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USACE / NAVFAC / AFCEC / NASA **UFGS-32 11 13.13 (November 2019)**

Preparing Activity: USACE **Superseding**
UFGS-32 11 29 (November 2009)
UFGS-32 11 30 (August 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2023
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DIVISION 32 - EXTERIOR IMPROVEMENTS

SECTION 32 11 13.13

LIME TREATED SUBGRADE

11/19

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SECTION 32 11 13.13

LIME TREATED SUBGRADE
11/19

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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 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: 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 NAVFAC Engineering and Expeditionary Warfare Center (EXWC) 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 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 are 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]

Perform measurement by the square m yd of work completed and accepted.

1.2.1.2 Lime

Perform measurement by the number of metric 2000 lb tons of lime used in the completed and accepted work. Do not permit measurement for wasted lime or lime used in work determined defective.

1.2.1.3 Bituminous Material

Measure bituminous material in terms of the number of [L gal of the material used in the completed and accepted work, corrected to L at 16 degrees C gal at 60 degrees F in accordance with [ASTM D633] [ASTM D1250]. Use a coefficient of 0.000139 per degree C 0.00025 per degree F for asphalt emulsion.] [metric 2000 lb tons of the material used in the completed accepted work.]

1.2.2 Basis for Payment

Pay for the lime [stabilization] [modification], constructed and accepted, including lime, [bituminous material] and other materials, labor and equipment required to provide a product meeting the requirements at the respective Contract unit prices in the bidding schedule. Do not permit payment for material wasted, used for the convenience of the Contractor, unused or rejected, or for water used. Do not permit separate payment for sanding or dusting the bituminous prime-coated surfaces, as the costs for sanding or dusting are included in the Contract unit price for bituminous material.

1.2.3 Waybills and Delivery Tickets

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

1.3 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text. 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 user adds 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 the user chooses to reconcile references in the publish print process.

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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 2017) Standard Specification for Cutback Asphalt (Rapid-Curing Type)
AASHTO M 82	(2017) Standard Specification for Cutback Asphalt (Medium-Curing Type)
AASHTO T 102	(2009; R 2013) Standard Method of Test for Spot Test of Asphaltic Materials
AASHTO T 135	(2013; R 2017) Standard Method of Test for

	Wetting-and-Drying Test of Compacted Soil-Cement Mixtures
AASHTO T 136	(2013; R 2017) Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures

ASTM INTERNATIONAL (ASTM)

ASTM C25	(2017) Standard Test Methods 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 C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C977	(2010) Quicklime and Hydrated Lime for Soil Stabilization
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 D633	(2011; R 2016) Standard Volume Correction Table for Road Tar
ASTM D977	(2019a; E 2019) Standard Specification for Emulsified Asphalt
ASTM D1250	(2019; E 2020) Standard Guide for Use of the Joint API and ASTM Adjunct for Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils: API MPMS Chapter 11.1
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 D2027/D2027M	(2019) 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 D2397/D2397M	(2019a) Standard Specification for Cationic Emulsified Asphalt
ASTM D3551	(2008) Laboratory Preparation of Soil-Lime Mixtures Using a Mechanical Mixer
ASTM D3740	(2019) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D4318	(2017; E 2018) Standard Test Methods for 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 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

NATIONAL LIME ASSOCIATION (NLA)

NLA BUL 326	(2004) Lime-Treated Soil Construction Manual: Lime Stabilization and Lime Modification

1.4 DEFINITIONS

1.4.1 Lime-[Stabilized][Modified] Course

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

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 list provided, 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.

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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

Plant, Equipment, Machines, and Tools; G[, [_____]]

Submit a list of construction equipment 7 days prior to bringing equipment on the job.

Mix Design; G[, [_____]]

Waybills and Delivery Tickets

Contractor's Plans; G[, [_____]]

SD-04 Samples

Lime

Submit a typical cured sample of on-site material with the required percent of lime content. Refer to ASTM C50/C50M for sample size requirements.

SD-05 Design Data

Job-Mix Formula; G[, [_____]]

SD-06 Test Reports

****

NOTE: Allow nuclear testing methods for site preparation testing or final in place testing on larger projects of over 3300 per square m 4000 square yd.

