Preparing Activity: USACE Superseding
UFGS-32 11 33 (August 2008)
UFGS-32 11 34 (August 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC / NASA **UFGS-32 11 33.13 (May 2020)**

Preparing Activity: USACE **Superseding**
UFGS-32 11 33 (August 2008)
UFGS-32 11 34 (August 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023

****

SECTION 32 11 33.13

PORTLAND CEMENT-STABILIZED BASE COURSES
05/20

****

NOTE: This guide specification covers the requirements for portland cement-stabilized base or subbase for airfields, roads, and streets.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

PART 1 GENERAL

****

NOTE: In general, this specification is written for portland cement-stabilized base or subbase courses. Use UFGS 32 11 36.13, LEAN CONCRETE BASE COURSE, for Lean Concrete Base (LCB) or Econocrete applications.

****

1.1 UNIT PRICES

1.1.1 Measurement

****

NOTE: Delete this paragraph when lump sum payment is desired.

****
Measure by the square m yard of work completed and accepted.

1.1.2 Payment

****
Delete the last sentence in brackets if sanding and dusting of the bituminous-cured surfaces is not required or if bituminous-cured surfaces are to receive bituminous surfacing under the contract.
****

Cement stabilization, constructed and accepted, will be paid for at the respective contract unit prices in the bidding schedule. No payment will be made for any material wasted, used for convenience, unused or rejected, or for water used. [No separate payment will be made for sanding or dusting the bituminous prime-coated surfaces, and all costs for sanding or dusting will be included in the contract unit price for bituminous material.]

1.2 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C171	(2020) Standard Specification for Sheet Materials for Curing Concrete
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2022) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	(2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1602/C1602M	(2022) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D558/D558M	(2019) Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures
ASTM D559	(2003) Wetting and Drying Compacted Soil-Cement Mixtures

ASTM D560	(2003) Freezing and Thawing Compacted Soil-Cement Mixtures
ASTM D977	(2019a; E 2019) Standard Specification for Emulsified Asphalt
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1632	(2007) Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory
ASTM D1633	(2000; R 2007) Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders
ASTM D2397/D2397M	(2019a) Standard Specification for Cationic Emulsified Asphalt
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.3 DEFINITION

Cement-stabilized mixture, as used herein, is a mixture of Portland cement and in-place or select borrow material uniformly blended and compacted as specified to produce a pavement base course or subbase which meets the criteria set forth in the drawings and specifications. The cement-stabilized mixture placed directly under the bituminous surface course or under the concrete pavement is a base course. The cement-stabilized mixture placed under a base course is a subbase course.

1.4 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mix Design; G[, [_____]]

Aggregate
Asphalt Emulsion

SD-06 Test Reports

Aggregate

Compressive Strength

1.5 QUALITY CONTROL

1.5.1 Qualifications

Perform sampling and testing using an approved commercial testing laboratory or on-site facilities that is accredited in accordance with ASTM C1077. Do not start work requiring testing until the facilities have been inspected and approved. The Government will inspect all laboratories requiring validation for equipment and test procedures prior to the start of any stabilization operations for conformance to ASTM C1077. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. Maintain this certification for the duration of the project.

1.5.2 Test Results

Verify that materials comply with the specification. When a material source is changed, [test the new material for compliance] [_____]. When deficiencies are found, repeat the initial analysis and retest the material already placed to determine the extent of unacceptable material. Replace or repair all in-place unacceptable material to conform to the contract requirements. Perform tests in sufficient numbers, and as specified, to ensure that materials and compaction meet specified requirements. Furnish copies of the test results within 24 hours of completion of tests.

