
USACE / NAVFAC / AFCEC / NASA UFGS-32 11 29 (November 2009)

Preparing Activity: USACE Superseding
UFGS-32 11 29 (May 2009)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2015

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SECTION 32 11 29

LIME-[STABILIZED][MODIFIED] SUBGRADE
11/09

NOTE: This guide specification covers the requirements for lime stabilization or modification of subgrades airfield pavements and for roads, streets, and parking areas.

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 items(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: The Designer should refer to UFC 3-250-11 or TM 5-822-14 for guidance on modification or stabilization of materials with lime.

Sulfate reaction with either the soil to be stabilized or mixing water used in the stabilization process may be detrimental to the finished product due to the expansive nature of the sulfate reaction. Soluble sulfate contents as low as 0.5 percent have resulted in excessive expansion of the soil due to the formation of ettringite and thaumasite. During the design phase soils and water anticipated to be included in the stabilized material should be tested for potential to cause an

adverse expansion reaction. The contractor should be required to test any off site borrow sources for sulfates.

If Lime stabilization or modification is considered where sulfates are present, the USACE Transportation Systems Center (CENWO-ED-TX), appropriate Air Force MAJCOM pavements engineer, or Naval Facilities Engineering Service Center should be consulted for up-to-date guidance.

1.1 SUMMARY

The work specified consists of the construction of a lime-[stabilized][modified] subgrade course. Perform the work in accordance with this specification conforming to the lines, grades, notes, and typical sections shown in the drawings. Select sources of materials well in advance of the time when materials will be required in the work.

1.2 UNIT PRICES

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

1.2.1 Measurement for Payment

NOTE: Delete method of measurement not applicable to the job conditions. If it is desirable for material to be paid for separately, select the desired method of measurement.

1.2.1.1 Lime [Stabilization] [Modification]

Measurement will be by the square meter yard of work completed and accepted.

1.2.1.2 Lime

Measurement will be by the number of metric 2000 pound tons of lime used in the completed and accepted work. No measurement will be made for wasted lime or lime used in work determined defective.

1.2.1.3 Bituminous Material

Bituminous material to be paid for will be measured in the number of [liters gallons of the material used in the accepted work, corrected to liters at 16 degrees C gallons at 60 degrees F in accordance with [ASTM D633] [ASTM D1250]. A coefficient of 0.000139 per degree C 0.00025 per degree F shall be used for asphalt emulsion.] [metric 2000 pound tons of the material used in the accepted work.]

1.2.2 Basis for Payment

NOTE: Delete method of measurement not applicable

to the job conditions.. If it is desirable for material to be paid for separately, select the desired method of measurement.

Lime [stabilization] [modification], constructed and accepted, including lime, [bituminous material] and all other materials, labor and equipment required to provide a product meeting the requirements of this specification 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 the convenience of the Contractor, 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 shall be included in the contract unit price for bituminous material.

1.2.3 Waybills and Delivery Tickets

Submit certified waybills and delivery tickets for all materials actually used. Submit copies of waybills or delivery tickets during the progress of the work. Before the final payment is allowed, waybills and certified delivery tickets shall be furnished for all lime [and bituminous materials] used in the construction.

1.3 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 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 81 (1992; R 2012) Standard Specification for
Cutback Asphalt (Rapid-Curing Type)

AASHTO M 82 (1975; R 2012) Standard Specification for
Cutback Asphalt (Medium-Curing Type)

AASHTO T 135	(2013) Standard Method of Test for Wetting-and-Drying Test of Compacted Soil-Cement Mixtures
AASHTO T 136	(2013) Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures
ASTM INTERNATIONAL (ASTM)	
ASTM C136/C136M	(2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C25	(2011; E 2014) Standard Test Method for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
ASTM C50/C50M	(2013) Sampling, Sample Preparation, Packaging, and Marking of Lime and Limestone Products
ASTM C977	(2010) Quicklime and Hydrated Lime for Soil Stabilization
ASTM D1250	(2008) Standard Guide for Use of the Petroleum Measurement Tables
ASTM D1556/D1556M	(2015) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³) (2700 kN-m/m ³)
ASTM D1632	(2007) Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory
ASTM D2027/D2027M	(2013) Cutback Asphalt (Medium-Curing Type)
ASTM D2028/D2028M	(2015) Cutback Asphalt (Rapid-Curing Type)
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D3551	(2008) Laboratory Preparation of Soil-Lime Mixtures Using a Mechanical Mixer
ASTM D3740	(2012a) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