****

Sampling and Testing

Field Density

SD-07 Certificates

Bituminous Material

Lime

Laboratory

1.6 WEATHER LIMITATIONS

Do not construct subgrade when weather conditions detrimentally affect the quality of the materials. Do not apply lime unless the air temperature is at least 2 degrees C 35 degrees F in the shade and rising. 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. Bring areas of completed [stabilized] [modified] materials that are damaged by freezing, rainfall, or other weather conditions to a satisfactory condition without additional cost to the Government.

1.6.1 Freeze Protection Method(s)

Submit Contractor's plans for freeze protection for approval.

1.7 DELIVERY AND STORAGE

Deliver lime, [bituminous materials] in containers showing or including designated trade name, product identification, specification number, manufacturer's name, and source. Store in a manner that prevents moisture damage, overexposure, and contamination.

1.8 QUALITY ASSURANCE

1.8.1 Required Data

[Ten][_____] days prior to the commencement of the work, submit a job-mix formula (JMF) showing the amount of lime and water required per cubic m cubic yd, and procedures for blending the lime/subgrade mixture for each type of existing soil or for blended soil, as applicable. Include process type and number of: lime applications, stages of mixing, slurry injection depths, mixing depths and depths of compaction lifts. Also, include a list of equipment to be used and their relation to method of mixing

proportioning, spreading, pulverizing and compacting subgrade, slurry injection, jet slurry mixing and other related work. The formula contains the amount of lime, either in sacks or kg per cubic me lbs per cubic yd and the amount of water to be used, if slurry method is used. Use ASTM D3551 laboratory test method.

PART 2 PRODUCTS

2.1 PLANT, EQUIPMENT, MACHINES, AND TOOLS

****
NOTE: Delete types of equipment specified but not required for the work 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 for Government approval.

2.1.1 General Requisites

Plant, equipment, machines, and tools used in the work are subject to approval and maintained in satisfactory working condition. Allow use of other compacting equipment 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

Use self-propelled steel wheeled rollers . Use tandem or 3-wheel self-propelled non-vibratory steel-wheel rollers or steel-wheel trailer not weighing less than 4.5 metric tons 5 tons. When drive rolls or trailer rolls produce a compressive force of not less than 3.6 kg/mm 200 lbs per linear in of contact area, allow a roller weighing less than 4.5 metric tons 5 tons to be used. Equip wheels of the rollers with adjustable scrapers. The use of vibratory rollers is optional.

2.1.3 Pneumatic-Tired Rollers

Use pneumatic-tired rollers having 4 or more tires, inflated to a minimum pressure of 0.6 MPa 90 psi. Equally distribute the loading to the wheels, and uniformly inflate the tires. Also provide pneumatic-tired towing equipment.

2.1.4 Tamping-Type Roller

Use a tamping type roller, under working conditions, having a minimum weight of 1.6 kg/mm 90 lbs per linear in of length of drum and a minimum load on each sheeps-foot of 0.07 kg per square mm 100 psi of cross sectional area of the sheeps-foot in contact with the ground. Do not allow the maximum area of the face of each sheeps-foot to be more than 7740 square mm 12 square in. Do not allow the feet on the sheeps-foot roller to project less than 180 mm 7 in from the face of the drum, and equip the roller 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 in nor more than 280 mm 11 in. Do not allow individual drums of the roller to exceed 1.5 m 5 ft in width. Use drums that oscillate independently. Operate the and tractor for pulling at a

speed of approximately 5 to 10 km/h 3 to 6 mph.

2.1.5 Mechanical Spreader

Use a self-propelled mechanical spreader or attached to a propelling unit capable of moving the spreader and material truck. Use a steerable device having variable forward and reverse speeds. Carry the spreader and propelling unit on tracks, rubber tires, or drum-type steel rollers that do not disturb the underlying material. Provide a spreader that conforms to the following:

a. Containing a hopper, an adjustable screed, and outboard bumper rolls;

b. Designed to have a uniform, steady flow of material from the hopper; and

c. 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.

[Provide a demonstration of the spreader prior to use in performance of the work.

]2.1.6 Pulvimixer

Use 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. Use mixing action capable of uniformly blending and mixing the required lime content with the subgrade soil. Use a rotor 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. Use the amount of lime spread required for mixing to the specified depth that results in the percentage determined in the JMF. Use a distributor truck that continually agitates the slurry to keep the mixture uniform.

