

**ITEM 5  
STABILIZED SUBGRADE**

**PART 1      CHEMICALLY STABILIZED SUBGRADE**

**5.1.1 DESCRIPTION**

This work consists of the contractor constructing one or more courses of a mixture of subgrade soil, approved stabilizing agent and water in substantial conformity with the design line, grades, thicknesses, and typical cross sections shown on the approved plans and the approved pavement thickness design.

5.1.1.1 Purpose

The purpose of the work shall be to provide a structural section on which paving materials can be placed and to meet design specifications, while at the same time, protecting the underlying moisture-treated subgrade soils. This specification can also be applied to achieve a stabilized paving platform without structural benefits.

**5.1.2 MATERIALS**

5.1.2.1 Stabilizing Agents

The pre-approved stabilizing agents are listed in Table 5.1.2.1. Various combinations of these materials may also be used, subject to a suitable mix design. Other agents may be used with prior written approval of the **AGENCY**.

TABLE 5.1.2.1

<b>PRE-APPROVED STABILIZING AGENTS</b>		
<b>Agents</b>	<b>Must conform to requirements of</b>	
Lime	ASTM	C 977, C110
Fly Ash (C and F)	ASTM	C 618
Cement Kiln Dust	ASTM	D 5050
Portland Cement	ASTM	C 114

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 3 minutes per ASTM C110. Dolomitic quicklime, magnesia quicklime with magnesium oxide contents in excess of 4 percent or carbonated hydrated lime, shall not be used. High-calcium quicklime must be applied in a 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 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 for the **AGENCY's** approval. Each lot of stabilizing agent furnished shall have the supplier's certificate of compliance.

5.1.2.2 Water

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 T 26.

5.1.2.3 Subgrade

The subgrade to be stabilized shall be free of roots, sod, weeds, wood, construction debris, ice, snow, or other frozen materials, deleterious matter, and stones larger than 3 inches. Material in the stabilized zone shall have a 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 be addressed to the specific methodology used to prevent adverse effects of sulfate reactions (e.g. heaving subgrade, cracked pavement).

5.1.2.4 Sealant

Emulsified asphalt is the only pre-approved sealant; no other sealant may be utilized without prior written approval of the **AGENCY**. Emulsified asphalt used for a bituminous seal per Item 5.1.8 shall conform to requirements in Table 5.1.2.4 below.

TABLE 5.1.2.4

PRE-APPROVED SEALANTS			
Sealant	Type	Requirements	
Emulsified Asphalt	SS-1	ASTM	D 977
Emulsified Asphalt	SS-1h	ASTM	D 977
Emulsified Asphalt	CSS-1	ASTM	D 2397
Emulsified Asphalt	CSS-1h	ASTM	D 2397

### 5.1.3 EQUIPMENT

All equipment shall be subject to approval by the **AGENCY**. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled.

#### 5.1.3.1 Dry Application Equipment

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.

#### 5.1.3.2 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.

#### 5.1.3.3 Mixing Equipment

Mixing equipment shall be of sufficient size to adequately mix the stabilizing agent into the soil and to pulverize the mixture according to the requirements of Item 5.1.6. 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 the **AGENCY**.

#### 5.1.3.4 Compaction Equipment

Compaction equipment shall be in good working order and of sufficient size and effective force to achieve the required compactive effort as prescribed in Item 5.1.6.

#### **5.1.4 CONSTRUCTION SUBMITTALS**

At least 15 days prior to commencing stabilization work, the **CONTRACTOR** shall furnish the following information to the **AGENCY**:

1. 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.
2. Description of the proposed construction equipment, construction methods, expected production rates and planned sequence of construction.
3. A mix design giving the percentage of stabilizing agent, source of the agent, properties and any special considerations.
4. Water Soluble Sulfate test results.

For each day's work, the **CONTRACTOR** shall furnish the following information to the **AGENCY** by the following day:

- A. Certified truck weight tickets of stabilizing agent, delivered or used at the site.
- B. 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.
- C. Prior to paving, final in place soil properties per Table 5.1.11.

#### **5.1.5 STABILIZED MIX DESIGN**

Mix designs shall be performed under the supervision of and signed by a Professional Engineer registered in the State of Colorado. Laboratories shall be accredited by AASHTO.