ASTM D422	(1963; R 2007; E 2014; E 2014) Particle-Size Analysis of Soils
ASTM D4318	(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5102	(2009) Standard Test Method for Unconfined Compressive Strength of Compacted Soil-Lime Mixtures
ASTM D633	(2011) Volume Correction Table for Road Tar
ASTM D6938	(2015) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates
ASTM D977	(2013; E 2014) Emulsified Asphalt
ASTM E11	(2015) Wire Cloth and Sieves for Testing Purposes

1.4 DEFINITIONS

1.4.1 Lime-[Stabilized][Modified] Course

Lime-[stabilized][modified] course, as used in this specification, is a mixture of lime and in-place or borrow material uniformly blended, wetted, and thoroughly compacted to produce a pavement course which meets the criteria set forth in the plans and this specification.

1.4.2 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated as percent laboratory maximum density.

1.5 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within

the submittal tags may be used following the "G" designation 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.

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, Machines, and Tools; G[, [_____]]
Mix Design; G[, [_____]]
Waybills and Delivery Tickets

SD-06 Test Reports

Sampling and Testing
Field Density

SD-07 Certificates

Bituminous Material.
Lime
Laboratory

1.6 ENVIRONMENTAL REQUIREMENTS

Do not work during freezing temperatures. When the temperature is below 5 degrees C 40 degrees F, protect the completed [stabilized] [modified] materials against freezing by a sufficient covering of straw, or by other approved methods, until the course has dried out. Any areas of completed [stabilized] [modified] materials that are damaged by freezing, rainfall, or other weather conditions shall be brought to a satisfactory condition without additional cost to the Government. Do not apply lime when the atmospheric temperature is less than 5 degrees 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 degrees C 35 degrees F completed lime-treated areas shall be protected against any detrimental effects of freezing.

PART 2 PRODUCTS

2.1 PLANT, EQUIPMENT, MACHINES, AND TOOLS

**NOTE: Delete types of equipment specified but not
required for the workd, and add other items of
equipment not listed as appropriate.**

Submit list of proposed equipment to be used in performance of construction work including descriptive data.

2.1.1 General Requisites

Plant, equipment, machines, and tools used in the work shall be subject to approval and maintained in satisfactory working condition at all times. Other compacting equipment may be used in lieu of that specified, where it can be demonstrated that the results are equivalent. Provide protective equipment, apparel, and barriers to protect the eyes, respiratory system, and the skin of workers exposed to contact with lime dust or slurry.

2.1.2 Steel-Wheeled Rollers

Steel wheeled rollers shall be the self propelled type. Unless otherwise provided, non-vibratory steel-wheel rollers shall be of the tandem or 3-wheel self-propelled type or steel-wheel trailer type weighing not less than 4.5 metric tons 5 tons. When drive rolls or trailer type rolls produce a compressive force of not less than 3.6 kg/mm 200 pounds per linear inch of contact area, a roller weighing less than 4.5 metric tons 5 tons may be used. Equip wheels of the rollers with adjustable scrapers. The use of vibratory rollers is optional.

2.1.3 Pneumatic-Tired Rollers

Pneumatic-tired rollers shall have 4 or more tires, inflated to a minimum pressure of 0.62 MPa 90 psi. The loading shall be equally distributed to all wheels, and the tires shall be uniformly inflated. Also provide pneumatic-tired towing equipment.

