

Section 02335**SUBGRADE****1.0 GENERAL****1.01 SECTION INCLUDES**

- A. Foundation course of lime and Portland Cement stabilized in situ subgrade material.
- B. References to Technical Specifications:
 - 1. Section 01200 – Measurement and Payment Procedures
 - 2. Section 01350 – Submittals
 - 3. Section 01450 – Testing Laboratory Services
 - 4. Section 01500 – Temporary Facilities and Controls
 - 5. Section 01564 – Control of Ground Water and Surface Water
 - 6. Section 01720 – Field Surveying
 - 7. Section 01140 – Contractor’s Use of Premises
- C. Referenced Standards:
 - 1. American Society for Testing and Materials (ASTM)
 - a. ASTM D 4318, “Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils”
 - b. ASTM D 698, “Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort”
 - c. ASTM D 1556, “Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method”
 - d. ASTM D 2922, “Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)”
 - e. ASTM D 3017, “Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)”
 - f. ASTM C 150 - Standard Specification for Portland Cement.
 - g. ASTM D 558 - Standard Test Method for Moisture-Density Relations of Soil-Cement-Mixtures.

1.02 MEASUREMENT AND PAYMENT

- A. Measurement for subgrade is on a square yard basis. Separate payment will be made for each different required type and thickness of stabilized Subgrade. Limits of measurement shall match actual pavement replaced, but no greater than maximum pavement replacement limits shown on Drawings. Limits for measurement will be extended to include installed stabilized subgrade material that extends 2 foot beyond outside edge of pavement to be replaced, except where proposed pavement section

shares common longitudinal or transverse edge with existing pavement section. No payment will be made for stabilized subgrade in areas beyond these limits.

- B. Measurement for hydrated lime and quicklime is by the ton of 2,000 pounds dry-weight basis, determined by the area to be covered and the rate of application. Do not include cost of hydrated lime or quicklime in Bid Item for subgrade.
- C. Measurement for lime slurry is by the ton of 2,000 pounds of lime calculated on the percentage by weight of dry solids for the grade of slurry. Do not include cost of lime slurry in Bid Item for subgrade.
- D. Measurement for Portland Cement is by the ton of 2,000 pounds of dry weight basis. Do not include cost of Portland Cement in Bid Item for subgrade.
- E. Refer to Section 01200 – Measurement and Payment Procedures.

1.03 SUBMITTALS

- A. Make Submittals required by this Section under the provisions of Section 01350 – Submittals.
- B. Submit certificates stating that hydrated lime, commercial lime slurry and quicklime complies with the requirements in this Section.
- C. Submit weight tickets, certified by supplier, with each bulk delivery of lime to Project Site.
- D. Submit manufacturer's description and characteristics for rotary speed mixer and compaction equipment for approval.

1.04 TESTING AND SAMPLING

- A. Testing will be performed under provisions of Section 01450 – Testing Laboratory Services.
- B. Tests and analysis of soil materials will be performed in accordance with ASTM D 4318.
- C. Sampling and testing of lime slurry shall be in accordance with Tex-600-J.
- D. Sample mixtures of Portland Cement, hydrated lime or quicklime in slurry form will be tested to establish compliance with the requirements in this Section.
- E. Soil will be evaluated to establish percent of hydrated lime, quicklime, or lime slurry to be applied to subgrade material.
- F. Moisture-density relationship will be established on material sample from roadway, after stabilization, in accordance with ASTM D 698.

- G. Soil will be evaluated to establish ratio of cement to soil to obtain desired stability. Normal range is 6 percent to 10 percent by weight.
- H. The percentage of moisture in soil, at time of cement application, will be determined by ASTM D 558. Moisture will not be allowed to exceed quantity that will permit uniform, complete mixture of soil and cement during dry mixing operations nor specified optimum moisture content for soil cement mixture, as determined.

1.05 PROTECTION OF PEOPLE AND PROPERTY

- A. Contractor shall conduct all construction operations under this Contract in conformance with the practices described in Section 01500 – Temporary Facilities and Controls.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Bagged lime shall bear manufacturer's name, product identification, and certified weight. Bags varying more than 5 percent of certified weight may be rejected; average weight of 50 random bags in each shipment shall not be less than certified weight.
- B. Store lime in weatherproof enclosures. Protect lime from ground dampness.
- C. Quicklime can be dangerous; exercise extreme caution if used for the Work. Contractor shall become informed about recommended precautions in the handling, storage and use of quicklime.

