

SECTION 305 – CHEMICALLY TREATED SUBGRADE

305.1 Description

This work consists of treating the earth subgrade by combining approved chemical stabilizing agents and water with the pulverized soil subgrade material to specified depth and compaction requirements.

305.2 Material Requirements

Approved stabilizing agents are listed in the Table below. Various combinations of these materials may also be used, subject to a suitable mix design approved by agency.

Approved Chemical Stabilizing Agents

Agents	Conformance Requirements
Lime	ASTM C977, C110
Fly Ash (C and F)	ASTM C618
Cement Kiln Dust	ASTM D 5050
Portland Cement	ASTM C114

High-calcium quicklime shall conform to the requirements of ASTM C 977, and rate of slaking test shall produce a temperature rise of 20°C in 30 seconds and 35°C in three (3) minutes per ASTM C110. Dolomitic quicklime (magnesia quicklime with magnesium oxide contents in excess of four (4) percent or carbonated hydrated lime) shall not be used. High-calcium quicklime must be applied in slurry.

Fly ash may consist of Class C or Class F. Class F fly ash shall only be allowed in conjunction with lime or other cementitious stabilizing agents. All stabilizing agents shall come from the same source as used in the design. If the source is changed, a new design must be submitted to the agency for approval. Each lot of stabilizing agent furnished shall have a supplier certificate of compliance.

Water used for mixing or curing should be from a potable source. In the event potable water is not used, non-potable water shall be tested in accordance with, and meet the requirements of, AASHTO T26, and used in the mix design.

The subgrade material stabilized shall be free of roots, sod, weeds, wood, construction debris, ice, snow, or other frozen materials, deleterious matter, and stones larger than two (2) inches in size. The subgrade material in the stabilized zone shall have a water-soluble sulfate content of less than 0.2 percent as per CPL 2103, Method B. If the subgrade soils have a soluble sulfate content exceeding 0.2 percent, the mix design shall address the specific methodology used to prevent adverse effects of sulfate reactions (e.g., heaving subgrade, cracked pavement).

305.3 Construction Requirements

305.3.1 General

The contractor shall construct one or more compacted courses of treated material, to the depth specified in the pavement design report, as indicated on the signed construction plans. The treatment material shall be a uniform blend of soil chemical stabilizing agent and water free from loose or segregated areas. It shall

have uniform density and moisture content and be free of vegetation and other deleterious material. The contractor shall regulate the sequence of the work to accurately apply and uniformly blend the chemical stabilizing agent at the designated rate and rework the course as necessary to meet the requirements.

Chemical stabilization shall not be placed or mixed when it is raining, when the subgrade material is frozen, or when ambient air and/or soil temperatures are less than 35°F.

305.3.2 Equipment

All equipment shall be subject to inspection by agency. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled.

Slurry Application Equipment A distributor or truck applicator shall be used and be capable of continuous agitation to keep the slurry mixture uniform. The applicator shall be capable of uniformly metering the stabilizing agent during application.

Dry Application Equipment (Cement, Fly Ash, cement kiln dust, only) Equipment for spreading dry stabilizing agent shall be of an approved screw-type spreader box, mixer, or other semi-enclosed equipment which is equipped with a metering device. Spreading of stabilizing agents by aggregate spreaders or motor-graders will not be allowed.

Mixing Equipment Mixing equipment shall be of sufficient size to adequately mix the stabilizing agent into the soil and to pulverize the mixture. The size of the mixer shall be adequate to mix and pulverize the mixture to a minimum depth of 12 inches in a single pass. Blades, discs, and similar equipment are not allowed without prior written approval of agency.

Compaction Equipment Compaction equipment shall be in good working order and of sufficient size and effective force to achieve the required compaction.

Proof Rolling All proof rolls shall be completed with the agency inspector.

A preliminary proof roll is required prior to chemical treatment to evaluate areas for additional stabilization, such as removal and replacement.

A final proof roll will be used to evaluate the stabilization.

305.3.3 Construction Submittals

At least 15 calendar days prior to commencing stabilization work, the contractor shall furnish the following information to the agency:

The source and supplier of stabilizing agent and certifications, including purity of stabilizing agent, from the manufacturer's testing agency indicating that the stabilizing agent meets the appropriate requirements.

Description of the proposed construction equipment, construction methods, expected production rates, and planned sequence of construction.

A mix design providing the water-soluble sulfate test results of the subgrade soils, percentage of stabilizing agent, source of the agent, properties, and any special considerations.