2.1.4 Tamping-Type Roller

The tamping type roller, under working conditions, shall have a minimum weight of 1.6 kg/mm 90 pounds per linear inch of length of drum and a minimum load on each sheeps-foot of 0.07 kg per square mm 100 pounds per square inch of cross sectional area of the sheeps-foot in contact with the ground. Maximum area of the face of each sheeps-foot shall not be more than 7742 square mm 12 square inches. The feet on the sheeps-foot roller shall project not less than 178 mm 7 inches from the face of the drum, and the roller shall be equipped with teeth-cleaning devices. Space the feet in adjacent rows so that the distance from center to center of adjacent parallel rows is not less than 150 mm 6 inches nor more than 279 mm 11 inches. Individual drums of the roller shall not exceed 1.5 m 5 feet in width and shall oscillate independently. Roller and tractor for pulling shall travel at a speed of approximately 5 to 10 km/h 3 to 6 mph.

2.1.5 Mechanical Spreader

Mechanical spreader shall be self-propelled or attached to a propelling unit capable of moving the spreader and material truck. The device shall be steerable and shall have variable speeds forward and reverse. The spreader and propelling unit shall be carried 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. The Contracting Officer may require a demonstration of the spreader prior to approving use in performance of the work.

2.1.6 Pulvimixer

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

2.1.7 Slurry Mixer/Distributor

Mix the lime with water in trucks with approved distributors and applied as a thin water suspension or slurry. Apply commercial lime slurry with a lime percentage not less than that applicable for the grade used. Attain the distribution of lime by successive passes over a measured section of subgrade until the proper amount of lime has been spread. The amount of lime spread shall be the amount required for mixing to the specified depth that will result in the percentage determined in the job mix formula. The distributor truck shall continually agitate the slurry to keep the mixture uniform.

2.1.8 Central Mixing Plant

A lime-slurry central mixing plant shall consist of a lime storage silo, water supply tank, lime and water metering devices, and a lime-water mixer. Provide storage tanks for lime-water slurry with mechanical agitation to maintain the lime-water slurry in suspension.

2.1.9 Sprinkling Equipment

Provide sprinkling equipment consisting of tank trucks, pressure distributors, or other approved equipment designed to apply controlled quantities of water uniformly over variable widths of surface.

2.1.10 Tampers

Provide tampers of an approved mechanical type, having sufficient weight and striking power to produce the compaction required.

2.1.11 Straightedge

Furnish and maintain at the site, in good condition, one 3.66 meters 12 foot straightedge for use in the testing of the finished surface. Straightedge

shall be made available for Government use. Straightedges shall be constructed of aluminum or other lightweight metal with blades of box or box-girder cross section with flat bottom reinforced to insure rigidity and accuracy. Straightedges shall have handles to facilitate movement on pavement.

2.2 MATERIALS

2.2.1 Lime

Submit copies of certified test data. Lime shall be a standard brand of [quicklime] [hydrated lime] conforming to ASTM C977 and the following physical and chemical requirements. Sample lime in accordance with ASTM C50/C50M.

- a. Gradation that 97 percent passes a 0.590 mm No. 30 sieve and a minimum of 75 percent passes a 0.075 mm No. 200 sieve.
- b. Combined calcium oxide and magnesium oxide not less than 90 percent.
- c. [Quicklime] [Hydrated Lime] does not exceed 5 percent Carbon Dioxide or 2 percent free moisture (taken at the point of manufacture).

2.2.2 Bituminous Material

NOTE: Specify asphalt of one grade or type.

Submit copies of certified test data. Material conforming to one of the following:

2.2.2.1 Cutback Asphalt

[AASHTO M 82] [ASTM D2027/D2027M], Grade [MC-30] [MC-70] [MC-250] [MC-800];
[AASHTO M 81] [ASTM D2028/D2028M], Grade [RC-70] [RC-250] [RC-800] [_____].

2.2.2.2 Emulsified Asphalt

ASTM D977, Type [RS-1] [RS-2] [SS-1] [CSS-1] [_____].