1.5.3 Aggregate

Submit notification of sources from which aggregates are to be obtained, within 15 days after the award of contract. Perform tests for determining the suitability of aggregate including, but not limited to: sieve analysis in accordance with ASTM C136/C136M using sieves conforming to ASTM E11 and liquid limits and plasticity index in accordance with ASTM D4318. Take aggregate samples for laboratory tests in accordance with ASTM D75/D75M. Submit certified copies of aggregate test results, not less than [30] [_____] days before the material is required in the work.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not apply cement when the atmospheric temperature is less than 5 degree C 40 degrees F or to soils that are frozen or contain frost, or when the underlying material is frozen. If the temperature falls below 2 degree C 35 degrees F, protect completed cement-stabilized mixture against detrimental effects of freezing. Bring any areas of completed cement-stabilized mixture that are damaged by freezing, rainfall, or other weather conditions to a satisfactory condition in conformance with this specification.

1.7 ACCEPTANCE

1.7.1 Tolerances

Acceptance of cement-stabilized mixture is based on compliance with the tolerances presented in Table 1. Remove and replace cement-stabilized mixture represented by the failing tests or submit plan for approval.

TABLE 1	
Measurement	Tolerance
Grade	plus/minus 15 mm 0.05 foot
Smoothness	plus/minus 10 mm 3/8 inch
Thickness (individual measurement)	plus/minus 13 mm 1/2 inch
Thickness (average)	plus/minus 6 mm 1/4 inch
Field Density	98 percent minimum
Compressive Strength	minus 350 kPa 50 psi below specified strength

1.7.2 Test Section

[Place a test section of at least 2.5 by 30 m 8 by 100 feet, utilizing the equipment and procedures proposed for use, to demonstrate that cement stabilized mixture conforming to this specification can be produced. Acceptance of the test section is based on compliance with the tolerances listed in Table 1.] [A test section is not required].

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

2.1.1.1 Portland Cement

Provide cement conforming to ASTM C150/C150M, Type I, IA, II, or IIA low alkali or ASTM C595/C595M, Type IS or IS(A).

2.1.1.2 Slag Cement

Provide slag cement (ground-granulated blast-furnace slag) conforming to ASTM C989/C989M, [Grade 100 or]Grade 120.

2.1.1.3 Fly Ash

Provide fly ash conforming to ASTM C618, Class F, including the optional requirements for uniformity and a loss on ignition not exceeding 6 percent.

2.1.2 Material to be Stabilized

****
NOTE: For base courses, delete requirements for in-place materials. For cement-treated base to be overlaid with Portland cement concrete pavement, limit maximum aggregate size to 25 mm 1 inch.
****

2.1.2.1 Aggregate for Cement Treated Base

Provide aggregate consisting of crushed or uncrushed gravel and/or stone, free of roots, sod, and weeds, meeting the requirements below:

a. Plasticity index of less than 6 and liquid limit less than 25 in accordance with ASTM D4318.
b. Percentage of wear less than 40 percent in accordance with ASTM C131/C131M.
c. Soundness loss after 5 cycles of 10 percent maximum using Sodium Sulfate or 15 percent maximum using Magnesium Sulfate in accordance with ASTM C88.
d. Flat, elongated or flat and elongated particles 10 percent maximum, by weight, for fraction retained on the 12.5 mm 1/2 inch sieve and 20 percent maximum, by weight, for the fraction passing the 12.5 mm 1/2 inch sieve in accordance with ASTM D4791.
e. Clay lumps and friable particles less than or equal to 3 percent in accordance with ASTM C142/C142M
f. Test virgin crushed stone or gravel sources for alkali-aggregate reactivity in accordance with ASTM C1260, and reject materials having a measured expansion greater than 0.10 percent in 16 days.
g. Gradation meeting the limits of Table 2, in accordance with ASTM C117 and ASTM C136/C136M.

TABLE 2

Sieve Designation	Percent Passing By Weight
50 mm2 inch	100
25 mm1 inch	90-100
4.75 mmNo.4	45-95
2.00 mmNo. 10	37-80
425 micrometersNo. 40	15-50
75 micrometersNo. 200	0-15
Note: For Cement Treated Base under concrete surfacing, limit the 25 mm 1 inch size to 100 percent passing.	