2.1.8 Central Mixing Plant

Use a lime-slurry central mixing plant consisting 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

Provide and maintain at the site one 3. meter 12 ft straightedge for use in the testing of the finished surface. Make available a straightedge for Government use. Use straightedges 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. Use straightedges with handles to facilitate movement on pavement.

2.2 MATERIALS

2.2.1 Lime

Submit copies of certified test data. Use 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 0.60 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).

The percent of[hydrated lime][quicklime] by weight of dry soil material is: [_____] percent.

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] [_____].

Conform to ASTM D977,[Type RS-1][Type RS-2][Type SS-1][or][Type SS-1h]; ASTM D2397/D2397M,[Type CSS-1][or][Type CSS-1h][_____]. Use a base asphalt to manufacture the emulsion that shows a negative spot when tested in accordance with AASHTO T 102 using standard naphtha.

2.2.2.3 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. Check the soluble sulfate content of the materials to be stabilized and tested during design to determine if stabilization with lime can react and induce heave. Refer to UFC 3-250-11 and UFC 3-260-02 for further guidance.

****

Use material to be [stabilized] [modified] consisting of in situ, borrow, or compacted fill material [if preliminary earthwork is required: See Section 31 00 00 EARTHWORK]. Provide material free of deleterious substances such as sticks, debris, organic matter, and stones greater than 75 mm 3 in in any dimension. Confirm at least 10 percent of the material passes the 0.425 mm No. 40 sieve. [Confirm the plasticity index is greater than 18].

2.2.2.4 Water

Use water 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 subject to approval. Test water for conformance to the requirements of ASTM C1602/C1602M including the optional requirements of Table 2. Allow potable water sources to be used without testing.

2.2.3 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.

2.2.4 Mix Design

****

NOTE: Determine the compressive strength requirement based on the use of the final pavement. The required compressive strength varies with the pavement type and stabilization or modification product. Refer to Table 2-2 of UFC-3-250-11 for the appropriate values. Refer to UFC 3-250-11 for the appropriate valuesfurther 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 from the Government

prior to starting the work. Develop mix designs 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 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.][Provide a soil stabilization mix design capable of producing an unconfined compressive strength of [_____] [1] MPa [_____] [150] 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. Do not allow samples to 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.] Provide the mix design submittal information including 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, as a Percent of Initial Specimen Weight
Silt	8
Clays	6

]

[Modify the in situ soil or compacted fill with lime at a rate of [_____] percent to [_____] percent per dry unit weight of soil.]

PART 3 EXECUTION

****

NOTE: Consider in which application methods there are 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. Consider use of a pulvimixer to incorporate either a dry material or slurry where available.

****

3.1 LIME [STABILIZATION] [MODIFICATION] MIXTURE

Pulverize the subgrade material to be [stabilized] [modified] and, [when lime is applied in the dry state,] blend the mix at a moisture content below optimum. Confirm the proportions of the mixture are in accordance with the approved mix design after blending is completed. After blending, add water into the dry mix in amounts to bring the moisture content to a minimum of [5][_____] percent above optimum. After mixing, 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 sweepers or power brooms. Allow hand brooms to 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 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. Allow methods of operating pits and the processing and blending of materials to be changed or modified to obtain material conforming to the specified requirements. Upon completion of the work, condition pits 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. Perform clearing and grubbing [to a depth of [_____] mm in] [as specified in Section[31 11 00 CLEARING AND GRUBBING][31 00 00 EARTHWORK]] [as required]. Remove rocks larger than 75 mm 3 in. Inspect original ground for adequacy for the forthcoming compactive effort of lime treatment work. Inspect the area for adequate compaction and that it is capable of withstanding, without displacement, the compaction specified for the soil-lime mixture. Dispose of debris and removed unsatisfactory in-place material as specified. [Rough grade and shape the area to be stabilized to conform to the lines, grades, and cross-sections indicated.] [Comply with subgrade requirements of Section 31 00 00 EARTHWORK].

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. Make soft or yielding subgrade areas stable before construction is begun. Remove and replace unsatisfactory material 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. Loosen the material in the affected areas and remove unsatisfactory material. Add approved material where directed. Shape the area to line, grade, and cross section, and compact to the specified density.] [Use subgrade conforming 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 meets the fixed grade. When stabilized course is to be constructed to meet a fixed grade, provide adequate line and grade stakes for control. Locate grade stakes in lanes parallel to center line of areas under construction, and suitably placed for string lining. Maintain line and grade. Confirm finished and completed stabilized area conform to the lines, grades, cross section, and dimensions indicated.