2.2.3 Material to be [Stabilized] [Modified]

NOTE: Soils classified as CH, CL, MH, SC, and GC have potential for lime stabilization; however, it is not recommended to use lime alone for the stabilization of sandy soils. The soluble sulfate content of the materials to be stabilized should be checked and tested during design to determine if stabilization with lime can react and induce heave. Designer should refer to UFC 3-250-11 and UFC 3-260-02 for further guidance. Appendix C of UFC 3-250-11 provides test methods and listing of sulfate limits.

Material to be [stabilized] [modified] shall consist of in situ, borrow, or compacted fill material. Provide material free of deleterious substances such as sticks, debris, organic matter, and stones greater than 75 mm 3 inches in any dimension. At least 10 percent of the material shall pass the 0.425 mm No. 40 sieve. [Plasticity index shall be greater than 18].

2.2.4 Water

Water shall be clean, fresh, and free from injurious amounts of oil, acid, salt, alkali, organic matter, and other substances deleterious to the lime or soil-lime mixture, and shall be subject to approval. Water shall be tested and conform to the requirements of ASTM C1602/C1602M including the optional requirements of Table 2. Potable water sources may be used without testing.

2.3 STOCKPILING MATERIALS

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

2.4 MIX DESIGN

NOTE: The designer should determine the compressive strength requirement based on the use of the final pavement. The required minimum compressive strength varies with the pavement type and intended stabilization product. Refer to Table 2 for the appropriate values. Designer should refer to UFC 3-250-11 for further guidance, including applicability of stabilization or modification with lime.

Lime modification to provide an improved working platform, reduce shrink-swell potential, or provide a more uniform work surface can often be specified as a given percentage range based on local experience, or it can be estimated by the designer using the pH test per ASTM D6276.

[Submit certification of testing laboratory compliance. Develop and submit for approval a proposed mix design for each material type to be [stabilized] [modified] at least [14] [_____] days before it is to be used. Obtain approval of the proposed mix designs prior to starting the work. Mix designs shall be developed by an approved commercial laboratory which meets the requirements of ASTM D3740 [and which has been approved by the Corps of Engineers Materials Testing Center]. Develop the mix design using representative samples of each soil to be [stabilized] [modified] and using the proposed project lime. Conduct three trials for each mix design tested. Prepare samples in accordance with ASTM D3551. Allow the prepared samples to mellow for [24 hours for modified materials] [48 hours for stabilized materials] before any testing is performed.[For soil stabilization, vary the lime content to produce a maximum plasticity index of 10 when tested in accordance with ASTM D4318. Provide the results in a graph of plasticity index versus lime content. Determine the maximum dry density and optimum moisture content for the proposed lime-soil mixture in

accordance with ASTM D1557. Cure samples at a constant moisture content and temperature for [7] [28] [____] days.][The soil stabilization mix design shall be capable of producing a unconfined compressive strength of [____] [1.035] MPa [____] [200] psi at 28-days [____] age (average of three specimens) when compacted to the design percent of laboratory maximum density and tested in accordance with ASTM D5102, Method A. Prepare three specimens per test evaluation for durability testing for each mix design tested. Samples shall not exceed loss indicated in Table 2 after 12 cycles of the wet-dry test in accordance with AASHTO T 135.][Conduct freeze thaw tests in accordance with AASHTO T 136 (but omitting wire brushing) for projects susceptible to freeze/thaw conditions.] The mix design submittal information shall include the following:

- a. Material type
- b. Material classification including plasticity test data
- c. Laboratory maximum density
- d. Percent of lime and rate of application
- e. Optimum water content during mixing, curing, and compaction
- f. Gradation of material before and after treatment
- g. Compressive strength
- h. Durability Wet-Dry [and Freeze/Thaw]test data
- i. Mixing or equipment requirements
- j. Mellowing time requirements
- k. Water quality test data, if non-potable source used

Table 2	
Type of Soil Stabilized	Maximum Allowable Weight Loss After 12 Wet-Dry or Freeze-Thaw Cycles Percent of Initial Specimen Weight
Silt	8
Clays	6

]

[The in situ soil or compacted fill shall be modified with lime at a rate of [____] percent to [____] percent per dry unit weight of soil.]