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For each day's work, the contractor shall furnish the following information to the agency inspector by the following day:

1. Certified truck weight tickets of stabilizing agent delivered or used at the site.
2. A summary of the amount of stabilizing agent used each day, areas stabilized and first mixed, areas second mixed and compacted, and areas with curing completed.

305.3.4 Processing Material

Application - The subgrade shall not be treated when the ambient air temperature falls below 35°F, during precipitation or when the subgrade material is frozen, or when weather predictions suggest that subgrade material temperature may fall below freezing within 24 hours without prior written approval of the agency.

Prior to beginning any treatment, the subgrade shall be constructed and finished to a smooth and uniform surface in conformity to the grade and typical section specified. Variation from the subgrade plan elevation specified shall not be more than ± 0.08 ft.

The in-place density shall be at least 95 percent of maximum dry density as determined by ASTM D 698, Standard Proctor Density and within 0-3 percent of optimum moisture content for fly ash or cement treated soils. For lime treated materials, the moisture content shall be a minimum three (3) percent above optimum.

Chemical stabilizing agent shall be applied at the minimum rate specified by the mix design for the depth of stabilized subgrade shown on the plans. Rate of application shall be verified using area/quantity calculations or testing of stabilized subgrade. Stabilizing agent shall be spread only on the area where the first mixing operations can be completed during the same working day.

Stabilizing agent shall be applied using the following methods:

Slurry Placement - The distribution of stabilizing agent shall be attained by successive applications over a measured section of subgrade until the proper amount of agent has been spread. The amount spread shall be the amount required for mixing to the specified depth, which will result in the percentage determined in the design. When quicklime is used in place of hydrated lime, the amount of quicklime used will be determined by the certified lime purity for each load supplied as follows:

delivered X % purity * 1.32 = A
delivered * X % inert material = B
A + B = total hydrated lime available

Note: When a double treatment of is required, the first 50 percent of the agent shall be placed, moisture treated and allowed to mellow or cure for up to three weeks, as determined by the Design Engineer. The last half of the agent shall then be applied.

Slurry shall not be left exposed to the air for more than four (4) hours without initial mixing. The agency reserves the right to require variation of the rate of application of stabilizing agent from the mix design application rates during the progress of construction as necessary to maintain the desired characteristics of the stabilized subgrade.

Dry Placement (This method can only be used for Fly Ash, cement kiln dust, and Portland cement): The amount of stabilizing agent spread shall be the amount required for mixing to the specified depth, which will result in the percentage specified by the design. The stabilizing agent shall be distributed in such a manner that scattering by wind will be minimal. Agents shall not be applied when wind conditions, in the opinion of City inspector, are detrimental to a proper application. The blended material shall be sprinkled or watered until moisture content is as specified in subgrade stabilization design. The combination of

stabilizing agent, soil, and water shall be called the “mixture.” After spreading of stabilizing agent and during mixing, water shall be added to hydrate the agent and for dust control.

Mixing: Mixing shall be continuous. The full depth of the treated subgrade material shall be mixed with an approved mixing machine to the specified depth below the bottom of the pavement structure and/or curb. The mixing machine shall make enough passes to adequately achieve 100 percent of the material passing the one-inch sieve and 60 percent passing the 1/4-inch sieve. Water shall be added to the subgrade during mixing to provide a moisture content of at least three (3) percent above the optimum moisture of the mixture, or as specified in subgrade stabilization design. Mixing and remixing will be performed as necessary to assist in the stabilizing agent-soil reaction and produce a homogeneous mixture. Mixing and remixing shall continue until the combination of stabilizing agent and subgrade material is free of streaks or pockets of stabilizing agent.

Mellowing (Lime or Lime/Fly Ash only): The moisture content of the subgrade mixture shall be maintained above optimum for a minimum of two (2) days and until the subgrade stabilization design criteria is met. Remixing will be done as necessary to assist the reaction, as determined by the design engineer. Application of water shall be performed as necessary during the mellowing period; the material shall maintain a moisture content of at least three (3) percent above optimum. The stabilized material shall not be subjected to traffic. If, during the mellowing period, the material is not in a semi-loose state, the chemical reaction process may slow and require additional time and/or mixing as determined by the design engineer.