3.3.4 Soil Testing

****
NOTE: Perform site preparation tests dependent upon the criteria required, the condition of the existing site and the purpose of the stabilization.
****

Test original ground prior to scarification in accordance with ASTM D1557.

3.4 INSTALLATION

3.4.1 Mixed In-Place Method

3.4.1.1 Application Requirements

****
NOTE: Specify double application of lime or two stage pulverization and mixing when the site contains extremely plastic or heavy clays.
****

Comply with NLA BUL 326 and sequence of construction operations, unless specified otherwise.

After site preparation, scarify subgrade and spread lime. Blend lime into subgrade to required depth as indicated. Apply lime and water only to those areas where mixing operations can be completed during the same working day. Accomplish application and mixing of lime by either the dry placing method or the slurry method. Use same method during a single day's operation. [Double application of lime is required; use between 2 and 3 percent of lime for the initial application. Apply curing seal as specified and allow 6 to 7 days curing.]

3.4.1.2 Scarifying and Pulverizing of Soil

Prior to application of lime, scarify and pulverize the soil [to the depth shown in the drawings][to a depth of [_____] mm in]. Control scarification so that the layer beneath the layer to be treated is not disturbed. Do not exceed the depth of scarification with pulverizing. Remove organic materials such as stumps and roots. Remove rocks larger than 75 mm 3 in.

3.4.1.3 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. Spread lime 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, spot the bags accurately on the area being stabilized so that when the bags are opened the lime is dumped and spread uniformly on the area being processed. Limit hand spreading to areas inaccessible to mechanical spreaders. Do not permit equipment, except that used in spreading and mixing, to pass over the freshly applied lime.

a. Dry Placing: Spread and distribute lime at a uniform rate with protection from wind as an important distribution and timing criteria. Prevent dry lime from blowing by adding water to lime or by other suitable means. Do not apply lime when wind conditions are objectionable.

b. Slurry Method: Apply or inject mixture of lime and water into the existing soil. Maintain the water content at 5 percent above optimum during application to lime/soil mixture. Prepare hydrate slurry either

in a central mixing tank or tank trucks, with agitation provided for mixing or using a jet slurry maker. Prepare quicklime slurry using a portable batch slaking unit. Accurately weigh or meter lime and water. Use standard water or asphalt trucks, properly cleaned, with or without pressure distributors, to apply lime treatment. Spread or inject lime slurry evenly to yield uniform distribution of lime throughout soil. Distribute lime in successive passes over subgrade materials until proper amount of lime has been spread or injected to proper depth. Continually agitate slurry to keep mixture uniform. Keep pumps, distribution spray bars, slurry injection equipment and other equipment clean of excessive lime slurry. Verify the specified amount and rate of application of lime for the various materials encountered.

3.4.1.4 Initial Mixing

Distribute lime uniformly by mixing and pulverizing subgrade. Mix the lime and soil immediately after the lime has been distributed. Use sufficient initial mixing to alleviate dusting or wetting of the lime that might occur in the event of wind or rainstorms. During mixing, add water to subgrade to provide a moisture content of material and to insure chemical action of lime and subgrade materials. Make passes with the mixer until it has produced a homogenous, uniform mixture of lime, soil, and water. After initial mixing, control field moisture content within plus [2][_____] or minus [1][_____] percent of optimum. Continue mixing or remixing operations, until material is free of streaks or pockets of lime and mixture is uniform as indicated by testing. After initial mixing, shape and roll subgrade lightly to seal surface in order to reduce evaporation of moisture and lime carbonation. Allow this to be accomplished several days in advance of the final application and mixing.

3.4.1.5 Water Application and Moist Mixing

Determine moisture content of the mixture in preparation for final mixing. Do not allow moisture in the mixture following final mixing to be less than the water content determined to be optimum based on dry weight of soil and or to exceed the optimum water content by more than [2] [_____] percentage points. Add water in increments as large as the equipment permits; however, partially incorporate such increments of water 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. Mix soil in two stages, allowing for an intervening 24 to 48 hour mellowing period. Allow the [stabilized] [modified] mixture to mellow to allow the chemical reaction to alter (break down) the material. Identify the duration of this mellowing period in the mix design and base on soil type. After mellowing, remix the soil before compaction.