PART 3 EXECUTION

NOTE: The designer should consider in which application methods are allowed potential health and safety issues associated with lime dust. Breathing the dust may cause respiratory issues, safety issues related to visibility both on and off the site, and complaints from off site due to dust settlement at nearby facilities. Use of quicklime can increase health risks, but can be of use for drying existing materials if the site is too wet. If a significant amount is lost it can affect the total amount applied and result in inadequate materials to achieve the design intent. Dry application may also lead to greater variability in the rate of application. Application as a slurry may reduce the

number of construction steps required and give a more uniform application. Use of a pulvimixer to incorporate either a dry material or slurry should be considered where available.

3.1 LIME [STABILIZATION] [MODIFICATION] MIXTURE

The subgrade material to be [stabilized] [modified] shall be thoroughly pulverized and, [when lime is applied in the dry state,] the mix shall be thoroughly blended at a moisture content below optimum. After blending is completed, the proportions of the mixture shall be in accordance with the approved mix design. After blending, water shall be added into the dry mix in amounts necessary to bring the moisture content to a minimum of [3] [_____] percent above optimum. Control field moisture content within plus [2] [_____] or minus [1] [_____] percent of optimum. When the [stabilized] [modified] course is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweeper 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 area to be [stabilized] [modified] 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: Determine if onsite borrow sources for materials are available and if sufficient quantities required are available from designated borrow sources.

[Clear, strip and excavate borrow pits in a manner that exposes vertical faces of the deposit for suitable working depths. Waste strata of unsuitable materials overlying or occurring in the deposit. Methods of operating pits and the processing and blending of materials may be changed or modified if necessary to obtain material conforming to the specified requirements. Upon completion of the work, pits shall be conditioned to drain readily, and be left in a satisfactory condition as determined by the Government.] [Obtain borrow material from offsite sources.]

3.3 PREPARATION OF AREA TO BE [STABILIZED] [MODIFIED]

Clean the area of debris, roots, thrash, organic and other deleterious materials. The area will be inspected for adequate compaction and shall be capable of withstanding, without displacement, the compaction specified for the soil-lime mixture. Debris and removed unsatisfactory in-place material shall be disposed of as specified.

3.3.1 In-Place Material to be [Stabilized] [Modified]

Grade the entire area to conform to the lines, grades, and cross sections shown in the drawings prior to being processed. Soft or yielding subgrade areas shall be made stable before construction is begun. Unsatisfactory material shall be removed and replaced as directed by the Government.

3.3.2 In-Place Material to Receive [Stabilized] [Modified] Course

[Correct soft, yielding areas and ruts or other irregularities in the surface. The material in the affected areas shall be loosened and unsatisfactory material removed. Add approved material where directed. The area shall then be shaped to line, grade, and cross section, and shall be compacted to the specified density.] [Subgrade shall conform to Section 31 00 00 EARTHWORK.]

3.3.3 Grade Control

Excavate underlying material to sufficient depth for the required [stabilized][modified]-course thickness so that the finished [stabilized] [modified] course with the subsequent surface course will meet the fixed grade. Finished and completed stabilized area shall conform to the lines, grades, cross section, and dimensions indicated.

3.4 INSTALLATION

3.4.1 Mixed In-Place Method

3.4.1.1 Scarifying and Pulverizing of Soil

Prior to application of lime, the soil shall be scarified and pulverized [to the depth shown] [to a depth of [_____] mm inches]. Scarification shall be controlled so that the layer beneath the layer to be treated is not disturbed. Depth of pulverizing shall not exceed the depth of scarification.

3.4.1.2 Application of Lime

Shape pulverized material to approximately the cross section indicated. Apply lime so that when uniformly mixed with the soil, the specified lime content is obtained, and a sufficient quantity of lime-treated soil is produced to construct a compacted lime-treated course conforming to the lines, grades, and cross section indicated. Lime shall be spread only on areas where the mixing operations can be completed during the same work shift or day.[Use mechanical spreaders in applying bulk lime.] [Apply lime as a slurry, and use distributors in applying slurry.] If lime is spread by hand, the bags shall be spotted accurately on the area being stabilized so that when the bags are opened the lime will be dumped and spread uniformly on the area being processed. Limit hand spreading to areas inaccessible to mechanical spreaders. No equipment, except that used in spreading and mixing, shall pass over the freshly applied lime.