Final Mixing (Lime or Lime/Fly Ash only): Final mixing of the treated subgrade shall not occur if the temperature of the soil to be stabilized is below 35°F. The treated subgrade shall be maintained at a temperature of 35° F or above until the treated material has been compacted. The material shall be uniformly mixed by an approved method to meet the following requirements when tested dry by laboratory sieves:

Sieve	Minimum Percent Passing
1-inch	100
No. 4 sieve	60

Compaction: Compaction of the mixture, for the full depth of the stabilized subgrade shown on the plans, shall begin as soon as practical after final mixing. Stabilized subgrade with cementitious stabilization agent shall be completed within 90 minutes of the time the cementitious stabilization agent and water are mixed. The field density of the compacted mixture shall be at least 95 percent of the maximum dry density of laboratory specimens prepared from samples taken from the treated subgrade material immediately prior to compacting. The specimens shall be compacted and tested in accordance with ASTM D 698 or ASTM D 558, as specified in the subgrade stabilization mix design. The in-place field density shall be determined in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. The moisture content of the mixture of shall be between 0-3 percent above the optimum moisture content. The optimum moisture content shall be determined in accordance with ASTM D 698 or ASTM D 558, as specified in subgrade stabilization design. Initial compaction shall be done by means of a sheepsfoot or segmented wheel roller. Final compaction shall be by means of a smooth wheel or pneumatic tired roller. Areas inaccessible to a mechanical roller shall be compacted to the required density by other means acceptable to the engineer. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding or removing materials as required, and reshaping and re-compacting by moisture conditioning and rolling. Adding additional stabilized material to an initial cured section, resulting in lamination and potential slip plane, is not allowed. The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed thereon, or the work is accepted. Should the material, due to any reason or cause, lose the required stability, density, or finish before the next course or pavement is placed, it shall be corrected and refinished at the sole expense of the contractor, as directed by inspector.

Finishing and Curing After the final layer of stabilized subgrade is compacted, the shape of the surface shall be achieved by blading. The surface shall be smooth and conform to the required lines, sections, and grades, in accordance with the plans and thoroughly cured, or to within a minimum of 0.1 foot above the finished subgrade elevation to allow for trimming to final grade prior to placement of surface course. The completed section shall then be finished by rolling with suitable pneumatic tired equipment with sufficiently light effort to prevent hairline cracking. Curing may be accomplished by periodic water application to maintain moisture content preventing sloughing or cracking of the surface of the stabilized subgrade to a depth no greater than 0.1 foot, or by the utilization of a bituminous seal. When bituminous seal is utilized, the minimum application will be at the rate of 0.12 gallons per square yard, as directed and approved by the design engineer. The completed section shall be cured for a minimum of five (5) days before further courses are added or any traffic is permitted, unless otherwise permitted by the design engineer. The moisture cure duration may be reduced if a non-yielding surface is obtained to support construction traffic and either the next layer of stabilized soils is placed or the pavement layer is constructed, as approved by the engineer. If the surface of the finished layer is above the approved plan elevation tolerance specified in this section, the excess material shall be trimmed, removed, and disposed of properly. Any low areas will be replaced with the subsequent surface courses. No loose material shall be left in place after trimming. After trimming the stabilized subgrade surface shall be rolled again with a steel wheel or pneumatic tired roller to seal the surface.

Curing (Cement Kiln Dust and Portland Cement Only)

Moisture Cure – Shall include the use of a water truck to moisten the surface of the stabilized subgrade three (3) times per working day at a minimum. Additionally, moisture shall be applied to the surface of the subgrade before it becomes dry.

- a. Moisture Cure for a minimum of 48 hours to a maximum of 72 hours, from the time of placement, when average daily temperatures are above 60 °F.
- b. Moisture Cure for a minimum of four (4) days to a maximum of six (6) days, from the day of placement, when the average daily temperatures are below 60 °F.

Micro Fracturing (Cracking) shall be performed when the field cylinders for compressive strength exceeds the chemical stabilized subgrade design compressive strength. Micro fracturing can be monitored by the methods listed below.

Standard Method

- a. Shall be performed with the same (or equivalent tonnage) steel drum vibratory roller used for compaction of the CTS.
- b. A minimum of 12-ton roller is required.
- c. Three full passes with the roller operating at maximum amplitude and traveling at 2- 3 mph shall be applied. If the treated material breaks up excessively at the surface, the vibration amplitude shall be decreased or eliminated.
- d. Test report or letter stating the micro-fracturing was done per the above specifications.

OR

Falling Weight Deflectometer (FWD) Testing:

- a. A truck mounted FWD shall drive through the chemically treated subgrade prior to micro fracturing testing a minimum of every 250 feet staggered through each lane to determine the base modulus.

- b. Micro fracturing shall be performed as directed by the geotechnical engineer. The number of passes, vibration amplitude, or traveling speed shall be adjusted to meet the 40 percent reduction of the base modulus portable FWD testing.
- c. A truck mounted FWD shall drive the micro fractured chemically treated subgrade with testing a minimum of every 250 feet staggered through each lane to determine the base modulus after micro fracturing. The base modulus FWD tests after micro-fracturing should see a minimum of 50 percent reduction of the base modulus.
- d. Test report or letter indicating the micro fracturing achieved the reduction in strength from the geotechnical engineer of record shall be submitted prior to paving.