[3.4.1.6 Two-Stage Pulverization and Mixing

****
NOTE: Specify double application of lime or two stage pulverization and mixing when the site contains extremely plastic or heavy clays.
****

After curing, pulverize lime treated material until soil particles pass a 25 mm 1 in sieve and 60 percent pass the 4.75 mm No. 4 sieve. If resultant

mixture contains clods, reduce their size by scarifying, remixing, or pulverization to meet specified gradation. Compact lime-treated material immediately after final mixing and testing. Aerate or sprinkle to provide moisture content within plus [2][_____] or minus [1][_____] percent of optimum moisture content during compaction.

]3.4.1.7 Preliminary Curing

Moisture cure lime-soil mixture up to 48 hours until adhesive quality of clay is reduced to almost normal soil consistency. Allow 7 days or more for curing heavy clays.

3.4.1.8 Confined Areas

In areas inaccessible to machinery, excavate soils to be [stabilized] [modified] and move to an area to perform machine mixing, process, and place 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 to 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 ft 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. Moisten underlying course, and place the mixture on the prepared area in a uniform layer with mechanical spreaders. Confirm the layer is uniform in thickness and surface contour; and confirm the completed layer, after compaction, conforms to the required grade and cross section.

3.4.4 Traveling-Plant Method

Move the traveling plant at a uniform rate of speed and accomplish mixing of the materials in one pass. Deliver water and lime from supply trucks or bins at a predetermined rate. Use windrows of prepared soil-lime mixture covering a predetermined width to the indicated compacted thickness.

3.4.5 Layer Thickness

Confirm the compacted thickness of the [stabilized] [modified] course is [as indicated] [[_____] mm in]. Do not allow layers more than 200 mm 8 in or less than 75 mm 3 in in compacted thickness.

3.4.6 Compaction

Before compaction operations are started and as a continuation of the mixing operation, loosen and pulverize the mixture to the full depth. Start compaction immediately after final mixing is completed. During final compaction moisten the surface and shape it to the required lines,

grades, and cross section. Confirm the density of compacted mixture is at least [95] [_____] percent of laboratory maximum density. Base density value on a representative soil sample obtained from site and treated with required proportion of lime. 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. Do not permit the speed of the roller to cause displacement of the mixture to occur. Compact areas inaccessible to the rollers with mechanical tampers; shape and finish the areas by hand methods. As compaction progresses, maintain the shape of the lifts by blading. Check that the surface upon completion is smooth and conforms to indicated section and established lines and grades. Perform initial compaction with sheeps-foot roller or other suitable roller. Perform final rolling by means of sheeps-foot, steel-tired, or pneumatic rollers.

3.4.7 Finishing

Finish the surface of the top layer to the grade and cross section shown in the drawings. Confirm the surface is of uniform texture. Allow light blading during rolling for the finished surface to conform to the lines, grades, and cross sections. Do not permit the surface to vary more than 15 mm 0.6 in[_____] above or below established grade. Finish completed section by rolling with a pneumatic or suitable roller sufficiently light to prevent hairline cracking. If the surface becomes rough, corrugated, uneven in texture, or traffic-marked prior to completion, scarify, rework, relay, or replace the unsatisfactory portions. If the course, when laid, becomes watersoaked, remove that portion 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. Keep surface of each compacted layer or lime-treated material moist until covered by a subsequent layer of lime-treated material or curing seal.

3.4.8 Construction Joints

At the end of each working day, prepare a temporary joint in fully compacted material normal to paved surface centerline. 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. Construct a longitudinal temporary joint for partial width sections against which future material is to be placed. Remove temporary joints during next work period by trimming 75 mm 3 in into treated material for continuity. Allow trimmed material to be incorporated in subsequent work. Do not allow temporary joints to coincide with longitudinal or transverse temporary joint location of previous or subsequent construction. Allow remixing 100 mm 4 in into the previous day's work to be substituted for joints providing the method and equipment is acceptable. Remove and replace material along construction joints not properly compacted with soil-lime mixture that is mixed, moistened, and compacted as specified.