3.4.1.3 Initial Mixing

Mix the lime and soil immediately after the lime has been distributed. Initial mixing shall be sufficient to alleviate any dusting or wetting of the lime that might occur in the event of wind or rainstorms. This may be accomplished several days in advance of the final application and mixing.

3.4.1.4 Water Application and Moist Mixing

Determine moisture content of the mixture in preparation for final mixing. Moisture in the mixture following final mixing shall not be less than the water content determined to be optimum based on dry weight of soil and shall not exceed the optimum water content by more than [2] [_____] percentage points. Water may be added in increments as large as the

equipment will permit; however, such increment of water shall be partially incorporated in the mix to avoid concentration of water near the surface. After the last increment of water has been added, continue mixing until the water is uniformly distributed throughout the full depth of the mixture, including satisfactory moisture distribution along the edges of the section. Soil shall be mixed in two stages, allowing for an intervening 24 to 48 hour mellowing period. The [stabilized] [modified] mixture should mellow sufficiently to allow the chemical reaction to alter (break down) the material. The duration of this mellowing period shall be identified in the mix design and should be based on soil type. After mellowing, the soil shall be remixed before compaction.

3.4.1.5 Confined Areas

In areas inaccessible to machinery, excavate soils to be [stabilized] [modified] and move to an area where machine mixing may be performed, processed, and placed back in the original location. Place material in its final location within 24 hours of initial mixing, and prior to final mixing and compaction.

3.4.2 Edges of [Stabilized] [Modified] Course

Place approved material along the edges of the [stabilized] [modified] course in a quantity that 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 [stabilized] [modified] course.

3.4.3 Central-Plant Method

Provide a plant capable of producing a uniform lime-treated mixture at the specified lime and moisture contents. Haul the mixture to the job in trucks equipped with protective covers. Underlying course shall be thoroughly moistened and the mixture then placed on the prepared area in a uniform layer with mechanical spreaders. The layer shall be uniform in thickness and surface contour; and the completed layer, after compaction, shall conform to the required grade and cross section.

3.4.4 Traveling-Plant Method

Traveling plant shall move at a uniform rate of speed and shall accomplish thorough mixing of the materials in one pass. Deliver water and lime from supply trucks or bins at a predetermined rate. Windrows of prepared soil-lime mixture shall cover a predetermined width to the indicated compacted thickness.

3.4.5 Layer Thickness

Compacted thickness of the [stabilized] [modified] course shall be [as indicated] [[_____] mm inches]. No layer shall be more than 200 mm 8 inches or less than 75 mm 3 inches in compacted thickness.

3.4.6 Compaction

Before compaction operations are started and as a continuation of the mixing operation, the mixture shall be thoroughly loosened and pulverized to the full depth. Start compaction immediately after final mixing is completed. During final compaction moisten the surface, if necessary, and

shape it to the required lines, grades, and cross section. Density of compacted mixture shall be at least [90] [_____] percent of laboratory maximum density. 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. Make alternate trips of the roller slightly different lengths. At all times, the speed of the roller shall not cause displacement of the mixture to occur. Compact areas inaccessible to the rollers with mechanical tampers; shape and finish the areas by hand methods.

3.4.7 Finishing

Finish the surface of the top layer to the grade and cross section shown. The surface shall be of uniform texture. Light blading during rolling may be necessary for the finished surface to conform to the lines, grades, and cross sections. If for any reason the surface becomes rough, corrugated, uneven in texture, or traffic-marked prior to completion, the unsatisfactory portions shall be scarified, reworked, relaid, or replaced as directed. If any portion of the course, when laid, becomes watersoaked for any reason, that portion shall be removed immediately, and the mix placed in a windrow and aerated until a moisture content within the limits specified is obtained; and then spread, shaped, and rolled as specified above.

