

# Soil-Cement

## INFORMATION



## Suggested Specifications for Soil-Cement Linings for Lakes, Reservoirs, Lagoons

### 1. GENERAL

**1.1. Description.** Soil-cement shall consist of soil, portland cement, and water proportioned, mixed, placed, compacted, and cured in accordance with these specifications; and shall conform to the lines, grades, thicknesses, and typical cross section shown in the plans.

### 2. MATERIALS

**2.1. Soil.** Soil shall consist of the material in area to be lined or of approved select soil. Soil shall not contain any material retained on a 2-in. (50.8-mm) sieve, nor more than 45% retained on a No. 4 (4.75-mm) sieve, nor more than 35% or less than 5% passing the No. 200 (0.075-mm) sieve. The distribution and gradation of materials in the soil-cement lining shall not result in lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from surrounding material.

**2.2. Portland Cement.** Portland cement shall comply with the specifications for portland cement (ASTM C150, CSA A-5, or AASHTO M85) or blended hydraulic cements (ASTM C595 or AASHTO M240), excluding slag cements types S and SA, for the type specified. The amount of cement required should be determined by tests described in the Portland Cement Association publication *Soil-Cement for Water Control: Laboratory Tests (IS166W)* and made with the specific cement type and soil to be used in the lining.

**2.3. Water.** Water shall be free from substances deleterious to hardening of the soil-cement.

**2.4. Admixtures.** Pozzolans, such as fly ash, if used, shall comply with the specifications for fly ash and other pozzolans (ASTM C618). The amounts of cement and pozzolan required should be determined by tests with the specific cement type, pozzolan, and soil to be used in the lining.

### 3. PROPORTIONING

**3.1. Description.** The contractor shall use the soil aggregate designated by the engineer and the cement type and content and moisture content determined by the engineer in accordance with standard laboratory tests and set

forth in the plans and specifications. With the written approval of the engineer, the contractor may use a soil aggregate, cement type and content, and moisture content other than those designated by the engineer and set forth in the plans and specifications.

### 4. EQUIPMENT

**4.1. Description.** Soil-cement may be constructed with any machine or combination of machines or equipment that will produce completed soil-cement meeting the requirements for soil pulverization, cement and water application, mixing, transporting, placing, compacting, finishing, and curing as provided in these specifications.

**4.2. Mixing Methods.** Mixing shall be accomplished in a central mixing plant or in place, using single-shaft or multiple-shaft mixers.

**4.3. Cement Proportioning.** The cement meter for central-plant mixing and the cement spreader for in-place mixing shall be of approved types that will uniformly distribute the cement at the specified rate.

**4.4. Application of Water.** Water may be applied through the mixer or with water trucks equipped with pressure-spray bars.

**4.5. Compaction.** Soil-cement shall be compacted with one or a combination of the following: tamping or grid roller, pneumatic-tire roller, steel-wheel roller, vibratory roller, or vibrating-plate compactor.

### 5. CONSTRUCTION REQUIREMENTS (GENERAL)

**5.1. Preparation of Subgrade.** Before soil-cement processing begins, the area to be lined shall be graded and shaped to lines and grades as shown in the plans or as directed by the engineer. During this process any unsuitable soil or material shall be removed and replaced with acceptable material. The subgrade shall be firm and able to support without yielding or subsequent settlement the construction equipment and the compaction of the soil-cement hereinafter specified. Soft or yielding subgrade shall be corrected and made stable before construction proceeds.

**5.2. Mixing and Placing.** The soil aggregate shall be so pulverized that, at the completion of moist mixing, 100% by dry weight passes a 1-in. (25.4-mm) sieve, and a minimum of 80% passes a No. 4 (4.75-mm) sieve, exclusive of gravel or stone retained on those sieves.

Soil-cement shall not be mixed or placed when the soil aggregate or subgrade is frozen, or when the air temperature is below 45° F (8°C). However, when the air temperature is at least 40° F (5°C) and rising, soil-cement construction may proceed.

Moisture in the soil at the time of cement application shall not exceed the quantity that will permit a uniform and intimate mixture of the soil and cement during mixing operations, and shall be no more than the optimum moisture content for the soil-cement mixture.

The operations of cement application, mixing, spreading, compacting, and finishing shall be continuous and completed within 4 hours in daylight or under satisfactory lighting. Any soil-cement mixture that has not been compacted and finished shall not be left undisturbed for longer than 30 minutes.

## **6. CENTRAL-PLANT MIXING, HANDLING, PLACING**

**6.1. Mixing.** Soil-cement shall be central-plant mixed in an approved continuous-flow or batch-type pugmill mixer. The plant shall be equipped with metering and feeding devices that will supply the soil, cement, and water into the mixer in the specified quantities. If the actual quantities in the mix deviate more than 3% by weight from the specified quantities, the engineer may require such changes in the plant operation as will provide the required accuracy.

The mixing time shall be that which is required to secure an intimate uniform mixture of the soil, cement, and water.

**6.2. Handling.** The soil-cement mixture shall be transported in trucks or other equipment having beds that are smooth, clean, and tight. The contractor shall protect the soil-cement mixture whenever it is transported during unfavorable weather. Any soil-cement wet excessively by rain, whether during transport or after it has been spread, will be subject to rejection.

The total elapsed time between the addition of water to the soil and cement and the start of compaction shall not exceed 60 minutes.

The contractor shall take all necessary precautions to avoid damage to completed soil-cement by the equipment.

**6.3. Placing.** Immediately prior to placement of the soil-cement, the receiving surface shall be in a moist condition. The mixture shall be placed with spreading equipment that will produce layers of such widths and thicknesses as are necessary for compaction to the specified dimensions of the completed soil-cement.