3.4.9 Final Curing

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

****

NOTE: Select the application temperatures from the following table and insert in the blanks:

Asphalt Types	Degrees C Degrees F
Cutback Asphalt	
MC-30	29-87 85-190
MC-70	50-107 120-225
RC-250, MC-250	65-105 150-220
RC-800, MC-800	80-125 175-255
Emulsified Asphalt:	
RS-1	25-55 75-130
RS-2	45-70 115-160
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. Apply bituminous material in quantities of not less than 0.45 L/square m 0.1 gal/square yd nor more than 1.13 L/square m 0.25 gal/square yd. Properly treat areas inaccessible to or missed by the distributor using the manually operated hose attachmentt. Apply bituminous material only to the top layer. At the time the bituminous material is applied, check that the surface of the area is free of loose or foreign matter and contains sufficient moisture to prevent excessive penetration of the bituminous material. Sprinkle the area immediately before the bituminous material is applied. [Sand][Dust][_____] the treated surface 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. Provide 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 which have been inspected by the Cement and Concrete Reference Laboratory (of ASTM/CCRL) within the past 3 years or by a Government approved independent commercial testing laboratory provided by the Contractor. The first inspection and subsequent inspections required because of failure of the facilities to pass the first inspection is at the expense of the Contractor. Perform sampling and testing using a laboratory frequency of sampling and testing of materials for conformance and quality control as specified and to be performed at such

other times to document contract compliance. Provide certified copies of the test results within 24 hours of completion.

3.5.2 Results

Verify that results comply with the material 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 unacceptable in-place material.

3.5.3 Sampling

Take 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 on sieves conforming to ASTM E11. After the initial test, perform a minimum of one analysis for each [910] [_____] 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. Confirm the liquid limit and plasticity index are in accordance with ASTM D4318.

3.5.6 Chemical Analysis

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

3.5.7 Optimum Moisture, Maximum Density

Perform optimum moisture, maximum density test on lime-treated material sampled after final mixing and prior to final compaction. Laboratory compact soil mixture within 3 hours of sampling and then moist-cure for 24 hours prior to optimum moisture-maximum density determination. Perform testing in accordance with ASTM D1557, Method D and the JMF.

3.5.8 Uniformity Tests

After placement and mixing of each lift perform a series of uniformity tests. Excavate a hole 250 mm 10 in in diameter through full depth of lift and impregnate sides of hole with a standard phenolphthalein alcohol indicator. Non-conformity of color reaction, when material is treated as above, is considered evidence of inadequate mixing.

3.5.9 Compaction

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NOTE: Allow nuclear testing methods for site

preparation testing or final in-place testing on larger projects of over 3300 square m 4000 square yd. The required frequency of ASTM D1556/D1556M check testing varies according to the critical nature and purpose of the project.

****

Perform in-place density test to determine degree of compaction between 24 and 72 hours after final compaction and 24 hour moist cure period. Test in accordance with ASTM D1556/D1556M. Allow use of ASTM D6938 and compatible meter methods providing one ASTM D1556/D1556M check test is made after every [four] [_____] nuclear tests.

3.5.10 Thickness and Smoothness

Do not allow the thickness of the final lime treated subgrade to be less than thickness shown. Do not allow the final grade smoothness to deviate by more than 10 mm 3/8 in, when tested with a 3 m 10 ft straightedge.

[3.5.11 Field Application Rate Test

Test for initial lime spreading rate.

]3.5.12 Frequency of Tests

Use the minimum number and type of quality control tests as follows:

a. Optimum moisture, maximum density. [Two] [_____] of each type or change of material with in-place density requirements.

b. Thickness, smoothness and uniformity. [Two] [_____] tests each day for every 840 square m 1000 square yd [_____] or less mixed and placed.

c. Field density. One set of [3] [_____] tests for each lift for every 1670 square m 2000 square yd [_____] or less.

[d. Field application rate test. One test for each lime spreading vehicle to be used on site.]

]3.6 FIELD QUALITY CONTROL

Provide a moisture-density relationship for the lime-soil mixture from the tests. Verify that the material complies based on results of field quality control testing. When a material source is changed, [test the new material for compliance] [_____]. Repeat the initial analysis when deficiencies are found. Retest material already placed to determine the extent of unacceptable material. Replace and repair unacceptable in-place material at no additional cost to the Government.

