OKLAHOMA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISIONS
FOR
SUBGRADE STABILIZATION

These Special Provisions revise, amend and where in conflict, supersede applicable sections of the 1999 Standard Specifications for Highway Construction, English and Metric, as applicable. Units of measurement are provided in the subsections in both English and Metric equivalents. The units applicable for this project will be those specified on the project plans.

(Substitute the following)

326.01. DESCRIPTION.

This work shall consist of furnishing, placing and compacting one or more courses of a mixture of soil, a stabilization additive and water in accordance with these Specifications and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the Plans or established by the Engineer for the purpose of increasing the shear strength of subgrade soil. Stabilization additives for the purposes of this specification will be defined as cementitious additive (Portland Cement, fly ash or cement kiln dust) or lime.

326.02. MATERIALS.

Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials.

Portland Cement	701.02
Water	701.04
Fly Ash	702.01
Cement Kiln Dust	702.03
Hydrated Lime	706.01
Quick Lime	706.02
By-Product Lime	706.03

Any cementitious additives shall be stored in a suitable, weather-tight building or compartment which will (1) protect it from dampness and (2) permit easy access for proper inspection and identification of each shipment. Do not mix cementitious additives from different sources in storage. Cementitious additives shall not be used if for any reason it has become partially set or if it contains hard lumps or cakes.

The lime shall be stored in a suitable, weather-tight building or compartment which will (1) protect it from dampness and (2) permit easy access for proper inspection and identification of each shipment. Lime shall not be used if for any reason it has become partially set or if it contains hard lumps or cakes. Do not mix limes from different sources in storage, even though they have been tested. By-product lime from residual or waste piles from approved sources may be used in lieu of hydrated or quick lime.

326.03. EQUIPMENT.

All equipment necessary for subgrade stabilization shall meet the requirements of Subsection 301.03 and as further specified in this Section.

326.04. CONSTRUCTION METHODS.

(a) **General.** The primary requirement of these Specifications is to secure a completed course of stabilized material containing a uniform mixture of soil, stabilization additive, and water:

(1) free from loose or segregated areas,
(2) of uniform density and moisture content,
(3) well bound for its full depth and
(4) with a smooth surface suitable for placing subsequent courses.

It shall be the responsibility of the Contractor to regulate the sequence of this work, to use the prescribed amount of stabilization additive, to maintain the work, and to rework the courses as necessary to meet the above requirements.

(b) **Weather Limitations.** Stabilization additives shall not be applied unless the air temperature is at least 40˚F (4˚C) and rising. The air temperature shall be taken 4 feet (1.2 m) above the ground in the shade and away from artificial heat. Stabilization additives shall not be applied when any portion of the ground is frozen. The Contractor shall be responsible for the protection and quality of the stabilization additive and stabilized subgrade under any weather conditions.

(c) **Preparation of Existing Roadbed.** Prior to beginning any subgrade stabilization, the roadbed shall be compacted and shaped to reasonably close conformity with the typical sections, lines, and grades as shown on the Plans or established by the Engineer. The subgrade shall be rolled in a manner approved by the Engineer, and any soft areas revealed by this rolling shall be corrected.

(d) **Scarifying and Loosening.** Scarifying and loosening may be required prior to the application of stabilization additive to achieve the desired results as determined by the Engineer. The Contractor shall take precautions to avoid forming furrows of loosened material below the depth specified for the bottom of the stabilized subgrade.

Except by special permission from the Engineer, the length of roadway scarified and loosened at any time shall not exceed the length in which the mixing with stabilization additive (paragraph 326.04(f)) can be completed in two calendar days.

In subgrade extents designated on the Plans or by the Engineer as having excessive rock—the dimensions or quantities of which 25 percent or more are greater than 2 ½ inches (63 mm) in size, making compliance with these Specifications impractical—the Engineer may waive certain portions of the work as described below. The Engineer may require exploratory scarifying by the Contractor before designation of extents for which full compliance of these Specifications is waived.

(e) **Application.**

General. The type and proportion of stabilization additive indicated on the plans is approximate. The type and the final rate of application of stabilization additive ultimately used shall be based on tests of the subgrade soil. The tests of the subgrade soils shall be performed by the Department. However, with the approval of the Engineer the Contractor has the option of having the tests performed by a laboratory approved by the Department in accordance with the Materials Division policy for soil stabilization at no additional cost to the Department. The stabilization additive shall be applied at the rate prescribed by the Engineer based on tests of the subgrade soil.