OR

Portable Falling Weight Deflectometer (PFWD) Testing.

- a. A PFWD shall test a minimum of every of every 250 feet staggered through each lane and each soil type to determine the base modulus.
- b. Micro fracturing shall be performed as directed by the geotechnical engineer. The number of passes, vibration amplitude, or traveling speed shall be adjusted to meet the 40 percent reduction of the base modulus PFWD testing.
- c. A PFWD shall drive the micro fractured chemically treated subgrade with testing a minimum of every 250 feet staggered through each lane to determine the base modulus after micro fracturing. The base modulus FWD tests after micro-fracturing should see a minimum of 40 percent reduction of the base modulus.
- d. Test report or letter indicating the micro fracturing achieved the reduction in strength from the geotechnical engineer of record shall be submitted prior to paving.

305.3.5 Minimum Project Testing

During chemical stabilization, testing shall be completed on a regular basis to verify specification compliance. Required laboratory testing shall be completed on samples secured from the jobsite.

**MINIMUM PROJECT TESTING
CHEMICALLY STABILIZED SOIL**

Test Type	Testing Standard	Minimum Frequency
Sampling	AASHTO T 87	One per 2,500 square yards
Sample Preparation	ASTM D 3551	One per 2,500 square yards
Maximum Dry Density and Optimum Moisture Content	ASTM D 698 (Lime) ASTM D558 (Cement)	Minimum of one per soil type or as directed by City Engineering
In Place Soil Density and Moisture Content	ASTM D 1556 ASTM D 2167 ASTM D 6938	One test for each 250 lane feet (not less than one test per day)
	ASTM D 2216 ASTM D 6938	
Ph	ASTM D 6276	One test per 2,500 square yards
Swell	ASTM D 4546 Method B	Minimum one test per 2,500 square yards or as directed by City of Colorado Springs,

Unconfined Compressive Strength (Lime)	ASTM D 5102 (Procedure B)	One set of four cylinders per 2,500 square yards.
Compressive Strength Cementitious Agents	ASTM D 1633 (Method A)	One set of four cylinders per 2,500 square yards
Atterberg Limits	AASHTOT 89 & T 90	One test per 2,500 square yards
Stabilization Thickness	As directed by testing agency	One test every 500 feet per lane
Falling Weight Deflectometer/Portable Falling Weight Deflectometer		One test every 250 feet per lane, staggered

305.3.6 Tolerances

Grade - Prior to placement of surface course, any deviation in excess of 1/2 inch in cross-section and 1/2 inch in 10 feet measured longitudinally shall be corrected. Variations in excess of this tolerance shall be corrected by the contractor, at the contractor's expense, in a manner satisfactory to the agency. Thickness requirements shall be met in areas corrected for grade.

Strength - Specimens will be prepared from samples taken from the cement soil material in place prior to compacting. The stabilized subgrade must develop a laboratory compressive strength of at least 160 psi at five (5) days. Samples shall be molded from stabilized soil within 1.5 hours of final mixing with the material compacted per ASTM D 558 or ASTM D 698, as specified in subgrade stabilization design, at the field moisture content.

Thickness and Strength - When the measurement of the thickness is deficient by more than one (1) inch from the plan thickness, two additional locations shall be measured randomly within the deficient area and used in determining the average thickness. When thickness and/or strength criteria fail to meet design parameters, even after all possible attempts have been made to correct said deviations, remediation will be required. Evaluation of the roadway pavement section will be made by the design engineer with written approval of the Agency. The pavement structural section shall be adjusted to compensate for any deficiency in the stabilized subgrade thickness and strength, at the contractor's expense. Placement of subsequent surface course will not occur until the stabilized subgrade is accepted in writing by the Agency

Conformity Specifications

Deficiency	Remediation
Less than 25% of design thickness	Evaluate roadway design section
Greater than 25% of design thickness	Remove and Replace
Less than 24% of required strength	Evaluate roadway design section
Greater than 25% of required strength	Remove and Replace

305.4 Measurement and Payment

The area of stabilized subgrade shall be measured by the plan quantities completed, in place, and accepted. No separate measurement of depth or area, except as required for thickness testing, shall be performed. The quantity of stabilizing agent accepted and used shall be measured by the ton of Fly Ash, Portland cement, cement kiln dust, or hydrated lime used (or the calculated dry hydrated lime content of the lime slurry).