3.4.8 Construction Joints

At the end of each phase of 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. Material along construction joints not properly compacted shall be removed and replaced with soil-lime mixture that is mixed, moistened, and compacted as specified.

3.4.9 Curing and Protection

Immediately after the soil-lime area has been finished as specified above, the surface shall be protected against rapid drying for 7 days by the application of a bituminous material.

NOTE: The application temperatures will be selected from the following table and inserted in the blanks:

	Degrees C	Degrees F
Cutback asphalt		
MC-30	29-87	85-190
MC-70	50-107	125-225
RC-250, MC-250	65-105	145-220
RC-800, MC-800	80-125	180-255
Emulsified asphalt		

	Degrees C Degrees F
RS-1	25-55 75-130
RS-2	45-70 110-160
SS-1	20-70 70-160

Uniformly apply bituminous material by means of a bituminous distributor within a temperature range of [_____] to [_____] degrees C [_____] to [_____] degrees F. Bituminous material shall be applied in quantities of not less than 0.45 L/square meter 0.1 gallon/square yard nor more than 1.13 L/square meter 0.25 gallon/square yard. Areas inaccessible to or missed by the distributor shall be properly treated using the manually operated hose attachment. Apply bituminous material only to the top layer. At the time the bituminous material is applied, the surface of the area shall be free of loose or foreign matter and shall contain sufficient moisture to prevent excessive penetration of the bituminous material. When necessary, sprinkle the area immediately before the bituminous material is applied. Treated surface shall be [sanded] [dusted] [_____] to prevent the bituminous material from being picked up by traffic.

3.5 SAMPLING AND TESTING

Submit calibration curves and related test results prior to using the device or equipment being calibrated. Furnish copies of field test results within [24] [_____] hours after the tests are performed. Submit certified copies of test results of materials and sources not less than [30] [_____] days before material is required for the work.

3.5.1 General Requirements

Perform sampling and testing using an approved commercial testing laboratory or facilities furnished by the Contractor. Work requiring testing will not be permitted until the facilities have been inspected and approved. The first inspection will be at the expense of the Contractor. Cost incurred for any subsequent inspection required because of failure of the facilities to pass the first inspection will be charged to the Contractor. Perform tests in sufficient numbers and at the locations and times directed to ensure that materials and compaction meet specified requirements. Furnish certified copies of the test results to the Contracting Officer within 24 hours of completion.

3.5.2 Results

Results shall verify that the material complies with the specification. When [the source of materials is changed] [deficiencies are found], repeat the initial analysis including mix design studies if the material source is changed, and retest the material already placed to determine the extent of unacceptable material. Replace all in-place unacceptable material.

3.5.3 Sampling

Take all aggregate samples for laboratory testing in accordance with ASTM D75/D75M. Take samples of lime in accordance with ASTM C50/C50M. Prepare specimens for the unconfined compression tests in accordance with

ASTM D1632.

3.5.4 Sieve Analysis

Before starting work, test one sample of material to be [stabilized] [modified] in accordance with ASTM C136/C136M and ASTM D422 on sieves conforming to ASTM E11. After the initial test, perform a minimum of one analysis for each [1000] [_____] metric tons [1000] [_____] tons of material placed, with a minimum of three analyses for each day's run until the course is completed.

3.5.5 Liquid Limit and Plasticity Index

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

3.5.6 Chemical Analysis

Test lime for the specified chemical requirements in accordance with ASTM C25.

3.6 FIELD QUALITY CONTROL

Provide a moisture-density relationship for the lime-soil mixture from the tests. Results of field quality control testing shall verify that materials comply with this specification. When a material source is changed, [test the new material for compliance] [_____]. When deficiencies are found, the initial analysis shall be repeated and the material already placed shall be retested to determine the extent of unacceptable material. All in-place unacceptable material shall be replaced or repaired, as directed by the Contracting Officer, at no additional cost to the Government.

