

**SECTION 9  
STABILIZED SOIL**

**9.01 GENERAL**

Replace State Standard Specifications Section 24 in its entirety with the following:

- A. SUMMARY - Section 9.01 includes general specifications for stabilizing soils.
- B. DEFINITIONS
  - 1. Stabilizing Agent: Material added to improve strength and durability of the Subgrade material.
- C. SUBMITTALS
  - 1. General
    - a. At least fifteen (15) days before starting soil stabilization activities, submit the name of the laboratory the Contractor will use for QC tests if required by the project. The laboratory must be accredited by AASHTO resource and/or Caltrans for all proposed QC testing.
    - b. Before performing QC sampling and testing, submit the time and location the sampling and testing will occur. Submit QC testing results within twenty-four (24) hours of receiving the results.
    - c. Submit a certificate of compliance with the stabilizing agent samples that includes a statement certifying the stabilizing agent furnished is the same as on the current Caltrans Authorized Material Source List for the stabilizing agent specified.
    - d. Submit a weighmaster certificate for stabilizing agent remaining on hand after completion of the work. Submit a stabilized soil quality control plan within fifteen (15) days prior to start of work.
- D. QUALITY ASSURANCE
  - 1. General
    - a. If requested, perform QC testing in the presence of the Engineer.
    - b. If required, construct test strips with materials, tools, equipment, and methods you will use in the work.
    - c. Construct test pads for compaction tests by scraping away material to the depth ordered. If a compaction test fails, corrective action must include the layers of material already placed above the test pad elevation.
  - 2. Preparing Subgrade Material
    - a. After preparing an area for soil stabilization, verify the surface grades.
  - 3. Mixing
    - a. Randomly test the adequacy of the mixing with a phenolphthalein pH indicator solution.
  - 4. City Acceptance
    - a. Stabilized soil acceptance is based on:
      - i. Visual inspection

ii. Compliance with the requirements shown in the following table:

**Table 9-1 - Stabilized Soil Requirements for Acceptance**

Quality Characteristic	Test Method	Requirement
Relative compaction, (min, %)	California Test 231 and 216	See section for the specified stabilization agent <sup>1</sup>
Stabilization agent application rate	Calibrated tray or equal	Final application rate ordered by the Engineer $\pm$ 5%

<sup>1</sup>For lime stabilized soil, see Section 9.04, C Construction. For cement stabilized soil, see Section 9.05, C Construction.

## 9.02 MATERIALS

### A. GENERAL

1. Reserved

### B. WATER

1. Water for stabilized soil must be clean and contain no more than six-hundred-fifty (650) parts per million of chlorides as Cl determined under California Test 422 and no more than one-thousand-three hundred (1,300) parts per million of sulfates as SO<sub>4</sub> determined under California Test 417.

### C. CURING SEAL

1. Curing seal must be asphaltic emulsion, Grade SS-1, SS-1h, CSS-1, or CSS-1h.

### D. STABILIZING AGENT

1. Lime sources must be on the current Caltrans Authorized Material List for approved producers of lime for use in soil stabilization or approved by City Engineer.

## 9.03 CONSTRUCTION

### A. GENERAL

1. Do not mix different types of stabilizing agent or from more than one source.
2. Deliver stabilizing agent in full loads unless it is the last load needed for a work shift.

### B. PREPARING SUBGRADE MATERIAL

1. For native soil and embankment, remove rocks or solids larger than one and one-half (1.5) inch. Minimum treatment depth is twelve (12) inches.
2. Grade the subgrade material to be stabilized to within eight-hundredths (0.08) foot of the lines and grades shown.

### C. APPLYING STABILIZING AGENT

1. The Geotechnical Engineer, per the Project Soils Report, orders the application rate as pounds of stabilizing agent per square foot of Subgrade material to be stabilized.
2. Do not vary from the design application rate by more than five (5) percent.

### D. MIXING

1. Stabilizing agent and Subgrade material must be uniformly mixed at least twice to within five-hundredths (0.05) foot of the depth shown at any point. If you exceed the mixing depth shown by more than ten (10) percent, add stabilizing agent in proportion to the exceeded depth.
2. Remix until the mixture is uniform with no streaks or pockets of stabilizing agent.