The Contractor may propose the use of a cementitious additive that was not specified on the Plans as a substitute, by submitting a proposal to the Engineer for review and approval. The proposal must include test results performed by a laboratory approved by the Department in accordance with the Materials Division policy for soil stabilization, the recommended application rates from those test results for the planned and proposed additives, and the cost comparison of the planned and proposed additives. Approval of the Engineer must be obtained prior to any substitution for the planned additive.

Additives shall be used as specified in the following table.

Additive	Soil Type – AASHTO M145						
	A-1	A-2	A-3	A-4	A-5	A-6	A-7
Portland Cement	✓	✓	✓	✓	✓	✓	
Fly Ash		✓	✓	✓	✓	✓	
Cement Kiln Dust	✓	✓	✓	✓	✓		
Lime						✓	✓

The Contractor shall provide equipment necessary for proper control of the application rate of stabilization additive. Where tests indicate a significant change in the subgrade soil, the Department will establish a new application rate as deemed necessary for the section of road affected prior to the Contractor placing and spreading the stabilization additive.

1. Application of Cementitious Additive. Dry methods of application shall be used for placement of the cementitious additive onto the subgrade. Equipment for spreading shall be approved types which demonstrate the ability to distribute cementitious additive uniformly.

Cementitious additive shall not be applied by the slurry method. Cementitious additive shall not be placed on wet subgrade or otherwise allowed to become wet during application prior to mixing.

Cementitious additive shall not be applied when wind conditions are such that blowing cementitious additive becomes objectionable to traffic or adjacent property owners. Cementitious additive shall be placed only on that area of roadway where mixing, compaction, and finishing can be completed in the same day. During the interval of time between application and completion of the first mixing operations, cementitious additive that has been exposed to weather conditions resulting in wetting or excessive loss by blowing will not be accepted for payment, and cementitious additive unacceptable as the result of wetting shall be removed from the project.

Specific extents of the subgrade may require modification with lime as a pretreatment to lower the plasticity index of the subgrade soils to below 20 prior to the application of a cementitious additive. The lime pretreatment shall be performed to the depth

and at the rate prescribed by the Engineer based on tests of the subgrade soil. Application of lime for pretreatment shall be in accordance with the application of lime as described in Subsection 326.04(e)2.

2. Application of Lime. Lime shall not be applied when wind conditions are such that blowing lime becomes objectionable to traffic and adjacent property owners. Equipment for spreading shall be approved types which demonstrate the ability to distribute lime uniformly.

When lime is applied to the soil ahead of the mixing equipment, the lime shall be placed only on that area where the first mixing operations can be completed during the same working day. During the interval of time between application and mixing, lime that has been exposed to the open air for a period of six hours or more may not be accepted for payment; in addition, payment will not be made for lime loss due to excessive washing or blowing.

2.1 Dry Method.

2.1.1 *Quick Lime.* When quick lime is used, the equipment for spreading lime shall be an approved type which shall demonstrate its ability to distribute the lime uniformly in controlled amounts.

2.1.2 *Hydrated Lime.* Bagged hydrated lime may be used for dry-method application only under unusual circumstances, i.e., when it would be impossible or impracticable to use other methods and only upon written approval of the Engineer and provided that all applicable Federal, State, and local laws are met. The bagged lime shall bear the manufacturer's certified weight.

2.2. Slurry Method. Lime shall be mixed with water into a slurry by either of the following methods.

2.2.1 *Central Plant.* Mixing shall be accomplished through integral paddles, recirculating pumps, or other devices that will meet mixing requirements. The slurry distributor truck, hauling from the central plant, shall be equipped with a recirculating pump or agitator of sufficient size which will keep the lime and water in a uniform mixture until spread.

2.2.2 *Transit Mix.* The lime from the storage bin shall be metered or weighed by an approved method into the tank transit mix equipment. The tank truck shall be equipped with a recirculating pump or agitator to maintain a uniform mixing of the lime and water while in transit.

The distributor truck shall be equipped with a pump, regardless of the type of mixing method used. The slurry will be applied through the spray bars under pressure to assure a uniform flow and distribution. The slurry produced by either method shall consist of a minimum mixture of approximately 1 ton (0.9 metric ton) of lime to each 500 gallons (1893 L) of water and shall not contain more than 40 percent lime.

Use of compressed air for mixing will not be permitted.

