap having a combined weight of 1.0 pounds per square yard in a dry condition. Burlap shall be either new or shall have been used only for curing soil cement or conventional portland cement concrete. Burlap strips shall have a length after shrinkage of at least 6 inches greater than necessary to cover the entire width and edges of the soil cement. Mats shall overlap each other at least 6 inches. Mats shall be thoroughly wetted before placing and shall be kept continuously wet and in intimate contact with the surface and edges of the area for the entire specified curing period.

3.5.1.5 Impervious Sheet Curing

The sheets, if used, shall comply with the requirements of ASTM C 171, except that the polyethylene film, if used, shall be white opaque. All surfaces shall be thoroughly wetted and be completely covered with waterproof paper or polyethylene film. Covering shall be laid with light-colored side up. Covering shall be taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or, replaced if tears or holes appear during the curing period.

3.5.1.6 Curing Compound

A curing compound conforming to ASTM C 309, Type 1-D, may be used on permanently exposed surfaces, which will not be in contact with succeeding layers of soil-cement. The curing compound shall be applied to surfaces as soon as final compaction has been completed. The curing compound shall be applied in a 1-coat continuous operation by approved motorized power-spraying equipment and pressure tank type equipment with provisions for continuous agitation. The compound shall be applied at a uniform coverage of not more than 150 square feet per gallon for each coat. Soil-cement surfaces, which have been subjected to rainfall within 3 hours after curing compound has been applied, shall be resprayed by the method and at the coverage herein specified. All surfaces on which the curing compound has been applied shall be adequately protected for the duration of the entire curing period from vehicular traffic and from any other cause, which will disrupt the continuity of the curing membrane.

3.5.2 Protection from Rain or Water Flow

If, prior to completion of compaction, the soil-cement mixture is wetted by rain or flowing water such that average moisture content exceeds the optimum moisture content specified by the mix design, at the time of final compaction, the entire layer affected, as determined by the Contracting Officer, shall be removed and shall be replaced in accordance with these specifications at the expense of the Contractor.

3.6 FINISHING

After compaction to the required lines and grades, the soil-cement surface shall be reasonably smooth with no trimming allowed. Finishing of the soil-cement shall be conducted at the completion of each day's production.

3.7 DISPOSAL OF UNSATISFACTORY MATERIALS

Any soil cement that is removed for the required correction of defective areas, waste material, and debris shall be disposed of as directed.

3.8 TESTS AND INSPECTIONS

3.8.1 General

The Contractor shall perform the inspection and tests as described below, and based upon the results of these inspections and tests, he shall take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the soil cement operation is out of control, soil cement placement shall cease. The laboratory performing the tests shall conform to ASTM E 329. Any test results requested by the Government for review shall be provided to the Government immediately, and all results of every test by the Contractor shall be furnished to the Government on a daily basis, not later than the day after the test or inspection is made.

3.8.2 Testing and Inspection Requirements

3.8.2.1 Calibration of Mixing Plant

a. Batch-Mixing Plants - Accuracy of the batching equipment shall be checked for each type of cementitious material and aggregate at the beginning of operations and at least once for every 10 shifts in the

presence of the Contracting Officer. Such checks shall also be made whenever there are variations in properties of the fresh soil cement, which could be the result of batching errors. Standard test weights accurate to plus or minus 0.1 percent shall be provided for checking plant scales.

b. Continuous-Mixing Plants - Accuracy of proportioning of the continuous-mixing plant shall be checked for each cementitious material every day at the beginning of operations and for soil aggregate at the beginning of construction and after every 10 shifts. The accuracy of proportioning shall be checked by simultaneously securing timed samples of the cementitious materials and the soil aggregate as they are fed to the mixer and weighing each as appropriate.

c. Mixing Time - Mixing time of the pug mill shall be checked at the direction of the Government. Unless otherwise required, determination of mixing time shall be by weight method using the following formula:

Mixing time in seconds = pug mill dead capacity in tons / pug mill output in tons per second.

3.8.2.2 Stockpiled Aggregate

Testing of stockpiled aggregate shall meet the requirements of paragraph STOCKPILING OF MATERIAL.

3.8.2.3 Batched Aggregate

At least once during each shift in which the mixing plant is operating, there shall be a sieve analysis in accordance with ASTM C 136 for the soil aggregate. The Contractor as the most advantageous for production control may select the location at which samples are taken. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. When deficiencies are found, the rate of testing shall be increased as directed. When two consecutive tests show the soil aggregate to be deficient in grading, the mixing operation shall be stopped until acceptable material is furnished for delivery to the mixer. Each time the Contractor performs a moisture-density relation, an additional gradation analysis in conformance with ASTM C 136 shall be performed, corresponding to the material used in the moisture-density relation.