3.6.1 Treatment Depth Checks

The depth of stabilization shall be measured at a frequency intervals for each of [[250] [_____] square meters ([250] [_____] square yards)] [[250] [_____] square yards] of [stabilized] [modified] course. Measurements shall be made in test holes soil by spraying with a pH indicator such as phenolphthalein. Phenolphthalein changes from clear to red between pH 8.3 and 10. The color change indicates the location of the bottom of the mixing zone. Other pH indicators can measure higher pH levels if there is reason to suspect that inadequate lime has been mixed into the soil.

3.6.2 Thickness Control

NOTE: When subgrade courses are constructed less than 150 mm 6 inches in total thickness, a deficiency of 13 mm 1/2 inch in thickness is considered excessive. Applicable to job conditions, thickness tolerance provisions may be modified as required, restricting all deficiencies to not over 6 mm 1/4 inch.

Completed thicknesses of the [stabilized] [modified] course shall be within [13] [6] mm [1/2] [1/4] inch of the thickness indicated. Where the measured thickness of the [stabilized] [modified] course is more than [13]

[6] mm [1/2] [1/4] inch deficient, correct such areas by scarifying, adding mixture of proper gradation, reblading, and recompact as directed. Where the measured thickness of the [stabilized] [modified] course is more than [13] [6] mm [1/2] [1/4] inch thicker than indicated, it shall be considered as conforming to the specified thickness requirement. Average job thickness shall be the average of all thickness measurements taken for the job, but shall be within 6 mm 1/4 inch of the thickness indicated. Thickness of the [stabilized] [modified] course shall be measured at intervals which ensure one measurement for each [250] [_____] square meters [250] [_____] square yards of [stabilized] [modified] course. Measurements shall be made in 75 mm 3 inch diameter test holes penetrating the [stabilized] [modified] course.

3.6.3 Field Density

Determine field in-place density in accordance with [ASTM D1556/D1556M] [ASTM D2167] [ASTM D6938]. [When ASTM D6938 is used, the calibration curves shall be checked, and adjusted if necessary, using the sand cone method as described in paragraph Calibration of the ASTM publication.] ASTM D6938 may be used to determine both the wet unit weight and the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. If ASTM D6938 is used, in-place densities shall be checked by ASTM D1556/D1556M at least once per lift and at a frequency not to exceed one test under ASTM D1556/D1556M per [8] [_____] tests performed under ASTM D6938. Furnish calibration curves and calibration tests results to the Contracting Officer within 24 hours of conclusion of the tests. Perform at least one field density test for each [250][_____] square meters [250] [_____] square yards of each layer of [stabilized] [modified] material.

3.6.4 Smoothness Test

The surface of a [stabilized] [modified] layer shall show no deviations in excess of 13 mm 1/2 inch when tested with the [3.05] [3.66] meter [10-] [12-] foot straightedge. Deviations exceeding this amount shall be corrected by removing material and replacing with new material, or by reworking existing material and compacting, as directed. Take measurements for deviation from grade and cross section shown in successive positions parallel to the pavement centerline with a [3.05] [3.66] meter [10-] [12-] foot straightedge. Measurements shall also be taken perpendicular to the pavement centerline at [15] [_____] meter [50-] [_____] foot intervals.

3.7 TRAFFIC

Completed portions of the lime-treated soil area may be opened to light traffic after a period of 3 days if cured with a bituminous material provided the curing is not damaged. After the curing period has elapsed, completed areas may be opened to all traffic, provided the [stabilized] [modified] course has hardened sufficiently to prevent marring or distorting of the surface by equipment or traffic. Heavy equipment is not permitted on the area during the curing period. [Lime and water may be hauled over the completed area with pneumatic-tired equipment if approved.] Protect finished portions of lime-[stabilized] [modified] soil, that are traveled on by equipment used in constructing an adjoining section, in a manner to prevent equipment from marring or damaging completed work.

3.8 MAINTENANCE

Maintain [stabilized] [modified] area in a satisfactory condition until the completed work is accepted. Maintenance shall include immediate repairs of any defects and shall be repeated as often as necessary to keep the area intact. Correct defects as specified herein.

3.9 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 waste disposal areas indicated].

-- End of Section --