2.3. By-product Lime. When by-product lime is used, the equipment for spreading lime shall be an approved type which will demonstrate its ability to uniformly distribute the lime at controlled amounts.

(f) **Mixing.**

General. Mixing of the stabilization additive with the subgrade soil shall follow application and spreading as a continuous construction operation. Work areas for mixing shall not exceed 5,000 square yards (4000 m^2) unless otherwise authorized by the Engineer.

1. Single Mixing for Cementitious Additive Stabilization: The Single Mixing procedure shall be as hereinafter described for soils classified as Groups A-1 and A-3 in AASHTO M145 soil classification. The Double Mixing procedure described in Subsection 326.04(f)(2) may be allowed at the Contractor's option for these soil classifications.

1.1. Mixing. Unless authorized by the Engineer, the pulvermixer shall be equipped with a spray bar in the mixing chamber that is capable of injecting a sufficient quantity of water to produce a soil-cementitious additive mixture with a moisture content within the specified range in a single pass of the mixer. The quantity of water necessary for the mixing will vary with the nature of materials, normally enough water will be added to obtain a water content 2 to 5 percentage points above the optimum moisture content for maximum density of the compacted soil-cementitious additive mixture. All clods shall be reduced in size by mixing until the soil-cementitious additive mixture meets the following size requirements when tested dry by laboratory sieves:

SIEVE SIZE	PERCENT PASSING
1 ½ inch (37.5 mm)	100
3/4 inch (19.0 mm)	50 minimum

Cementitious additive shall be added and the section shall be repulverized at the correct moisture content to any portion of the work area that the cementitious additive has hydrated prior to compaction at the contractors expense, unless waived by the Engineer.

1.2. Additional Mixing. The specified degree of pulverization and the specified range of the moisture content of the mixture shall be achieved in the initial mixing of the cementitious additive or a second pass with a pulvermixer will be required. The pulvermixer shall be equipped to add additional water, if required.

Cementitious additive shall be added and the section shall be repulverized at the correct moisture content to any portion of the work area that the cementitious additive has hydrated prior to compaction at the contractors expense, unless waived by the Engineer.

2. Double Mixing for Cementitious Additive Stabilization: The double mixing procedure shall be as hereinafter described for soils classified as Groups A-2, A-4, A-5, and A-6 in AASHTO M145 soil classification. The Single Mixing procedure described in Subsection

326.04(f)(1) may be allowed only after approval by the Engineer for these soil classifications, if the mixing can be properly performed by using special equipment or construction methods proposed by the Contractor.

2.1. **First Mixing.** The moisture content of the subgrade soil shall not exceed 80 percent of the optimum moisture as determined by AASHTO T-99 at the time of first mixing. The soil and cementitious additive shall be mixed until a uniform mixture is obtained in which all clods and non-aggregate lumps are reduced to a maximum of 2 ½ inches (63 mm) diameter size. The addition of water will not be permitted during the first mixing. First mixing operations shall begin no later than 4 hours after the application of cementitious additive.

When deemed necessary by the Engineer, any portion of the area shall be rescarified and additional cementitious additive added to ensure adequate soil stabilization.

The cementitious additive and soil shall be thoroughly mixed prior to the beginning of final mixing operations.

2.2. **Final Mixing.** After the soil and cementitious additive have been satisfactorily mixed, water shall be added during the final mixing operations to initiate the soil-cementitious additive reaction. Water shall be sprinkled or sprayed as a mist onto the subgrade in a manner that produces a uniform coverage. The method of mixing shall be an approved procedure utilizing traveling mixing equipment that demonstrates uniform dispersion of cementitious additive and water throughout the soil. Sufficient water shall be added in the final mixing process to ensure chemical reaction between cementitious additive and soil. The quantity of water necessary for the final mixing operations will vary with the nature of the materials, normally enough water will be added to obtain a water content 2 to 5 percentage points above the optimum moisture content of the compacted soil-cementitious additive mixture.

All clods shall be reduced until the soil-cementitious additive mixture meets the following size requirements when tested dry by laboratory sieves:

SIEVE SIZE	PERCENT PASSING
1 ½ inch (37.5 mm)	100
3/4 inch (19.0 mm)	50 minimum

3. **Double Mixing for Lime Stabilization:** The mixing procedure shall be as hereinafter described.