2.1.2.2 Aggregate for Cement-Treated Subbase

****
NOTE: Evaluate native subgrade for potential sulfate reaction. If the soil has a water-soluble sulfate content greater than 0.10 percent, by weight, do not use cement stabilization for subbase materials. Consult UFC 3-260-02, Chapter 9, for additional guidance for airfield projects.
****

[Aggregate materials conforming to ASTM D2487, classified as GW, GP, GM, SW, SM, SP or combination(s) thereof. Sample materials in accordance with ASTM D75/D75M. Plasticity index of less than 12 [_____] and liquid limit

less than 25 [_____] in accordance with ASTM D4318. Perform sieve analysis in accordance with ASTM C117 and ASTM C136/C136M. Provide aggregates with a maximum size of 50 mm 2 inches and within the limits specified as follows:

TABLE 3	
Sieve Designation	Percent by Weight Passing
4.75 mm No. 4	55 - 100
2.00 mm No. 10	36 - 60
150 micrometers No. 100	3 - 20

]

2.1.3 Water

Provide water which is clean, fresh, and free from injurious amounts of oil, acid, salt, alkali, organic matter, and other substances deleterious to the hardening of the cement-stabilized mixture, and subject to approval. Test non-potable water sources for conformance with ASTM C1602/C1602M.

2.1.4 Curing Materials

****

NOTE: It may be advantageous to specify only bituminous curing for stabilized base courses which are to receive bituminous surfacing or to specify membrane forming curing compound for stabilized base courses which are to receive Portland cement concrete surfacing, in which case, other curing materials and methods will be deleted.

****

2.1.4.1 Burlap

Conforming to AASHTO M 182.

2.1.4.2 Impervious Sheeting

White waterproof paper, white opaque polyethylene film or white burlap-polyethylene sheets conforming to ASTM C171.

2.1.4.3 Bituminous Material

Asphalt emulsion conforming to ASTM D977, Type [RS-1] [SS-1] or ASTM D2397/D2397M Type [CRS-1].

2.1.4.4 Curing Compound

White-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class A or Class B (wax-based) for curing cement-stabilized mixture placed as a base course under Portland cement concrete pavement.

2.2 MIX DESIGN

****

NOTE: Designer should refer to UFC 3-250-11 for

general guidance and UFC 3-260-02 for airfield pavement projects for further guidance on restrictions to be placed or requirements added to the mix design paragraph, and information on applicability of stabilization with portland cement.

Remove bracket from selected choice and delete the others.

****

Submit proposed mix design, prior to start of stabilization work. Develop the mix using the aggregate or soil-aggregate material to be stabilized. Design mix for a minimum 7-day compressive strength of [[1.75 MPa 250 psi for subbase,][5 MPa 750 psi for base] under flexible pavement,][[1.37 MPa 200 psi for subbase][3.44 MPa 500 psi for base] under Portland cement concrete pavement. Avoid higher strength due to potential to cause shrinkage and reflective cracks.] Limit weight loss to 14 percent or less after 12 cycles of the durability test.

2.2.1 Laboratory Density

Conduct moisture-density tests in accordance with the procedure contained in ASTM D558/D558M. Use the apparatus and procedures outlined in ASTM D1557 to compact the cement-stabilized mixture.

2.2.2 Unconfined Compression

Conduct three unconfined compression tests, in accordance with ASTM D1633, for each mix design tested. Prepare specimens to be used for unconfined compression tests in accordance with ASTM D1632. Use a 100 mm 4 inch diameter by 200 mm 8 inch high mold to prepare specimens when more than 35 percent of the material is retained on the 4.75 mm No. 4 sieve. Cure samples at a constant moisture content and temperature for 7 days.

2.2.3 Durability

****

NOTE: Where the aggregate is an approved select material, the use of the test procedures conforming to ASTM D 559 and ASTM D 560 may be waived. For other soil-aggregates, consult ASTM C 33, Figure 1 for weathering region of project site. Conduct wet-dry and freeze-thaw durability tests for sites located in the severe weathering region.