3.8.2.4 Scales

a. Weighing Accuracy - The accuracy of the scales shall be checked by test weights at least once a month for conformance with the applicable requirements of paragraphs BATCH PLANT and CONTINUOUS MIXING PLANT. Such tests shall also be made as directed whenever there are variations in properties of the fresh soil cement that could result from batching errors.

b. Batching and Recording Accuracy - Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. The Contractor shall confirm that the calibration devices described in paragraph BATCH PLANT for checking the accuracy of dispensed admixtures are operating properly. If a continuous mixing plant is provided, the accuracy and operation of all feeding and dispensing units shall be checked before the start of operation each day.

c. Scales Corrective Action - When the weighing accuracy or batching

accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.8.2.5 Mixing Plant Control

The measurement of all constituent materials including cementitious materials, soil aggregate, and water shall be continuously controlled. The aggregate weight and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. A report shall be prepared indicating type and source of cement used, type and source of pozzolan used, and aggregate source, during plant operation.

3.8.2.6 Field Density

a. Testing and Checking - Density shall be determined for every 360 cubic yards of soil cement placed with a calibrated nuclear density gauge in accordance with ASTM C 1040. Field density tests shall be performed as soon as possible, but no later than 20 minutes after the completion of vibratory rolling. Each test shall include readings taken at 2-inch increment to the full depth of the compacted lift, minus 1-inch. Only the deepest reading shall be used to evaluate the density. Both wet and dry densities shall be reported and all individual readings shall be reported. However, only the wet density shall be used for evaluation.

b. Action Required - Whenever the nuclear gauge indicates density less than the specified density, a retest shall be made. If the retest indicates unacceptable density, the Contracting Officer's Representative shall be notified, additional rolling shall be immediately provided, and a determination shall be made as to whether the lower density resulted from insufficient passes of the roller or a change in the mix properties. If the mix properties have changed, adjustments such as increasing or decreasing the moisture content shall be made at the batch plant. If the problem persists, the Contracting Officer may adjust the proportions of aggregates, cement, and/or pozzolan. If the lower density is the result of incomplete rolling, the operator shall be notified and the Contracting Officer may require removal of the incompletely compacted material at no cost to the Government.

3.8.2.7 Inspection Before Placing

The Contractor shall inspect construction joints and other horizontal surfaces in sufficient time prior to the next lift placement to certify to the Contracting Officer that they are ready to receive soil cement. The results of each inspection shall be reported in writing. The inspection of the lift surfaces of the soil cement will be a continuing activity and shall be accomplished in accordance with paragraphs SURFACE PREPARATION and JOINTS.

3.8.2.8 Placing Inspection

a. Inspection - The Contractor shall provide full time supervision of all placing operations to insure that the correct quality of soil cement or bedding mortar are performed in accordance with the contract. During placing operations, the quality control staff shall measure and record soil cement temperatures in accordance with ASTM C 1064, ambient temperature hourly, record weather conditions, time of placement, yardage placed, and method of placement.

b. Corrective Action - The placing foreman shall not permit soil cement placing to begin until he has verified that necessary equipment are all in working order and with competent operators. Placing shall not be continued if any lift of soil cement is not fully compacted.

3.8.2.9 Compressive Strength Tests

At least two compressive strength tests shall be conducted for each 1000 cubic yards of soil cement placed. A test is defined as the average of two companion soil cement specimens. Samples shall be taken from the wet batched mix. Tests shall determine the one (1) day and seven (7) day compressive strengths in accordance with ASTM D 1633, Method A except that curing of specimens in the mold will be required only for the length of time necessary to satisfactorily remove the specimens from the mold without damage to the specimens. The one (1) day compressive strength test shall be used to monitor the daily output of the central mixing plant and shall be used to adjust soil cement mixture proportions as described in paragraph PROPORTIONING RESPONSIBILITY. The seven- (7) day compressive strength test shall be used for final acceptance of the soil cement.

3.8.2.10 Curing Inspection

a. Moist Curing Inspections - At least twice each shift and twice per day on nonwork days (weekends and holidays), an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist Curing Corrective Action - When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for those areas shall be extended by one day.

3.8.2.11 Cold-Weather and Hot-Weather Protection

At least once each shift and once per day on nonwork days an inspection shall be made of all areas subject to cold-weather or hot-weather protection. Any deficiencies shall be noted, corrected, and reported.

3.8.2.12 Cold-Weather and Hot-Weather Protection Corrective Action

When a daily inspection report lists deficiencies, the deficiency shall be corrected immediately and the period of protection extended for one day.

3.8.3 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of hot- and cold-weather protection, reports of pertinent temperatures shall be made daily. 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 --