

SOIL-CEMENT

Information

Suggested Specifications for Soil-Cement Base Course Construction

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-sections shown in the plans.

These suggested specifications cover construction of soil-cement base course, also referred to in some areas as cement-treated based, cement-treated aggregate base, full depth recycling of flexible pavements, cement-recycled asphalt and base, and other names.

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.

2. MATERIALS

2.1 Soil. "Soil" may consist of (1) any combination of gravel, stone, sand, silt, and clay; (2) miscellaneous material such as caliche, scoria, slag, sand-shell, cinders, and ash; (3) waste material from aggregate production plants; (4) high-quality crushed stone and gravel base course aggregates; or (5) old flexible pavements, including the bituminous surface and stone or gravel base course.

The soil shall not contain roots, topsoil, or any material deleterious to its reaction with cement. The soil as processed for construction shall not contain material retained on a 2-in. (50-mm) sieve except for bituminous surface recycling work, which can contain up to 5% of the total mixed material retained on a 2-in (50-mm) sieve.

2.2 Portland Cement. Portland cement shall comply with the latest specifications for portland cement (ASTM C 150, ASTM C 1157, CSA A-23.5, or AASHTO M 85) or blended hydraulic cements (ASTM C 595, ASTM C 1157, CSA A-362, or AASHTO M 240).

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

2.4 Pozzolans. If used, pozzolans including fly ash, slag, and silica fume shall comply with the appropriate specifications (ASTM C 618, AASHTO M 295 for fly ash; ASTM C 989, AASHTO M 302 for slag; ASTM C 1240 for silica fume; or CSA A-23.5 for all).

2.5 Curing Compounds. Curing compounds shall comply with the latest specifications for emulsified asphalt (ASTM D 9773) or liquid membrane-forming compounds for curing concrete (ASTM C 309).

2.6 Sand Blotter. Sand used for the prevention of pickup of curing materials shall be clean, dry, and non-plastic.

3. EQUIPMENT

3.1 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.

3.2 Mixing Methods. Mixing shall be accomplished in a central mixing plant or in place, using single-shaft or multiple-shaft mixers. Agricultural disks or motor graders are not acceptable mixing equipment.

3.3 Cement Proportioning. The cement meter for central-plant mixing and the cement spreader for in-place mixing shall be capable of uniformly distributing the cement at the specified rate. Cement may be added in a dry or a slurry form. If applied in slurry form, the slurry mixer and truck shall be capable of completely dispersing the cement in the water to produce a uniform slurry, and shall continuously agitate the slurry once mixed.

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

3.5 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.

4. CONSTRUCTION REQUIREMENTS

4.1 General

4.1.1 Preparation of Subgrade. Before soil-cement processing begins, the area to be paved 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.

4.1.2 Mixing and Placing. Soil-cement shall not be mixed or placed when the soil aggregate or subgrade is frozen, or when the air temperature is below 40 °F (4 °C). 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 within 2% of the optimum moisture content for the soil-cement mixture at start of compaction.

The operation of cement application, mixing, spreading, compacting and finishing shall be continuous and completed within 4 hours from the start of mixing. Any soil-cement mixture that has not been compacted and finished shall not be left undisturbed for longer than 30 minutes.

4.2 Central-Plant-Mixed Method

4.2.1 Mixing. Soil-cement shall be central-plant mixed in an approved continuous-flow or batch-type pugmill, or rotary-drum mixer. The plant shall be equipped with metering and feeding devices that will add the soil, cement, and water into the mixer in the specified quantities. If necessary, a screening device shall be used to remove oversized material greater than 2 in (50 mm) from the raw soil feed prior to mixing. Soil and cement shall be mixed sufficiently to prevent cement balls from forming when water is added. The maximum plasticity index of the soil shall be eight.

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

Free access to the plant must be provided to the engineer at all times for inspection of the plant's operation and for sampling the soil-cement mixture and its components. If the actual quantities of the mix vary more than 3% by weight of the specified quantities, the engineer may require such changes in the plant operation as will provide the required accuracy.

4.2.2 Handling. The soil-cement mixture shall be transported from the mixing plant to the paving area in trucks or other equipment having

beds that are smooth, clean, and tight. Truck bed covers shall be provided and used at the engineer's discretion to protect the soil-cement during transport from moisture variations due to weather conditions. 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 mixture and the start of compaction shall be the minimum possible. Haul time shall not exceed 30 minutes, and compaction shall start as soon as possible after spreading. In no case shall the total elapsed time exceed 45 minutes between the addition of water to the soil and cement and the start of compaction.