2.0 PRODUCTS

2.01 WATER

- A. Water shall be clean; clear; and free from oil, acids, alkali, or organic matter.

2.02 LIME

- A. Type A - Hydrated Lime: Dry material consisting essentially of calcium hydroxide or mixture of calcium hydroxide and an allowable percentage of calcium oxide and magnesium hydroxide.
- B. Type B - Lime Slurry: Liquid mixture consisting essentially of lime solids and water in slurry form. Water or liquid portion shall not contain dissolved material in sufficient quantity to be injurious or objectionable for purpose intended.
- C. Type C - Quicklime: Dry material consisting essentially of calcium oxide. Furnish quicklime in either of the following grades:

1. Grade DS: Pebble quicklime of a gradation suitable for use in the preparation of a slurry for wet placing.
2. Grade S: Finely-graded quicklime for use in the preparation of a slurry for wet placing. Do not use Grade S quicklime for dry placing. (So called "Blue Lime" is not acceptable.)

D. Lime shall conform to following requirements:

CHEMICAL COMPOSITION	TYPE		
	A	B	C
Active lime content, % by weight $\text{Ca}(\text{OH})_2 + \text{CaO}$	90.0 min ¹	87.0 min ²	-
Unhydrated lime content, % by weight CaO	5.0 max	-	87.0 min
Free water content, % by weight H_2O	5.0 max	-	-
SIZING			
Wet Sieve, as % by weight residue retained:			
No. 6	0.2 max	0.2 max ²	8.0 max ³
No. 30	4.0 max	4.0 max ²	-
Dry sieve, as % by weight residue retained:			
1-inch	-	-	0.0
3/4-inch	-	-	10.0 max

Notes:

¹ Maximum 5.0% by weight CaO shall be allowed in determining total active lime content.

² Maximum solids content of slurry.

³ Total active lime content, as CaO, in material retained on the No. 6 sieve shall not exceed 2.0% by weight of original Type C lime.

E. Lime Slurry may be delivered to the Project Site as Commercial Lime Slurry, or may be prepared at the Project Site using Hydrated Lime or Quicklime. The slurry shall be free of liquids other than water and shall be of a consistency that can be handled and uniformly applied without difficulty.

2.03 PORTLAND CEMENT (ONLY WHEN DIRECTED BY ENGINEER)

A. ASTM C 150 Type I, bulk or sacked.

2.04 SOIL

- A. Provide soil consisting of approved material free from vegetation or other objectable matter encountered in existing roadbed.

3.0 EXECUTION**3.01 EXAMINATION**

- A. Verify backfill of new or relocated utilities and structures below future grade is complete.
- B. Verify compacted subgrade is ready to support imposed loads.
- C. Verify subgrade lines and grades are correct.

3.02 PREPARATION

- A. Install and operate necessary dewatering and surface water control measures in accordance with requirements of Section 01564 – Control of Ground Water and Surface Water.
- B. Identify required lines, levels, and datum. Coordinate with Section 01720 – Field Surveying.
- C. Cut material to bottom of subgrade using an approved cutting and pulverizing machine meeting following requirements:
 - 1. Cutters accurately provide a smooth surface over entire width of cut to plane of secondary grade.
 - 2. Visible indication that cut is to proper depth.
- D. Alternatively, scarify or excavate to bottom of stabilized subgrade. Remove material or windrow to expose secondary grade. Correct wet or unstable material below secondary grade by scarifying, adding lime, and compacting. Obtain uniform stability.
- E. Upon discovery of unknown or badly deteriorated utilities, or concealed conditions, discontinue work. Notify Engineer and obtain instructions before proceeding in such areas.

3.03 LIME SLURRY APPLICATION

- A. Mix hydrated lime or quicklime with water to form a slurry of the solids content specified. Commercial lime slurry shall have dry solids content as specified. Conform to cautionary requirements in this Section, 1.06C, concerning use of quicklime.