****

[Conduct wet-dry tests in accordance with ASTM D559.] [Conduct freeze-thaw tests in accordance with ASTM D560.] Test three specimens for each mix design.

2.2.4 Mix Design Report

Perform trial design batches, mixture proportioning studies, testing, and include results demonstrating that the proposed mixture proportions produce cement-stabilized mixture of the qualities indicated. Submit test results in a mix design report to include:

a. Coarse and fine aggregate gradations and plots.
b. Coarse aggregate quality test results, include deleterious materials.

c. Fine aggregate quality test results.
d. Durability test results.
e. Mill certificates for cement and supplemental cementitious materials.
f. Recommended proportions and volumes for proposed mixture.
g. Moisture-density curve for selected cement content.
h. Individual compressive strength test results.
i. Narrative discussing methodology on how the mix design was developed.

2.3 EQUIPMENT

****
NOTE: Specify a Central Plant for mixing cement-treated base and delete the pulvimixer and traveling plant provisions. For cement-treated subbase, retain central plant, pulvimixer, and traveling plant provisions.
****

Plant, equipment, machines, and tools used in the work are subject to approval. Maintain in a satisfactory working condition at all times. Provide equipment with the capability of producing the required compaction, meeting grade controls, thickness control and smoothness requirements specified.

2.3.1 Central Plant

Provide a batch or continuous flow type central plant capable of producing a uniform cement stabilized mixture at the required cement and moisture contents. Equip the mixer with calibrated metering and feeding devices that introduce the aggregate, cement, water, and cementitious additives (if used) into the mixer in the specified quantities. If necessary, use a screening device to remove oversized material from the raw aggregate feed prior to mixing.

2.3.2 Mechanical Spreader

Provide a steerable, self propelled, mechanical spreader having variable speeds forward and reverse. Mount the spreader on tracks, rubber tires, or drum-type steel rollers that will not disturb the underlying material. Provide a spreader containing a hopper, an adjustable screed, and outboard bumper rolls; designed to have a uniform, steady flow of material from the hopper; and capable of laying material without segregation, across the full width of the lane, to a uniform thickness and to a uniform loose density so that when compacted, the layer or layers conform to thickness and grade requirements indicated.

2.3.3 Pulvimixer

Provide self-propelled, four-wheel drive pulverizing and mixing equipment, capable of pulverizing the soil in a single pass for the full depth to be stabilized and providing a mixing action capable of uniformly blending and mixing the required cement content with the aggregate. Equip with a rotor capable of up or down cutting.

2.3.4 Traveling Plant

Provide a traveling plant capable of moving at a uniform rate of speed and accomplishing thorough mixing of the materials in one pass. Deliver water and cement from supply trucks or bins at a predetermined rate.

Construct windrows of prepared cement stabilized mixture to cover a predetermined width to the indicated compacted thickness.

2.3.5 Rollers

Compact the cement stabilized mixture using one or a combination of the following pieces of equipment: tamping or grid roller; steel-wheeled roller; vibratory roller; pneumatic-tire roller, and/or vibrating plate compactor (for areas inaccessible to rollers). Compact the cement stabilized mixture to the required density using the number, type, and weight of rollers and/or compactors sufficient to compact the mixture to the required density.

2.3.6 Straightedge

Furnish and maintain at the site, in good condition, one [3.0] [3.7] meter [10] [12] foot straightedge for use in the testing of the finished surface. Make straightedges available for Government use. Construct straightedges of aluminum or other lightweight metal with blades of box or box-girder cross section with flat bottom reinforced to insure rigidity and accuracy. Provide handles on straightedges to facilitate movement on pavement.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Do not apply cement if the soil moisture content exceeds optimum moisture content specified for the cement-stabilized mixture. When the stabilized course is constructed in more than 1 layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. Provide adequate drainage during the entire construction period to prevent water from collecting or standing on the areas to be stabilized or on pulverized, mixed, or partially mixed material. Provide line and grade stakes as necessary for control. Place grade stakes in lines parallel to the centerline of the area under construction and suitably spaced for string lining.