Mix design shall comply with the following requirements in Table 5.1.5 below:

TABLE 5.1.5

<b>STABILIZATION MIX DESIGN REQUIREMENTS</b>			
<b>Stabilization Agent</b>	<b>Minimum pH</b> Note 1 & 2	<b>Maximum Swell Potential (%)</b> Note 3	<b>Minimum Unconfined Compressive Strength (psi)</b> Note 4
Lime	12.0	1.0	160
Fly Ash	N/A	1.0	160
Cement Kiln Dust	N/A	1.0	160
Portland Cement	N/A	1.0	160
Lime-Fly Ash	12.3	1.0	160

Note:

1. When lime is used, the pH should be no less than 12.0 as measured after completion of initial mixing with stabilizing agent and at ambient temperature.
2. Testing of pH is to be done in accordance with Eades-Grim pH test method (ASTM D 6276).
3. Swell Potential to be less than 1.0 percent at 200 psf, ASTM D 4546.
4. Minimum of 160 psi ( $M_R > 34,800$  psi, where  $M_R = 10,000 + 124q_U$ ) in five (5) days of moist curing at 100°F (38°C). Testing is in accordance with ASTM D 1633 Method A for pozzolanic agents and ASTM D 5102 Procedure B for Hydrated Lime.

When lime is used, Plasticity Index is to be reported from initial to final construction to all interested parties and shall not be used for acceptance purposes. The design stabilizing agent percentage as determined by the designer shall be increased by 0.5 percent in the field to account for waste, inert materials, and construction variability.

### 5.1.6 PROCESSING MATERIALS

It is the primary requirement of this specification to secure a completed subgrade structural section containing a uniform stabilized mixture. The mixture is to have a uniform density and moisture content, free from loose or segregated areas, well bound for its full depth, well cured, and with a surface suitable for placing subsequent courses.

It shall be the responsibility of the **CONTRACTOR** to regulate the sequence of their work, to use the proper amount of stabilizing agent, maintain the work, and rework the courses, as necessary, to meet the requirements.

#### 5.1.6.1 Application

The subgrade shall not be treated when the ambient air temperature falls below freezing or the subgrade material is below 40° F, or when weather predictions suggest that subgrade material temperature may fall below 40° F within 24 hours, unless prior written approval of the **AGENCY** has been issued. Prior to beginning any treatment, the subgrade shall also be constructed and finished to a smooth and uniform surface that is in conformity to the grade and typical section specified. Variation from the subgrade plan elevation specified shall not be more than  $\pm 0.08$  ft. The in-place density shall be at least 95% of maximum dry density as determined by ASTM D 698, Standard Proctor Density, and within 0 to 3% of optimum moisture content.

Stabilizing agent shall be applied at the minimum rate specified by the mix design for the depth of stabilized subgrade shown on the plans. The rate shall be determined from a design using the on-site soils and shall meet the requirements found in Item 5.1.5. Rate of application shall be verified using area/quantity calculations or testing of stabilized subgrade. Stabilizing agent shall be spread only on that area where the first mixing operations can be completed during the same working day. Lime slurry shall not be left exposed to the air for more than four hours without initial mixing.

The **AGENCY** or **ENGINEER** 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.

Stabilizing agent shall be applied using the following methods:

##### 5.1.6.1.1 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:

$$\text{Quicklime delivered} \times \text{\% purity} \times 1.32 = A$$

$$\text{Quicklime delivered} \times \text{\% inert material} = B$$

$$A + B = \text{total hydrated lime available}$$

#### 5.1.6.1.2 Dry Placement (This method only can 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 the AGENCY, 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 to reduce dusting.

#### 5.1.6.1.3 High Sulfate Treatment

Where sulfates are over 0.2 percent the **ENGINEER** must address the method of treatment.

*Note: When a double treatment of lime 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 **ENGINEER**. The last half of the lime shall then be applied.*

#### 5.1.6.2 Mixing

No stabilization shall take place when precipitation may cause damage to the subgrade, as determined by the **AGENCY**. 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 a sufficient number of 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 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 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.

#### 5.1.6.3 Mellowing (Lime or Lime/Fly Ash Only)

The water content of the subgrade mixture shall be maintained at a moisture content above the optimum moisture content for a minimum of 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 **AGENCY**. Application of moisture shall be performed as necessary during the mellowing period; the material shall maintain a moisture content of at least 3 percent above the optimum moisture content. 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 down and, therefore, require additional time and/or mixing as determined by the **AGENCY or ENGINEER**

#### 5.1.6.4 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 40°F. The treated subgrade shall be

maintained at a temperature of 40° 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 Size	Minimum Percent Passing
1-inch sieve	100
No. 4 sieve	60

### 5.1.7 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 cementitious stabilization agent or water is applied. 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 subgrade stabilization 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 shall be between 0 to 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 sheep foot 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 suitable to the **ENGINEER** or **AGENCY**.