- B. Apply slurry with a distributor truck equipped with an agitator to keep lime and water in a consistent mixture. Make successive passes over measured section of roadway to attain proper moisture and lime content. Limit spreading to an area where preliminary mixing operations can be completed on the same working day.

3.04 PRELIMINARY MIXING

- A. Do not mix and place material when temperature is below 40 degrees F and falling. Base may be placed when temperature taken in shade and away from artificial heat is above 35 degrees F and rising.
- B. Use approved single-pass or multiple-pass rotary speed mixers to mix soil, lime, and water to required depth. Obtain a homogeneous friable mixture free of clods and lumps.
- C. Shape mixed subgrade to final lines and grades.
- D. Seal subgrade as a precaution against heavy rainfall by rolling lightly with light pneumatic rollers.
- E. Cure soil-lime material for 1 to 4 days. Keep subgrade moist during cure.

3.05 FINAL MIXING

- A. Use approved single-pass or multiple-pass rotary speed mixers to uniformly mix cured soil and lime to required depth.
- B. Add water to bring moisture content of soil mixture to a minimum of optimum or above.
- C. Mix and pulverize until all material passes a 1 inch sieve; a minimum of 90 percent, excluding non-slaking fractions, passes a 3/4-inch sieve; and a minimum of 65 percent excluding non-slaking fractions passes a No. 4 sieve.
- D. Shape mixed subgrade to final lines and grades.
- E. Do not expose hydrated lime to open air for more than 6 hours during interval between application and mixing. Avoid excessive hydrated lime loss due to washing or blowing.

3.06 MIXING - PORTLAND CEMENT (ONLY WHEN DIRECTED BY ENGINEER)

- A. Do not place and mix cement when temperature is below 40 degrees F and falling. Place Portland Cement base when temperature taken in shade and away from artificial heat is above 35 degrees F and rising.

- B. Spread cement uniformly on soil at rate specified by laboratory. When bulk cement spreader is used, position it by string lines or other approved method to ensure uniform distribution of cement. Apply cement only to area where operations can be continuous and completed in daylight, within 1 hour of application. Amount of moisture in soil at time of cement placement shall not exceed quantity that will permit uniform mixture of soil and cement during dry mixing operations. Do not exceed specified optimum moisture content for soil cement mixture.
- C. Do not allow equipment other than that used in spreading and mixing, to pass over freshly spread cement until it is mixed with soil.
- D. Dry mix cement with soil after cement application. Continue mixing until cement has been sufficiently blended with soil to prevent formation of cement balls when water is applied. Mixture of soil and cement that has not been compacted and finished shall not remain undisturbed for more than 30 minutes.
- E. Immediately after dry mixing is complete, uniformly apply water as necessary and incorporate it into mixture. Pressurized equipment must provide adequate supply to ensure continuous application of required amount of water to sections being processed within 3 hours of cement application. Ensure proper moisture distribution at all times. After last increment of water has been added, continue mixing until thorough and uniform mix has been obtained.
- F. Ensure percentage of moisture in mixture, based on dry weights, is within 2 percentage points of specified optimum moisture content prior to compaction. When uncompacted soil cement mixture is wetted by rain indicating that average moisture content exceeds tolerance given at time of final compaction, reconstruct entire section in accordance with this Section at no additional cost to City.

3.07 COMPACTION - LIME SUBGRADE

- A. Aerate or sprinkle to attain optimum moisture content as determined by Testing Laboratory. Remove and reconstruct sections where average moisture content exceeds ranges specified at time of final compaction.
- B. Start compaction immediately after final mixing, unless approved by Engineer.
- C. Spread and compact in two or more approximately equal layers where total compacted thickness is to be greater than 8 inches.
- D. Compact with approved heavy pneumatic or vibrating rollers, or a combination of tamping rollers and light pneumatic rollers. Begin compaction at the bottom and continue until entire depth is uniformly compacted.
- E. Do not allow stabilized base to mix with underlying material. Correct irregularities or weak spots immediately by replacing material and re-compacting.