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

4.2.3 Placing. Immediately prior to placement of the soil-cement, the receiving surface shall be in a moist condition. The mixture shall be placed without segregation at a quantity per linear foot (meter) that will produce a uniformly compacted layer conforming to the required grade and cross section. The mixture shall be spread by one or more approved spreading devices. Not more than 60 minutes shall elapse between placement of soil-cement in adjacent lanes at any location except at longitudinal and transverse construction joints.

4.3 Mixed-in-Place Method

4.3.1 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.

4.3.2 Scarifying. Before cement is applied, the soil to be processed may be scarified to the full depth of mixing. Scarification and pre-pulverization are required for the following conditions:

(1) For cohesive soils with a plasticity index greater than 20, the soil shall be damp at the time of scarifying to reduce dust and aid in pulverization.

(2) For full depth recycling of flexible pavements where the bituminous surface is incorporated into the mixture, the pulverization to final specified gradation, as noted in Section 4.3.4, shall be accomplished prior to cement application.

(3) For slurry application of cement, initial scarification shall be done to provide a method to uniformly distribute the slurry over the soil without excessive runoff or ponding.

4.3.3 Application of Cement. The specified quantity of cement shall be applied uniformly in a manner that minimizes dust and is satisfactory to the engineer. If cement is applied as a slurry, the time from first contact of cement with water to application on the soil shall not exceed 60 minutes. The time from slurry placement on the soil to start of mixing shall not exceed 30 minutes.

4.3.4 Mixing. Mixing shall begin as soon as possible after the cement

has been spread and shall continue until a uniform mixture is produced. The mixed material shall meet the following gradation conditions:

(1) For soils, 100% of the soil-cement mixture shall pass a 1-in. (25-mm) sieve and a minimum of 80% shall pass a No. 4 (4.75-mm) sieve, exclusive of any gravel or stone. Gravel or stone shall be no more than 2-in. (50-mm) nominal maximum size.

(2) For full-depth recycling, the final mixture (bituminous surface, granular base, and subgrade soil) shall be pulverized such that 95% passes the 2-in. (50-mm) sieve and at least 55% passes the No. 4 (4.75-mm) sieve. No more than 50% of the final mixed material shall be made of the existing bituminous material unless approved by the engineer and included in a mixture design. Additional material may be added to the top or from the subgrade to improve the mixture gradation, as long as this material was included in the mixture design.

The final pulverization test shall be made at the conclusion of mixing operations. Mixing shall be continued until the product is uniform in color, meets gradation requirements, and is 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.

4.4 Compaction. Soil-cement shall be uniformly compacted to a minimum of 98% of maximum density based on a moving average of five consecutive tests with no individual test below 96%. Field density of compacted soil-cement can be determined by the 1) nuclear method in the direct transmission mode (ASTM D 2922, AASHTO T 238); 2) sand cone method (ASTM D 1556, AASHTO T 191); or rubber balloon method (ASTM D 2167 or AASHTO T 205). Optimum moisture and maximum density shall be determined prior to start of construction and also in the field during construction by a moisture density test (ASTM D 558 or AASHTO T 134).

At the start of compaction whether central-plant mixed or mixed-in-place, the moisture content shall be within 2% of the specified optimum moisture. No section shall be left undisturbed for longer than 30 minutes during compaction operations. All compaction operations shall be completed within 2 hours from the start of mixing.

4.5 Finishing. As compaction nears completion, the surface of the soil-cement shall be shaped to the specified lines, grades, and cross sections. If necessary or as required by the engineer, the surface shall be lightly scarified or broom-dragged to remove imprints left by equipment or to prevent compaction planes. Compaction shall then be continued until uniform and adequate density is obtained. During the finishing process the surface shall be kept moist by means of fog-type sprayers. Compaction and finishing shall be done in such a manner as to produce dense surface free of compaction planes, cracks, ridges, or loose material. All finishing operations shall be completed within 4 hours from start of mixing.

4.6 Curing. Finished portions of soil-cement that are traveled on by equipment used in constructing an adjoining section shall be protected in such a manner as to prevent equipment from marring or damaging completed work.

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. If curing material is used, it shall be applied as soon as possible, but not later than 24 hours after completing finishing operations. The surface shall be kept continuously moist prior to application of curing material.