#### E. COMPACTION

1. Compact using a sheepsfoot or segmented wheel roller immediately followed by steel drum or pneumatic-tired rollers.
2. Wherever the thickness shown is one (1.0) foot or less, compact in one (1) layer. Wherever the thickness shown is more than one (1.0) foot, compact in two (2) or more layers of approximately equal thickness. The maximum compacted thickness of any one (1) layer must not exceed one (1.0) foot unless you first construct a test strip to demonstrate your equipment, and methods provide uniform distribution of stabilizing agent and achieve the specified compaction. The test strip must contain at least five hundred (500) sq yd of material and no more material than one (1) day's production. Construct test strips with materials, tools, equipment, and methods you will use in the work.
3. Use other compaction methods in areas inaccessible to rollers.

#### F. FINISH GRADING

1. Wherever the finished surface of stabilized soil is above the allowable tolerance, trim and remove the excess material. Do not leave loose material on the finished surface. If finish rolling cannot be completed within two (2) hours of trimming, defer trimming.
2. Finish rolling of trimmed surfaces must be performed with at least one (1) complete coverage with steel drum or pneumatic-tired rollers.
3. Do not proceed with construction activities for subsequent layers of material until the Engineer verifies the final grades of the stabilized soil.

#### G. CURING

1. General
  - a. Cure by one of the following methods:
    - i. Water cure.
    - ii. Curing seal.
    - iii. Moist material blanket.
1. Water Cure
  - a. Water may be used to cure the finished surface before you place a moist material blanket or apply curing seal. Keep the surface above the optimum moisture content of the stabilized soil. Use this method for no more than three (3) days, after which you must apply a curing seal or place a moist material blanket.
2. Curing Seal:
  - a. Curing seal equipment must have a gauge indicating the volume of curing seal in the storage tank.

- b. Apply curing seal to the finished surface of stabilized soil under State Standard Specifications Section 37-1.03 when the stabilized soil is at optimum moisture content.
  - i. When the ambient temperature is above 40 degrees Fahrenheit and rising.
  - ii. At a rate from one-tenth (0.10) to two-tenths (0.02) gallon per square yard. The exact rate is determined by the Engineer.
- a. Repair damaged curing seal the same day the damage occurs.
- 3. Moist Material Blanket
  - a. Moist material blanket may be either a temporary or permanent layer of material of sufficient thickness to prevent drying of the stabilized soil. You may use moist material blanket if the stabilized soil can bear the weight of construction equipment. Maintain the moist material blanket above the optimum moisture content, as appropriate, until the next structural layer is placed.

## **9.04 LIME STABILIZED SOIL**

### **A. GENERAL**

- 1. Summary
  - a. Section 9.04 includes specifications for stabilizing soil by mixing Subgrade material with lime and water.
- 1. Definitions
  - a. Mellowing period: Time between the initial and final mixing to promote initial chemical reactions between lime, water, and Subgrade material.
- 2. Applying Lime
  - a. The Geotechnical Engineer determines the final application rate for each lime product proposed from the samples submitted based on California Test 373. Wherever the Subgrade material to be stabilized changes, the Geotechnical Engineer changes the application rate. The Geotechnical Engineer provides the optimum moisture content determined under California Test 373 for each application rate.
  - b. Whenever lime in slurry form is used, report the quantity of slurry placed by measuring the volume of slurry in the holding tank once per forty thousand (40,000) sq ft stabilized, or twice per day, whichever is greater.
  - c. The Engineer verifies the application rate of lime used in dry form with a calibrated tray, or equal, once per forty thousand (40,000) sq ft of stabilized soil, or twice per day, whichever is greater.
- 3. Mixing
  - a. During mixing operations, measure and record the ground temperature at full mixing depth.
  - b. Take a composite sample from five (5) random locations after initial mixing. The moisture content of the composite sample tested under California Test

226 must be a minimum of three (3) percent greater than optimum. Determine the moisture versus density relationship of the composite sample material under California Test 216, except part 2, section E, paragraph 6 is modified as follows:

- c. After adjustment of the moisture content, compact each of the remaining test specimens in the mold, then record the water adjustment, tamper reading, and the corresponding adjusted wet density from the chart on Table 1 using the column corresponding to the actual wet weight of the test specimen compacted. Note each of these wet weights on Line I.
  - d. After mixing and before compacting, determine maximum density under California Test 216 from composite samples of mixed material samples from five (5) random locations and at each distinct change in material. Test the gradation for compliance with section 9-2.03C Test the moisture content of the mixed material under California Test 226.
  - e. Moisture content during the mellowing period determined under California Test 226 must be at least three (3) percent higher than the optimum moisture content.
4. Compaction
- a. Test relative compaction on a wet weight basis.
  - b. After initial compaction, determine the in-place density under California Test 231 and moisture content under California Test 226, at the same locations. Perform three tests per one thousand (1,000) sq yd of lime stabilized soil. Test in one (1) foot depth intervals.
5. Quality Control Testing
- a. Lime stabilized soil quality control must include testing the quality characteristics at the frequencies shown in the following table:

**Table 9-2 - QC Testing Frequencies**

Quality Characteristic	Test Method	Sampling Location	Minimum Frequency
Ground surface temperature before adding lime and full depth ground temperature during mixing operations	--	Each temperature location	1 test per 20,000 sq ft, minimum 1 per day
Lime application rate	Calibrated tray or equal	Roadway	1 test per 40,000 sq ft, minimum 2 per day
Gradation on mixed material	California Test 202	Roadway	1 per 1000 sq yd, minimum 1 per day
Moisture content	California Test 226	Roadway	1 per 1000 sq yd on each layer, each day during mixing and mellowing periods, minimum 1 per day
Relative compaction	California Test 231	Roadway	1 per 1000 sq yd one each layer, minimum 1 per day

**A. MATERIALS**

1. Lime must comply with ASTM C977 and the requirements shown in the following table.

**Table 9-3 Lime Quality**

Quality Characteristic	Test Method	Requirement
Available calcium and magnesium oxide (min, %)	ASTM C25 or ASTM C1301 and C1271	High calcium quicklime: CaO > 90 Dolomitic quicklime: CaO > 55 and CaO + MgO > 90
Loss on ignition (max, %)	ASTM C25	7 (total loss) 5 (carbon dioxide) 2 (free moisture)
Slaking rate	ASTM C110	30 °C rise in 8 minutes

2. A one-half (0.50) lb. sample of lime dry-sieved in a mechanical sieve shaker for ten (10) minutes ± thirty (30) seconds must comply with the percentage passing for the sieve size shown in the following table:

**Table 9-4 - Lime Gradation**

Sieve Size	Percentage Passing
3/8"	98-100

3. Slurry must:
  - a. Be free of contaminants.

- b. Contain at least the minimum dry solids.
  - c. Have uniform consistency.
  - d. Prepared at the job site.
- B. CONSTRUCTION
- 1. General
    - a. Before applying lime, measure the ground surface temperature. Apply lime at ground temperatures above 35 degrees Fahrenheit Do not apply lime if you expect the ground temperature to drop below 35 degrees Fahrenheit before you complete mixing and compacting.
    - b. During mixing, maintain the in-place moisture of the subgrade material to be stabilized at a minimum of three (3) percent above the optimum moisture determined under California Test 216 as modified in Section 9.04 During compaction and finish grading, add water to the surface to prevent drying until the next layer of mixed material is placed, or until you apply curing treatment.
    - c. Scarify the surface of lime stabilized soil at least two (2) inches between each layer. Do not scarify the finished surface of the lime stabilized soil.
    - d. From the application of lime to three (3) days after the application of curing treatment, only equipment and vehicles essential to the lime stabilization work are allowed on the lime stabilized soil.
  - 2. Applying Lime
    - a. Apply lime in dry form. You may apply lime in slurry form, if authorized.
    - b. Apply lime uniformly over the area to be stabilized using a vane spreader.
    - c. Lime slurry must be in suspension during application. Apply lime slurry uniformly making successive passes over a measured section of the roadway until the specified lime content is reached. Apply the residue from lime slurry over the length of the roadway being processed.
  - 3. Mixing
    - a. Mix lime on the same day it is applied. After the initial mixing, allow a mellowing period for at least twenty-four (24) hours before final mixing for untreated Subgrade material with a plasticity index (ASTM D4318) of twenty-five (25) or less, and at least thirty-six (36) hours before final mixing for untreated Subgrade material with a plasticity index (ASTM D4318) higher than twenty-five (25). You may add water and mix during the mellowing period.
    - b. Complete all the mixing work within three (3) days of the initial application of lime.
    - c. Before comp action, the mixed material, except rock, must be within the percentage passing limits for the sieve sizes shown in the following table:

**Table 9-5 - Mixed Material Gradation**

Sieve Size	Percentage Passing
1.5"	100
1"	95-100
No. 4	60-100

4. Compaction
  - a. Do not use vibratory rollers.
  - b. Start compacting immediately after final mixing.
  - c. Compact the lime stabilized soil to at least ninety-five (95) percent relative compaction.
5. Finish Grading
  - a. The finished surface of the stabilized soil must not vary more than eight-hundredths (0.08) foot above or below the grade established by the project plans.
  - b. Maintain the moisture content of the lime stabilized soil at a minimum of three (3) percent above optimum moisture content through the entire finish grading operation.
  - c. Wherever lime stabilized soil is below the allowable tolerance, you may use trimmed material to fill low areas only if final grading and final compaction occurs within forty-eight (48) hours of beginning initial compaction. Before placing trimmed material, scarify the surface of the area to be filled at least two (2) inches deep.
6. Curing
  - a. Choose the method of curing and apply the chosen curing method within twenty-four (24) hours of completing the sheepsfoot or segmented wheel compaction and within the same day of any trimming and finish grading.
7. Payment
  - a. Payment shall be made at the contract price per square yard and shall include full compensation for furnishing all labor, materials, tools, equipment, traffic control, incidentals and for doing all the work in placing soil stabilization, compaction, trimming, and curing complete in place as shown on the plans, as specified in these specifications, and as directed by the City Engineer. The City does not adjust the unit price for an increase or decrease in lime quantity.

## **9.05 CEMENT STABILIZED SOIL (CSS)**

### **A. GENERAL**

1. Summary
  - a. Section 9.05 includes specifications for constructing CSS by mixing Subgrade material with cement and water.
2. Submittals

- a. Submit a certificate of compliance under State Standard Specifications Section 90-1.01C(3).
3. Quality Assurance
  - a. Stop CSS activities and immediately notify the Engineer if either of the following occurs:
    - i. Any quality control test result does not comply with the Specifications.
    - ii. Visual inspection shows noncompliant CSS.
  - b. If CSS activities are stopped, before resuming activities:
    - i. Notify the City of the adjustments you will make.
    - ii. Reprocess, remedy, or replace the noncompliant CSS until it complies with specifications.
    - iii. Construct a one thousand (1,000) square yard test strip of CSS demonstrating ability to comply with the specifications.
    - iv. Obtain the City's authorization.
4. Applying Cement
  - a. The Engineer determines the final application rate based on ASTM D1633, Method A, except:
    - i. Test specimens must be compacted under ASTM D1557, Method A or B.
    - ii. Test specimens must be cured by sealing each specimen with two (2) layers of plastic at least four (4) millimeters thick. The plastic must be tight around the specimen. Seal all seams with duct tape to prevent moisture loss. Sealed specimens must be placed in an oven for seven (7) days at  $100 \pm 5$  degrees F. At the end of the curing period, specimens must be removed from the oven and air-cooled. Duct tape and plastic wrap must be removed before capping. Specimens must not be soaked before testing.
  - b. The application rate is ordered as pounds of cement per square yard of Subgrade material to be stabilized.
  - c. Before applying cement, measure and record the air temperature and in situ moisture content of the Subgrade material to be stabilized.
  - d. The Engineer verifies the application rate using a calibrated tray or equal once per forty thousand (40,000) sq ft of stabilized Subgrade material, or twice per day, whichever is greater.
5. Mixing
  - a. During mixing operations, measure and record the air temperature for the Subgrade material to be stabilized.
  - b. For each day of mixing, test the in-place moisture content under California Test 231, Part 1, Section E and verify moisture content under California Test 226. Sample immediately after mixing.
  - c. After mixing, maintain the in-place moisture of the Subgrade material to be stabilized within a range of one (1) percent below to two (2) percent above the optimum moisture determined under California Test 216. Determine in-place moisture content under California Test 231. During compaction and finish

grading, add water to the surface to prevent drying until the next layer of mixed material is placed, or until you apply curing treatment.