- F. Compact to following minimum densities at a moisture content of optimum to 3 percent above optimum as determined by ASTM D 698, unless otherwise indicated on the Plans:
 - 1. Areas to receive pavement without subsequent base course: Minimum density of 98 percent of maximum dry density.
 - 2. Areas to receive subsequent base course: Minimum density of 95 percent of maximum dry density.
- G. Seal with approved light pneumatic tired rollers: Prevent surface hair line cracking. Rework and re-compact at areas where hair line cracking develops.
- H. Contractor shall conduct operations to minimize elapsed time between mixing and compacting stabilized subgrade in order to take advantage of rapid initial set characteristics. Complete compaction within 2 hours of commencing compaction and not more than 6 hours after adding and mixing the last stabilizing agent.

3.08 COMPACTION - PORTLAND CEMENT SUBGRADE (ONLY WHEN DIRECTED BY ENGINEER)

- A. Prior to beginning compaction, ensure mixture is in loose condition for its full depth. Uniformly compact the loose mixture to specified density, lines and grades.
- B. After soil and cement mixture is compacted, apply water uniformly as needed and mix thoroughly. Then reshape surface to required lines, grades and cross section and lightly scarify to loosen imprints left by compacting or shaping equipment.
- C. Roll resulting surface with pneumatic-tired roller and “skin” surface with power grader. Thoroughly compact mixture with pneumatic roller, adding small increments of moisture, as needed. When aggregate larger than No. 4 sieve is present in mixture, make one complete coverage of section with flat-wheel roller immediately after skinning operation. When approved by Project Manager, surface finishing methods may be varied from this procedure, provided dense uniform surface, free of surface compaction planes, is produced. Maintain moisture content of surface material at its specified optimum during finishing operations. Compact and finish surface within period not to exceed 2 hours, to produce smooth, closely knit surface, free of cracks, ridges, or loose material, conforming to crown, grade and line shown on Drawings within period not to exceed 2 hours.

3.09 CURING

- A. Moist cure for a minimum of 3 days before placing base or surface course, or opening to traffic. Time may be adjusted as approved by Engineer. Subgrade may be opened to traffic after 2 days if adequate strength has been attained to prevent damage. Restrict traffic to light pneumatic rollers or vehicles weighing less than 10 tons.

- B. Keep subgrade surface damp by sprinkling. Roll with light pneumatic roller to keep surface knit together.
- C. Place base, surface, or seal course within 14 days after final mixing and compaction unless prior approval is obtained from Engineer.

3.10 TOLERANCES

- A. Top of compacted surface: Plus or minus 1/4 inch in cross section or in 16 foot length.

3.11 FIELD QUALITY CONTROL

- A. A minimum of three phenolphthalein test will be made at random locations per 1000 linear feet per lane of roadway or 500 square yards of base to determine in-place depth.
- B. Contractor may, at his own expense, request additional cores in the vicinity of cores indicating nonconforming in-place depths. If the average of the tests falls below the required depth, place and compact additional material at no cost to the Owner.
- C. Compaction Testing will be performed in accordance with ASTM D 1556 or ASTM D 2922 and ASTM D 3017 at random locations near depth determination tests. Three tests will be performed for each 1000 foot roadway section. Rework and re-compact areas that do not conform to compaction requirements at no cost to the Owner.

3.12 CLEAN-UP AND RESTORATION

- A. Perform clean-up and restoration in and around construction zone in accordance with Section 01140 – Contractor’s Use of Premises.
- B. Fill test pits with new compacted lime stabilized subgrade.
- C. Completed surface shall be smooth and conform to typical section and established lines and grades.
- D. In unpaved areas, grade surface as a uniform slope from installed appurtenances to natural grade and stabilize as indicated on Plans.

3.13 PROTECTION OF THE WORK

- A. Maintain stabilized Subgrade to lines and grades and in good condition until placement of base or surface course.
- B. Protect the asphalt membrane, if used, from being picked up by traffic.

- C. Repair settlements, areas with loss of density, or areas of subgrade damaged by Contractor's operations at no additional cost to Owner by replacing and re-compacting material to full depth.

- D. Distribute construction traffic evenly over compacted areas, where practical, to aid in obtaining uniform compaction. Protect exposed areas having high moisture content from wheel loads that cause rutting.

END OF SECTION