## **7. MIXED-IN-PLACE MIXING AND PLACING**

**7.1. Preparation.** The surface of the soil to be processed into soil-cement shall be at an elevation so that, when mixed with cement and water and recompact to the required density, the final elevation will be as shown in the plans or as directed by the engineer. The material in place and surface conditions shall be approved by the engineer before the next phase of construction is begun.

**7.2. Pulverizing.** Before cement is applied, the soil to be processed may be scarified to the full depth of mixing. The soil should be damp at the time of scarifying to reduce the amount of dust and to aid in pulverization. The product of pulverization shall be such that at the completion of moist mixing, 100% by dry weight passes a 1-in. (25.4-mm) sieve, and not less than 80% passes a No. 4 (4.75-mm) sieve, exclusive of gravel or stone retained on those sieves.

**7.3. Application of Cement.** The specified quantity of cement shall be applied uniformly in a manner satisfactory to the engineer.

**7.4. Mixing.** Mixing with the addition of water, as specified in Section 8.1, shall be continued until the product is uniform in color and at the required moisture content throughout. The entire operation of cement spreading, water application, and mixing shall result in a uniform soil, cement, and water mixture for the full design depth and width.

## **8. COMPACTING AND FINISHING**

**8.1. Required Moisture.** Optimum moisture and maximum density for the section being processed shall be determined during construction by moisture-density test ASTM D558 or AASHTO T134 on representative samples of soil-cement mixture obtained from the area being processed at the time compaction begins. At time of compaction the moisture content shall not be less than 1 percentage point below optimum; shall be less than that which will cause the soil-cement to become unstable during compaction and finishing operations; and shall not be more than 2 percentage points above optimum.

**8.2. Compaction.** Soil-cement shall be uniformly compacted to at least 96% of maximum density as determined according to Section 8.1.

At the start of compaction the soil-cement mixture shall be in a loose condition for its full depth. No section shall be left undisturbed for longer than 30 minutes during compaction operations.

**8.3. Finishing.** As compaction nears completion, the surface of the soil-cement shall be shaped to the specified lines, grades, and cross sections. As necessary or as required by the engineer, the surface shall be lightly scarified to remove imprints left by equipment or to prevent compaction planes. During the finishing process the sur-

face shall be kept moist by means of fog-type sprays.

Compaction and finishing shall be done in such a manner as to produce, in not longer than 2 hours, a smooth, dense surface free of compaction planes, cracks, ridges, or loose material.

**8.4. Curing.** After completion of final finishing the surface shall be cured by application of a bituminous or other approved sealing membrane, or by being kept continuously moist for a period of 7 days with a fog-type water spray that will not erode the surface of the soil-cement.

**8.5. Construction Joints.** At the end of each day's work, or whenever construction operations are interrupted for more than 3 hours, a transverse construction joint shall be made. Such joints shall be full-depth vertical joints.

**8.6. Maintenance.** The contractor shall maintain the soil-cement in good condition until all work is completed and accepted. Such maintenance shall be done by the contractor at his own expense.

Maintenance shall include immediate repairs of any defects that may occur. If it is necessary to replace any soil-cement, the replacement shall be for the full depth, with vertical cuts, using either soil-cement or concrete. No skin patches will be permitted.

## 9. INSPECTION AND TESTING

**9.1. Description.** The engineer, with the assistance of and in cooperation with the contractor, shall make such inspections and tests as he deems necessary to ensure the conformance of the work to the contract plans and speci-

fications. These inspections and tests may include, but shall not be limited to (1) the close observation of the operation of all equipment used on the work, and (2) the taking of test samples of the soil-cement and its individual components at all stages of processing and after compaction and curing. Only those materials, machines, and methods meeting the requirements of the contract documents shall be approved by the engineer.

All testing of soil-cement or its individual components, unless otherwise provided specifically in the contract documents, shall be in accordance with the latest applicable ASTM or AASHTO specifications in effect on the date of advertisement for bids on the project.

## 10. MEASUREMENT AND PAYMENT

**10.1. Measurement.** This work will be measured (1) in cubic yards (cubic meters) of completed and accepted soil-cement lining as determined by the specified lines, grades, and cross sections shown in the plans; and (2) in tons or hundredweight (metric tonne) of cement incorporated into the soil-cement used for tests and for the lining in accordance with the instructions of the engineer.

**10.2. Payment.** This work will be paid for at the contract unit price per cubic yard (cubic meter) of soil-cement and at the contract unit price per unit of cement furnished, multiplied by the quantities obtained in accordance with Section 10.1. Such payment will constitute full reimbursement for all work necessary to complete the soil-cement slope protection, including watering, curing, inspection and testing assistance, and all other incidental operations.

Wherever multilayer soil-cement construction is required, scarifying, brooming, and protection of bonding surfaces shall be performed as described in applicable portions of Portland Cement Association publication IS167W, *Soil-Cement Slope Protection for Embankments: Construction*.

This publication is based on the facts, tests, and authorities stated herein. It is intended for the use of professional personnel competent to evaluate the significance and limitations of the reported findings and who will accept responsibility for the application of the material it contains. Obviously, the Portland Cement Association disclaims any and all responsibility for application of the stated principles or for the accuracy of any of the sources other than work performed or information developed by the Association.

These specifications are intended to serve as a guide to format and content for normal soil-cement construction. Most projects have special features or requirements that should be incorporated in the project documents.

PORTLAND CEMENT  ASSOCIATION

An organization of cement manufacturers to improve and extend the uses of portland cement and concrete through scientific research, engineering field work, and market development.

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