3.1. **First Mixing.** The Contractor shall mix the soil, lime, and water until a uniform mixture is obtained in which all clods and non-aggregate lumps are reduced to a maximum of 2 ½ inches (63 mm) diameter size. The quantity of water necessary for the first mixing operation will vary with the nature of the material, normally enough water will be added to obtain a water content 2 to 5 percentage points above the optimum moisture content of the compacted stabilized soil. Sufficient water shall be added in the first mixing process to insure proper chemical reaction between the lime and soil. When proper mixing has been accomplished, the mixture shall be

allowed to cure. Curing time when hydrated lime is used shall be 72 hours at ambient temperatures above 40˚F (4˚C). Curing time when quick lime is used shall be 48 hours at ambient temperatures above 40˚F (4˚C). Curing time when by-product lime is used shall be 60 hours at ambient temperatures above 40˚F (4˚C).

During the curing period, the material shall be maintained in a moist condition. The surface of the stabilized area shall be sealed by light rolling to the extent that the surface will repel water and contain the moisture. When deemed necessary by the Engineer, the Contractor shall rescarify any portion of the area under stabilization for additional sprinkling to insure proper moisture for the curing.

3.2. **Final Mixing**. After the required curing time, the material shall be mixed uniformly by approved methods. All clods shall be reduced until the soil-lime mixture meets the following requirements when tested dry by laboratory sieves:

SIEVE SIZE	PERCENT PASSING
1 ½ inch (37.5 mm)	100
No. 4 (4.75 mm)	60 minimum

3.3. **Quick Lime Mixing.** Within two hours after spreading quick lime and before water is added, approved means shall be used to turn under a significant portion of the quick lime to reduce harmful exposure to the heat of hydration. Sufficient water shall be added within 6 hours after spreading to permit hydration of the quick lime. CAUTION: Uncovered quick lime may be hazardous when in the presence of moisture.

4. **Mixing for Lime Pretreatment:** Mixing of lime for pretreatment shall be in accordance with the first mixing for lime described in Subsection 326.04(f)(3.1).

5. **Mixing for Depths of 8 inches (200 mm) or greater compacted thickness.** No course stabilized shall exceed 8 inches (200 mm) in depth. If the depth of material to be stabilized in cut sections is more than 8 inches (200mm), that portion above the lower 8 inches (200 mm) shall be removed so that the bottom course can be stabilized in place. The upper portions of the cut section also shall be stabilized in courses not more than 8 inches (200 mm) in depth.

During normal fill construction, stabilization shall be accomplished by adding and mixing the amount of stabilization additive as required on the plans to each 8 inch (200 mm) lift, completing the depth of fill to the typical section shown on the plans.

The initial mixing shall be considered the only mixing necessary for all except the top course.

Variations to the mixing depths that may be properly performed by special equipment or methods may be used only after approved by the Engineer.

6. **Mixing for Excessive Rock Areas.** In areas designated by the Engineer as excessive rock areas, it is the intent that the completed course of stabilized material shall comply with the

Standard Specifications as to uniformity of stabilization additive, density, moisture content, and depth insofar as practicable. Mixing and pulverization shall be accomplished in two stages and shall be sufficient to accomplish the intent of the Specifications. The particle size requirement may be waived by the Engineer.

(g) **Compaction.**

The soil-cementitious additive mixture shall be compacted immediately after mixing, so that the compaction operation is a continuation of the mixing operation. The soil-lime mixture shall be compacted during the same day as the final mixing unless approval is obtained from the Engineer to continue compaction on the following day. The target density shall be determined in the field by moisture- density tests on representative samples of the soil-stabilization additive mixture obtained from the roadway when compaction is started. The test method for the target density will be as specified in Subsection 202.04(b)(2), modified to provide one compacted specimen of the soil-stabilization additive mixture as obtained from the roadway; and separate portions of the sample will be used for additional specimens with the moisture reduced or increased.

The soil-stabilization additive mixture shall be compacted immediately after mixing and before any appreciable loss of mixing moisture occurs. Mixing and compaction operations shall be performed so that the mixture will be compacted within plus or minus 2 percentage points of optimum moisture content. However, during the course of construction, changes or adjustments in the specified moisture requirements to meet field conditions may be authorized by the Engineer.

Compaction shall be continued until the entire depth of the mixture is uniformly compacted to not less than 95 percent of target density. Field density will be determined in accordance with Subsection of 202.04(b)(2). The rate of operation and the number of rollers shall be sufficient to uniformly compact the section of roadway being processed as specified above for the cementitious additive and within two hours of the final mixing for the lime additive.