3.6.1 Treatment Depth Checks

Measure the depth of stabilization at an interval for each of [250][_____] square m [300][_____] square yd of [stabilized] [modified] course. Make measurements in test holes in 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 in in total thickness, a deficiency of 13 mm 1/2 in in thickness is considered excessive. Applicable to job conditions, modify thickness tolerance provisions as required, restricting deficiencies to not over 6 mm 1/4 in.
****

Complete thicknesses of the [stabilized] [modified] course within [13] [6] mm [1/2] [1/4] in of the thickness indicated. Where the measured thickness of the [stabilized] [modified] course is more than [13] [6] mm [1/2] [1/4] in deficient, correct such areas by scarifying, adding mixture of proper gradation, reblading, and recompacting as directed. Where the measured thickness of the [stabilized] [modified] course is more than [13] [6] mm [1/2] [1/4] in thicker than indicated, it consider it as conforming to the specified thickness requirement. Average the thickness measuremets taken for the job to be the job thickness within 6 mm 1/4 in of the thickness indicated. Measure the thickness of the [stabilized] [modified] course at intervals which ensure one measurement for each [210] [_____] square m [250] [_____] square yd of [stabilized] [modified] course. Make measurements in 75 mm 3 in 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, check the calibration curves, and adjust, using the sand cone method as described in paragraph Calibration of the ASTM publication.] Allow ASTM D6938 to be used to determine both the wet unit weight and the moisture content of the soil. Check calibration curves provided with the moisture gauges along with density calibration checks as described in ASTM D6938. If ASTM D6938 is used, check in-place densities 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. Provide calibration curves and calibration tests results within 24 hours of conclusion of the tests. Perform at least one field density test for each [210][_____] square m [250][_____] square yd of each layer of [stabilized] [modified] material.

3.6.4 Smoothness Test

Do not permit the surface of a [stabilized] [modified] layer to show deviations in excess of 13 mm 1/2 in when tested with the [3] [3.7] m [10-] [12-] ft straightedge. Correct deviations exceeding this amount 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] [3.7] m [10-] [12-] ft straightedge. Take measurements perpendicular to the pavement centerline at [15] [_____] m [50-] [_____] ft intervals.

3.7 TRAFFIC CONTROL, CURING MAINTENANCE, AND DRAINAGE PROTECTION

Allow completed portions of the lime-treated soil area to be opened to light traffic after a period of 3 days if cured with a bituminous material provided the curing is not damaged. Provide warning signs and barricades

so that traffic does not travel over freshly treated surfaces. After the curing period has elapsed, open completed areas to traffic, provided the [stabilized][modified] course has hardened sufficiently to prevent marring or distorting of the surface by equipment or traffic. Do not permit heavy equipment on the area during the curing period. [Allow lime and water to 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. Provide drainage during entire period of construction to prevent water from collecting or standing on area to be stabilized.

3.8 EQUIPMENT LIMITATIONS

3.8.1 General

Use the type of equipment for each category of work conforming to the NLA BUL 326 unless specified otherwise. Maintain equipment in satisfactory and safe operating condition.

3.8.2 Spreading Equipment

At windy locations, use an approved screw type spreader box, mixer, or other semi-enclosed equipment which offers protection from wind. Spreading hydrated lime by aggregate spreaders, dump trucks or agricultural spreaders is not allowed. Spreading by end-dumping or tailgate control methods are not allowed. Change or alter equipment to be used in the event of non-uniform spreading of lime.

3.8.3 Additional Mixing Equipment Limitations

a. Do not allow motor graders to mix lime with clays.

b. Allow use of deep-lift rotary mixers to facilitate changes in specified depths of operation, providing equipment and method of operation sustains uniform distribution of lime with required compacted density throughout the deeper layer, with approval of Contracting Officer.

3.8.4 Additional Compaction Equipment Limitations

Do not allow unauthorized equipment, hauling or transportation vehicles for compaction purposes.

3.9 SAFETY REQUIREMENTS

In addition to the Contract Clause entitled "Accident Prevention," prevent employee eye or skin contact with quicklime during transport or application. Provide and require employees use the following:

a. Protective clothing, high top boots, gauntlet-type gloves and protective headwear.

b. Splash-proof safety goggles and face shields.

c. Protective cream.

3.10 MAINTENANCE

Maintain [stabilized] [modified] area in a satisfactory condition until the completed work is accepted. Include immediate repairs of defects in maintenance and repeat to keep the area intact. Correct defects as specified.

3.11 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 --