All irregularities, depressions, or weak spots which develop, as determined by the **AGENCY**, shall be corrected immediately by scarifying the areas affected, adding or removing materials as required, and reshaping and recompacting 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, and 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 the **ENGINEER**.

#### **5.1.8 FINISHING AND CURING**

After the final layer of stabilized subgrade has been compacted, the shape of the surface shall be maintained 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 coarse. 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 in 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 (Item 5.1.2.4) is utilized, the minimum application will be at the rate of 0.12 gallons per square yard, as directed by the **ENGINEER** and approved by the **AGENCY**.

The completed section shall be cured for a minimum of 5 days before further courses are added or any traffic is permitted, unless otherwise permitted by the **AGENCY**. The moisture cured duration may be reduced if a non-yielding surface is obtained to support construction traffic and either the next layer of stabilized soils are placed or the pavement layer is constructed, as approved by the **AGENCY**.

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. 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.

## 5.1.9 TOLERANCES

### 5.1.9.1 Thickness

Stabilized zone thickness shall be verified by the use of phenolphthalein and shall be performed at intervals of approximately every 500 feet in each lane. When the measurement of the thickness is deficient by more than 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 the average thickness is deficient by more than 1 inch, the entire area shall be reprocessed to meet the design parameters or the roadway design section must be re-evaluated (Item 5.1.10).

### 5.1.9.2 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.

### 5.1.9.3 Strength

The stabilized subgrade must develop a laboratory compressive strength of at least 160 psi at 5 days in accordance with Table 5.1.12. 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.

### 5.1.10 CONFORMITY WITH PLANS AND SPECIFICATIONS

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 as listed in Table 5.1.10 below. Evaluation of the roadway pavement section will be made by the **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 has been accepted in writing by both the **ENGINEER** and the **AGENCY**.

TABLE 5.1.10

Deficiency	Remediation
< 25% of design thickness	Evaluate roadway design section
> 25% of design thickness	Remove and replace
< 25% of required strength	Evaluate roadway design section
> 25% of required strength	Remove and replace

### 5.1.11 MEASUREMENT

5.1.11.1 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.

5.1.11.2 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).

### 5.1.12 TESTING AND INSPECTION

Testing and inspection shall be performed in accordance with Table 5.1.12

TABLE 5.1.12

<b>SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING</b>		
<b>Test Type</b>	<b>Test Standard</b>	<b>Minimum Frequency of Tests</b>
Sampling	AASHTO T 87	One per 1,000 square yards
Sample Preparation	ASTM D 3551	
Maximum Dry Density and Optimum Moisture Content	ASTM D 698 (Lime) ASTM D558 (Cement)	As directed by <b>AGENCY</b> (minimum one per soil type)
In Place Soil Density	ASTM D 1556 ASTM D 2167 ASTM D 6938	One test for each 200 lane feet (not less than one test per day)
In Place Moisture Content	ASTM D 2216 ASTM D 6938	
Ph	ASTM D 6276	One test per 1,000 square yards
Swell	ASTM D 4546 Method B	As directed by <b>AGENCY</b> minimum one test per 1,000 square yards
Unconfined Compressive Strength (Lime)	ASTM D 5102 (Procedure B)	One set of four cylinders per 1,000 square yards. Sealed and moist cured at 100° F for 5 days.
Compressive Strength Cementitious Agents	ASTM D 1633 (Method A)	One set of four cylinders per 1,000 square yards. Sealed and moist cured at 100° F for 5 days.
Atterberg Limits	AASHTO T 89 & T 90	One test per 1,000 square yards
Stabilization Thickness	As directed by testing <b>AGENCY</b>	One test every 500 feet per lane

### 5.1.13 PAYMENT

Payment shall be made at the Contract unit price per square yard based upon plan quantities for the stabilization. Stabilizing agent shall be paid for by the ton. The price shall be full compensation for furnishing all material and for all preparation of the subgrade material removed and replaced, proof rolling of secondary grade, delivering, placing, mixing, and compacting these materials, all labor, equipment, tools, and incidentals necessary to complete this item, including curing. Stabilized subgrade found deficient in thickness or strength shall be removed and replaced. At the option 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 as noted in Item 5.1.10.

Item	Description	Payment
5.1	Processing of Stabilized Subgrade	\$/yd <sup>2</sup>
5.2	Stabilizing agent	\$/ Ton