3.2 OPERATION OF BORROW PITS

****

NOTE: Paragraph will be deleted when select material is not required or when small quantities do not justify the inclusion of select material.

****

[Clear, strip, and excavate borrow pit working depth in a manner that produces excavation faces that are as nearly vertical as practicable for the materials being excavated. Waste strata of unsuitable materials overlying or occurring in the deposit. Upon completion of the work, condition pit to drain readily, and leave in a satisfactory condition.] [Obtain borrow material from approved offsite sources.]

3.3 STOCKPILING MATERIALS

****

NOTE: Delete this paragraph when select material is not required or when small quantities do not justify

the inclusion of select material.
****

Stockpile select material, including approved material available from excavation and grading, in the manner and at the locations designated. Before stockpiling of material, clear, drain and level the storage sites. Separately stockpile materials obtained from different sources.

3.4 PREPARATION OF AREA TO BE STABILIZED

****
NOTE: Delete inapplicable paragraph.
****

Clean debris from area to be stabilized; inspect for adequate compaction; and ability to withstand, without displacement, the compaction specified for the cement stabilized mixture. Dispose of debris and removed unsatisfactory in-place material as specified.

3.4.1 In-Place Material to be Stabilized

Grade the entire area to be stabilized and shape to conform to the lines, grades, and cross sections shown in the plans, prior to being processed. Stabilize soft or yielding areas before construction is begun.

3.4.2 In-Place Materials to Receive Stabilized Course

****
NOTE: If this paragraph is retained, delete inapplicable portions.
****

[Correct soft, yielding areas and ruts or other irregularities in the surface. Loosen material in the affected areas and remove unsatisfactory material. Add approved select material where directed. Shape the area to line, grade, and cross section, and compact to the specified density.] [Conform Subgrade to Section 31 00 00 EARTHWORK.] [Conform Subbase course to Section 32 11 20 [BASE COURSE FOR RIGID][AND][SUBBASE] [SELECT-MATERIAL] [FOR FLEXIBLE PAVING].]

3.4.3 Select Material

****
NOTE: Delete if select material is not required.
****

Utilize sufficient select material to provide the required thickness of the cement stabilized mixture layer after compaction and process to meet the requirements specified before cement stabilization is undertaken.

3.5 INSTALLATION

****
NOTE: For base courses using imported select material, specify central plant mixing and delete requirements for in-place materials, traveling plant, and in-place mix method. For native soil subbase courses, retain all methods as a contractor option.

****

3.5.1 Edges of Stabilized Course

Placed approved material along the edges of the cement-stabilized mixture in such quantity as will compact to the thickness of the course being constructed, or to the thickness of each layer in a multiple-layer course, allowing at least a 300 mm 1 foot width of the shoulder to be rolled and compacted simultaneously with the rolling and compacting of each layer of the cement-stabilized mixture.

3.5.2 Mixed-in-Place Method

3.5.2.1 Scarifying and Pulverizing of Soil

Prior to the application of cement, scarify and pulverize the soil [to the depth shown] [to a depth of [_____] mm inches]. Carefully control scarification so that the layer beneath the layer to be stabilized is not disturbed. Do not pulverize to a depth exceeding the depth of scarification. Unless otherwise permitted, do not scarify and pulverize an area greater than can be completed in 2 working days.

3.5.2.2 Application of Cement

Approximately shape pulverized material to the cross section indicated. Apply cement so that when uniformly mixed with the soil, the specified cement content is obtained, and a sufficient quantity of cement-treated soil is produced to construct a compacted cement-stabilized mixture conforming to the lines, grades, and cross section indicated. Do not pass over the freshly spread cement-stabilized mixture, except for equipment used in spreading and mixing operations.