6. Compaction

- a. After compaction, determine in-place wet density under California Test 231 and moisture content under California Test 226, at the same locations. Perform one test per one thousand (1,000) sq yd of CSS. Test in one (1) foot depth intervals from the bottom of the CSS layer regardless of the layer thickness. Convert wet density to dry density and calculate relative compaction under California Test 216 on a dry density basis.

7. Quality Control Testing

- a. Cement stabilized soil quality control must include testing the quality characteristics at the frequencies shown in the following table:

**Table 9-6 - QC Testing Frequencies**

Quality Characteristic	Test Method	Sampling Location	Minimum Frequency
Air temperature before adding cement to Subgrade material	--	Each temperature location	1 test per 20,000 sq ft, minimum 1 per day
Moisture content of Subgrade material before adding cement	California Test 226	Roadway	1 per 1,000 sq yd per layer, minimum 1 per day
Cement application rate	Calibrated tray or equal	Roadway	1 test per 20,000 sq ft, minimum 2 per day
Gradation on mixed material	California Test 202	Roadway	1 per 1,000 sq yd per layer, minimum 1 per day
Moisture content of mixed material	California Test 226	Roadway	1 per 1,000 sq yd per layer, minimum 1 per day
Moisture content of compacted material at time of relative compaction testing	California Test 231	Roadway	1 per 1,000 sq yd per layer, minimum 1 per day
Relative compaction	California Test 231	Roadway	1 per 1,000 sq yd per layer, minimum 1 per day

B. MATERIALS

- 1. Cement must comply with SSS Section 90-1.02B(2).

C. CONSTRUCTION

1. General

- a. Remove standing water from the Subgrade material.
- b. Apply cement at air temperatures above 40 degrees F and rising. Do not apply cement to frozen Subgrade material.
- c. During compaction and finish grading, add water to the surface to prevent drying until the next layer of mixed material is placed, or until you apply curing treatment.
- d. Do not scarify surfaces of intermediate or final layers of CSS.

2. Applying Cement
  - a. Apply cement uniformly over the area to be stabilized using a vane spreader.
  - b. Do not apply dry cement in windy conditions that will result in dust outside the treatment area.
3. Mixing
  - a. You may mix cement and the Subgrade material off the job site.
  - b. Complete initial mixing work within thirty (30) minutes of the application of cement.
  - c. After mixing, maintain the in-place moisture of the Subgrade material to be stabilized within a range of one (1) percent below to two (2) percent above the optimum moisture.
  - d. Before compaction, the CSS, except rock, must be within the percentage passing limits for the sieve sizes shown in the following table:

**Table 9-7 - Cement Stabilized Soil Gradation**

Sieve Sizes	Percentage Passing
2"	100
3/4"	98-100
No. 4	55-100

4. Compaction
  - a. Complete initial compaction of a layer within two (2) hours of initial mixing of cement.
  - b. Complete all compaction of a layer within four (4) hours of mixing of cement.
  - c. Compact the CSS to at least ninety-seven (97) percent relative compaction.
5. Finish Grading
  - a. Maintain the moisture content of the CSS to within a range of one (1) percent below and two (2) percent above the optimum moisture content through the entire finish grading operation.
  - b. Finish rolling of trimmed surfaces must be performed within two (2) hours of completion of compacting.
  - c. The finished surface of the CSS must not vary more than five-hundredths (0.05) foot above or below the grade established by the project plans unless approved by the City.
  - d. Fill areas of finished CSS that are lower than the grade established by the Engineer with material specified for the subsequent layer.
6. Curing
  - a. Choose the method of curing and apply the chosen cure method on the same day as completing compaction and any trimming and finish grading.
  - b. Do not trim CSS after curing.
  - c. For CSS you may cure by placing a subsequent pavement layer over the finished CSS.

- d. You may place subsequent pavement layers any time after finish grading if the CSS is sufficiently stable to support the required construction equipment without marring or permanently distorting the surface.

**D. PAYMENT**

1. Payment shall be made at the contract price per square yard and shall include full compensation for furnishing all labor, materials, tools, equipment, traffic control, incidentals and for doing all the work in placing soil stabilization, compaction, trimming, and curing complete in place as shown on the plans, as specified in these specifications and as directed by the City Engineer. The City will not pay for subsequent layer material used to fill low areas of cement stabilized soil. The City does not adjust the unit price for an increase or decrease in cement quantity.