For bituminous curing material, the soil-cement surface shall be dense, free of all loose and extraneous materials, and shall contain sufficient moisture to prevent excessive penetration of the bituminous material. The bituminous material shall be uniformly applied to the surface of the completed soil-cement. The exact rate and temperature of application for complete coverage, without undue runoff, shall be specified by the engineer.

Should it be necessary for construction equipment or other traffic to use the bituminous-covered surface before the bituminous material has dried sufficiently to prevent pickup, sufficient sand blotter cover shall be applied before such use.

Sufficient protection from freezing shall be given the soil-cement for at least 7 days after its construction or as approved by the engineer.

4.7 Construction Joints. At the end of each day's construction a straight transverse construction joint shall be formed by cutting back into the completed work to form a true vertical face.

Soil-cement for large, wide areas shall be built in a series of parallel lanes of convenient length and width meeting approval of the engineer. Straight longitudinal joints shall be formed at the end of each day's construction by cutting back into completed work to form a true vertical face free of loose or shared material.

Special attention shall be given to joint construction to ensure a vertical joint, adequately mixed material, and compaction up against the joint. On mixed-in-place construction using transverse shaft mixers, a longitudinal joint constructed adjacent to partially hardened soil-cement built the preceding day may be formed by cutting back into the previously constructed area during mixing operations. Guide stakes shall be set for cement spreading and mixing.

4.8 Traffic. Completed portions of soil-cement can be opened immediately to low-speed local traffic and to construction equipment provided the curing material or moist curing operations are not impaired, and provided the soil-cement is sufficiently stable to withstand marring or permanent deformation. The section can be opened up to all traffic after the soil-cement has received a curing compound or subsequent surface, and is sufficiently stable to withstand marring or permanent deformation. If continuous moist curing is employed in lieu of a curing compound, the soil-cement can be opened to all traffic after the 7-day moist curing period, provided the soil-cement has hardened sufficiently to prevent marring or permanent deformation.

4.9 Surfacing. Subsequent pavement layers (asphalt, chip-seal, or concrete) can be placed any time after finishing, as long as the soil-cement is sufficiently stable to support the required construction equipment without marring or permanent distortion of the surface.

4.10 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.

5. INSPECTION AND TESTING

5.1 Description. The engineer, with the assistance and cooperation of the contractor, shall make such inspections and tests as deemed necessary to ensure the conformance of the work to the contract documents. These inspections and tests may include, but shall not be limited to, (1) the taking of test samples of the soil-cement and its individual components at all stages of processing and after completion and (2) the close observation of the operation of all equipment used on the work. 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, AASHTO, or CSA specifications in effect as of the date of advertisement for bids on the project.

6. MEASUREMENT AND PAYMENT

6.1 Measurement. This work will be measured (1) in square yards (square meters) of completed and accepted soil-cement base course as determined by the specified lines, grades, and cross sections shown on the plans and (2) in tons (tonnes) or cwt of cement incorporated into the soil-cement base course in accordance with the instructions of the engineer.

6.2 Payment. This work will be paid for at the contract unit price per square yard (square meter) of soil-cement base course and at the contract unit price per ton (tonne) or cwt of cement furnished, multiplied by the quantities obtained in accordance with Section 6.1. Such payment shall constitute full reimbursement for all work necessary to complete the soil-cement, including watering, curing, inspection and testing assistance, and all other incidental operations.

KEYWORDS: compacting, curing, density, finishes, inspection, joints, maintenance, measurement, soils, soil-cement, specifications, subgrades.

ABSTRACT: Specifies materials to use and construction methods needed to produce soil-cement base courses. A résumé of preparation; pulverization; cement application, mixing and spreading (mixed-in-place and central-plant-mixed methods); compaction; finishing; curing; jointing; maintenance; measurements; and basis of payment for a soil-cement base course.

REFERENCE: *Suggested Specifications for Soil-Cement Base Course (Soil-Cement, Cement-Treated Base, Cement-Treated-Aggregate Base)*, IS008.11, Portland Cement Association, 2001.

CAUTION: Avoid prolonged contact between unhardened (wet) cement or cement-treated mixtures and skin surfaces. To prevent such contact, it is advisable to wear protective clothing. Skin areas that have been exposed to wet cement or cement-treated mixtures, either directly or indirectly or through saturated clothing, should be thoroughly washed with water.

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