3.5.2.3 Dry Mixing

Immediately after the cement has been distributed, mix with the soil. Do not mix below the required depth. Continue mixing until the cement has been sufficiently blended with the soil to prevent the formation of cement balls when water is applied.

3.5.2.4 Water Application and Moist Mixing

Determine moisture content of the cement stabilized mixture immediately after completion of mixing of the soil and cement. Provide water-supply and pressure distributing equipment that will permit the continuous application within 3 hours of all water required on the section being processed. Incorporate water in the mix so that concentration of water near the surface does not occur. After all the mixing water has been added, continue mixing until the water is uniformly distributed throughout the full depth of the mixture, with no portion of the mixture remaining undisturbed during mixing for more than 30 minutes. Dispose of any portion of the cement stabilized mixture remaining undisturbed more than 30 minutes during mixing.

3.5.3 Central-Plant Method

Haul the cement stabilized mixture to the job in trucks equipped with protective covers. Thoroughly moisten the underlying course and deposit the material on the prepared area in a quantity that will produce a compacted base of uniform density to the required grade and cross

section. Operate spreading or spreading-trimming equipment to produce a layer of material which is uniform in thickness and surface contour and free from irregularities in density. Use spreading or spreading-trimming equipment in sufficient numbers and in staggered formation to obtain full-width spreading in one construction operation. Start the compaction of the treated layer within 60 minutes after the start of the moist mixing. Place cement stabilized mixture in adjacent lanes within 30 minutes.

3.5.4 Traveling-Plant Method

Move traveling plant at a uniform rate of speed to accomplish thorough mixing of the materials. Deliver water and cement from supply trucks or bins at a predetermined rate. Construct windrows of prepared cement stabilized mixture of sufficient size to cover a predetermined width to the indicated compacted thickness.

3.5.5 Layer Thickness

Compact thickness of the cement-stabilized mixture [as indicated] [to [_____] mm inches]. Do not compact layers in excess of 200 mm 8 inches nor less than 100 mm 4 inches in compacted thickness.

3.5.6 Compaction

****
NOTE: Density will be based on the material being stabilized.
****

As a continuation of the mixing operation, thoroughly loosen the mixture to the full depth before compaction operations are started. At the beginning of compaction, process the mixture to provide a uniform blend with 100 percent passing the specified maximum aggregate size. Start compaction immediately after mixing is completed. Compact the cement stabilized mixture to at least 98 [_____] percent of the maximum density obtained from the laboratory samples prepared and tested in accordance with paragraph: LABORATORY DENSITY. Uniformly and continuously compact the loose mixture until the entire depth and width of the area are compacted to the density specified. Maintain the moisture content at the surface near optimum at all times through the rolling, but less than that quantity which will cause the cement stabilized mixture to become unstable during compaction. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Use slightly different lengths on alternate trips of the roller. Do not permit displacement of the cement stabilized mixture due to the speed of the roller. Compact areas inaccessible to rollers with mechanical tampers.

3.6 FINISHING

Moisten the surface, if necessary, and shape to the required lines, grades, and cross section. Lightly scarify the surface, if necessary, to eliminate any imprints made by the compacting or shaping equipment. Thoroughly compact the surface to the specified density with rubber-tired rollers and smooth-wheel tandem rollers to the extent necessary to provide a smooth, dense, uniform surface that is free of surface checking, ridges, or loose material, and that conforms to the crown, grade, and line indicated. Complete these finishing operations within 2 hours after

completion of mixing operations. In places not accessible to finishing and shaping equipment, compact the cement-stabilized mixture with mechanical tampers to the density specified and shape and finish by hand methods. Correct, as specified below, any portion of the compacted mix that has density less than that specified, that has not properly hardened, or that is improperly finished.

3.7 CONSTRUCTION JOINTS

At the end of each day's construction, form a straight transverse construction joint by cutting back into the completed work to form a true vertical face free of loose or shattered material. Remove material along construction joints not properly compacted and replace with cement stabilized mixture mixed, moistened, and compacted as specified.