Depths of two or more lifts or courses shall be compacted as specified in the mixing procedure. The material shall be sprinkled or dried as necessary to provide the moisture for proper compaction. Compaction shall be continued until the entire depth of mixture is compacted to not less than 95 percent of the target density established in accordance with the paragraph above.

The material shall be sprinkled and rolled. All irregularities, depressions, or weak spots which develop shall be immediately corrected by scarifying the areas affected, adding or removing material as required, and reshaping and recompacting by sprinkling and rolling.

In addition to complying with the requirements specified for density, the full depth of the material shown on the Plans shall be uniformly compacted to the extent necessary for it to remain firm and stable under construction equipment. After each section is completed, density tests as necessary, will be made by the Engineer for acceptance. Throughout this entire operation the shape of the course shall be maintained and the surface upon completion shall be smooth and in conformity with the typical section shown on the Plans and to the established lines and grades. Should the material, due to any reason or cause, lose the required stability, density, or finish before the next course is placed or the work is accepted, it shall be replaced and refinished at the sole expense of the Contractor.

In areas designated by the Engineer as excessive rock areas, it is the intent that compaction be in substantial compliance with these Specifications. However, it is recognized that the soil-stabilization additive mixture may not be uniform and some variation is to be expected in both the target density and optimum moisture, depending on the stabilization additive content of a given sample. In the event the in-place density tests are not practical because of rock in the soil-stabilization additive mixture, the Engineer may waive the density and moisture content requirements and approve compacting by visual observation in lieu of such tests.

(h) **Finishing and Curing.** After the final layer of the stabilized subgrade has been compacted, it shall be brought within reasonable compliance to the lines, grades, and typical sections. The completed section shall then be finished with a suitable roller sufficiently light to prevent hair cracking. The stabilized subgrade shall be maintained at a moisture content satisfactory for proper curing by sprinkling until a prime, seal, or succeeding course is placed, whichever occurs first.

(i) **Tolerance.** The finished surface tolerance shall be in conformity with Section 301.

326.05. METHOD OF MEASUREMENT.

Fly ash will be measured by the ton (metric ton).

Cement kiln dust will be measured by the ton (metric ton).

Portland Cement will be measured by the ton (metric ton).

Cementitious stabilized subgrade will be measured by the square yards (square meters) of subgrade stabilization completed in place.

Lime will be measured by the ton (metric ton).

Lime stabilized subgrade will be measured by the square yard (square meter)of subgrade stabilization completed in place.

Lime Pretreatment will be measured by the square yard (square meter)of subgrade pretreatment completed in place.

Prime coat will be measured and paid for in accordance with Section 408.

Water and rolling will not be measured for payment.

326.06. BASIS OF PAYMENT.

Accepted quantities for stabilized subgrade, measured as provided above, will be paid for at the contract unit price as follows:

(A) (SP) FLY ASH..... TON (METRIC TON)
(B) (SP) LIME ..... TON (METRIC TON)
(C) (SP) CEMENT KILN DUST..... TON (METRIC TON)

(D) (SP) PORTLAND CEMENT..... TON (METRIC TON)
(E) (SP) CEMENTITIOUS STABILIZED SUBGRADE .. SQUARE YARD (SQUARE METER)
(F) (SP) LIME STABILIZED SUBGRADE ..... SQUARE YARD (SQUARE METER)
(G) (SP) LIME PRETREATMENT ..... SQUARE YARD (SQUARE METER)

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

- Payment for quick lime *shall be based upon a 90 percent available lime index by rapid sugar method, calculated as percent CaO by weight.*
- Payment for hydrated lime *shall be based upon a 90 percent available lime index by rapid sugar method, calculated as percent Ca(OH)2 by weight.*
- Payment for by-product lime *shall be based on a substitution ratio calculated on a 90 percent available lime index by rapid sugar method.*

When the available lime index percentage falls below 90 percent, payment will be made at an adjusted price—which shall be reduced at the rate of one percent of the Contract unit bid price for lime for each percent, or fraction thereof, from 90.0 percent down to—and including—an available lime index of 80.0 percent.

When the available lime index falls below 80.0 percent for the type of lime used, add a sufficient quantity of additional lime of the same type to bring the total amount to the required 90.0 percent of available lime index at no additional cost to the Department.