3.8 CURING AND PROTECTION

****

NOTE: Coordinate curing requirements with materials selection in Part 2. Delete Bond Breaker if the stabilized base will not be overlaid with Portland cement concrete.

****

Protect the finished surface against rapid drying for 7 days by one of the methods specified.

3.8.1 Burlap

Provide burlap consisting of 2 or more layers of burlap having a combined weight of 400 grams 14 ounces or more per square meter square yard in a dry condition. Provide burlap that is either new or used only for curing concrete. Provide burlap strips with a length, after shrinkage, of at least 300 mm 1 foot greater than necessary to cover the entire width and edges of the finished stabilized area. Overlap mats at least 150 mm 6 inches. Thoroughly wet mats before placing and keep continuously wet and in contact with the surface and edges of the finished stabilized area for the entire curing period.

3.8.2 Impervious Sheeting

Moisten the surface of the finished stabilized area with a fine spray of water and then cover with impervious sheeting. Thoroughly saturate the burlap of the polyethylene-coated burlap with water before placing. Place sheeting with the light-colored side up. Extend sheets over the edges of the stabilized area and hold securely in place throughout the curing period. Overlap edges of sheets each other at least 300 mm 12 inches and securely glue or tape to form continuous closed joints. Repair tears and holes in sheets immediately.

3.8.3 Bituminous Material

****

NOTE: The last sentence will be deleted if sanding and dusting of the bituminous-cured surfaces is not required or if bituminous-cured surfaces are to receive bituminous surfacing under the contract.

****

Apply bituminous material uniformly by means of a bituminous distributor

within a temperature range of 25 to 55 degrees C 75 to 130 degrees F, as directed. Uniformly apply bituminous material at the residual asphalt content rate of 0.7 to 1.4 L/square meter 0.15 to 0.30 gallon/square yard. Treat areas inaccessible to or missed by the distributor using the manually operated hose attachment. Apply bituminous material only to the top layer. At the time the bituminous material is applied, provide a surface free of loose or foreign matter and containing sufficient moisture to prevent excessive penetration of the bituminous material. When necessary, apply water in sufficient quantity to fill the surface voids immediately before the bituminous material is applied. [Sand or dust treated surface to prevent the bituminous material from being picked up by traffic.]

3.8.4 Liquid Membrane Forming Curing Compound

Uniformly spray the surface of the cement treated base course with the curing compound at the rate of 3.8 L/9.3 square meter one gallon/100 square feet to obtain a uniform cover over the surface. Provide spraying equipment of the fully atomizing type equipped with a tank agitator. Thoroughly and uniformly mix the curing compound with the pigment in the storage tank. During application, stir the compound continuously by mechanical means. Hand spray odd widths or shapes and surfaces.

3.8.5 [Bond Breaker]

[Within 8 to 24 hours before concrete pavement placement, coat the surface of the cement treated base course with an additional application of wax-based liquid membrane forming curing compound applied in a quality sufficient to prevent bonding of the concrete pavement to the base course.]

3.9 FIELD QUALITY CONTROL

3.9.1 Grade Control

Excavate underlying material to sufficient depth for the required stabilized-course thickness. Provide a finished stabilized course with the subsequent surface course meeting the fixed grade. Conform finished and completed stabilized area to the lines, grades, cross section, and dimensions indicated and the tolerances of Table 1. Correct deviations exceeding the tolerances by removing and replacing the cement-stabilized mixture. Do not permit skin patching of deficient areas.

3.9.2 Smoothness Test

****

NOTE: For subbase stabilization, paragraph should be deleted.

****

Take measurements for deviation from grade and cross section in successive positions parallel to the road centerline with a straightedge. Also take measurements perpendicular to the road centerline at [15] [_____] meter [50] [_____] foot intervals. Correct deviations exceeding the tolerances of Table 1 by removing and replacing the cement-stabilized mixture. Do not permit skin patching of deficient areas.

3.9.3 Thickness Control

****

NOTE: Thickness allowance may be modified to 6 mm 1/4 inch when the course thickness is 150 mm 6 inches or less. The designer may describe the sampling, testing, and approval considered necessary for a particular project.
****

Measure the thickness of the cement stabilized mixture at intervals which ensure one measurement for each [400] [_____] square meters [500] [_____] square yards of cement stabilized mixture. Make measurements in 75 mm 3 inch diameter test holes penetrating the cement stabilized mixture. Where the measured thickness exceeds the tolerances of Table 1, correct such areasby removing and replacing the cement-stabilized material. Where the measured thickness is more than 13 mm 1/2 inch thicker than indicated, the course will be considered as conforming with the specified thickness requirements. Calculate the average job thickness as the average of all thickness measurements taken for the job, but within the tolerances of Table 1.

3.9.4 Field Density

Perform field density tests in accordance with ASTM D1556/D1556M or ASTM D6938. Use ASTM D6938 to determine the moisture content of the soil. ASTM D6938 results in a wet unit weight of soil. Check calibration curves furnished along with the density gauge described in ASTM D6938. Make calibration checks of the density gauge at the beginning of a job on each type of material encountered. If ASTM D6938 is used, check in-place densities by ASTM D1556/D1556M at least once per lift for each 850 [_____] square meters 1000 [_____] square yards of stabilized material. Perform at least 1 field density test for each [200] [_____] square meters [250] [_____] square yards of each layer of cement-stabilized mixture.

3.9.5 Compressive Strength

Test composite sample of cement stabilized mixture for compressive strength. Fabricate three test cylinders for each set of tests in accordance with ASTM D558/D558M, Method A or B (as appropriate), cure and test according to ASTM D1632 and ASTM D1633. Test specimens for compressive strength at 7 days, and submit results. If the average of the three compressive strengths is less than 350 kPa 50 psi below the required strength, stop operations and adjust the mix design. If the average of the three compressive strengths is more than 350 kPa 50 psi below the required strength, remove and replace the area represented by the failing tests, as directed. Take samples not less than once a day, nor less than once for each [380] [_____] cubic meters [500] [_____] cubic yards of cement stabilized mixture.

3.9.6 Sieve Analysis

****
NOTE: Delete reference to source of material when select material is not required and edit submittal requirements accordingly.
****

Perform a minimum of one analysis for each [1000] [_____] metric tons tons of material to be stabilized, with a minimum of 3 analyses for each day's run until the course is completed. When the source of materials is changed or deficiencies are found, repeat the analysis and retest the

material already placed to determine the extent of unacceptable cement-stabilized mixture. Replace all in-place unacceptable cement-stabilized mixture.

3.9.7 Liquid Limit and Plasticity Index

Perform one liquid limit and plasticity index for each sieve analysis. Test for liquid limit and plasticity index in accordance with ASTM D4318.

3.9.8 Maintenance

Maintain the cement-stabilized mixture in a satisfactory condition until the completed work is accepted. Perform immediate repairs to any defects and repeat as often as necessary to keep the area intact. Repair defects as specified.

3.9.9 Traffic

Completed portions of the cement stabilized mixture may be opened immediately to light traffic provided the curing is not impaired. After the curing period has elapsed, completed areas may be opened to all traffic provided that the cement-stabilized mixture has hardened sufficiently to prevent marring or distorting of the surface by equipment or traffic. Heavy equipment will not be permitted on the area during the curing period. Cement and water may be hauled over the area with pneumatic-tired equipment as approved. Protect finished portions of cement-stabilized mixture that are traveled on by equipment used in constructing an adjoining section in a manner that prevents equipment from marring or damaging the completed work.

3.10 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of removed in-place materials that are unsuitable for stabilization, material that is removed for the required correction of defective areas, waste material, and debris [as directed] [in disposal area indicated].

-- End of Section --