

**STATE OF OHIO
DEPARTMENT OF TRANSPORTATION
SUPPLEMENT 1120
Mixture Design for Chemically Stabilized Soils**

July 20, 2007

1120.01 Description

1120.02 Untreated Soil Characteristics and Properties

1120.03 Lime or Lime Kiln Dust Mix Design Procedure

1120.04 Chemical Mixture, Cement, Cement and Lime, Cement and Lime Kiln Dust Mix Design Procedure

1120.05 Moisture Conditioning

1120.06 Expansion Testing

1120.07 UCS of the Cured and Moisture Conditioned Specimens

1120.08 Minimum Chemical Mixture Content for Soil Stabilization

1120.09 Field Verification of the Mix Design

1120.10 Reports and Final Report

1120.01 Description. This work consists of sampling and testing soils mixed with cement, cement and lime, cement and lime kiln dust, lime or lime kiln dust to determine the optimum mix design. This supplement can be used in design to compare alternative mixes, and in construction to determine the optimum design. During construction, only test, design and use the chemical(s) denoted for payment in 205.07 or 206.08.

Use an accredited Geotechnical Testing Laboratory with a qualified staff experienced in testing and designing chemical stabilization and capable of performing the tests listed in the tables below. The staff must be under the supervision of at least one Professional Engineer with specialized experience in geotechnical engineering for a minimum of five years. The Geotechnical Testing Laboratory must be currently accredited by either of the following:

AASHTO Materials Reference Laboratory (AMRL)
National Institute of Standards and Technology
100 Bureau Drive, Stop 8619
Building 202, Room 211
Gaithersburg, Maryland 20899-8619
(301)-975-5450 or www.amrl.net

American Association of Laboratory Accreditation (A2LA)
5301 Buckeystown Pike, Suite 350
Frederick, Maryland 21704
(301)-644-3248 or www.A2LA.org

The Geotechnical Testing Laboratory minimum accreditations required are a general laboratory inspection and the following AASHTO or ASTM designation tests:

:

TEST DESIGNATION		
AASHTO	ASTM	TITLE
T 87	D 421	Dry Preparation of Samples
T 88	D 422	Particle Size Analysis of Soils
T 89	D 4318	Determining the Liquid Limit of Soils
T 90	D 4318	Determining the Plastic Limit and Plasticity Index of Soils
T 99	D 698	Moisture-Density Relations of Soils (Standard Proctor)
T 100	D 854	Specific Gravity of Soils
T 208	D 2166	Unconfined Compression Strength of Cohesive Soil
T 265	D 2216	Laboratory Determination of Moisture Content of Soils

Ensure the Geotechnical Testing Laboratory is also experienced and proficient in the following tests:

TEST DESIGNATION		
AASHTO	ASTM	TITLE
M 145		Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes (as modified by the Department Specifications for Geotechnical Explorations)
	D 3877	One Dimensional Expansion, Shrinkage, and Uplift Pressure of Soil-Lime Mixtures
For Cement, Cement and Lime, Cement and Lime Kiln Dust:		
	D 1633	Compressive Strength of Molded Soil-Cement Cylinders
	D 1632	Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory
For Lime, and Lime Kiln Dust:		
	D 5102	Unconfined Compressive Strength of Compacted Soil-Lime Mixtures
	D 6276	Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization

1120.02 Untreated Soil Characteristics and Properties. When this supplement is used in design, the geotechnical consultant shall submit a plan to modify the sampling procedure below to quantify the effects of chemical mixtures on the proposed soil to be stabilized. Ensure the modified sampling procedure includes a minimum of 6 samples per mile (1.6 km).

When this supplement is used in construction, use the project soil borings to determine where to sample the soil to be stabilized.

Obtain 6 samples per mile (1.6 km) of work or one per soil classification, whichever is greater. A sample consists of 5 gallons (19 liters) of soil. Obtain the samples at 6 different locations along each mile (1.6 km) of work.

Determine, record, and report the following characteristics and properties of the soil for each sample:

- A. In place moisture content using AASHTO T 265 or ASTM D 2216.
- B. Particle size analysis using AASHTO T 88 or ASTM D 422, as modified by the Department Specifications for Geotechnical Explorations section 603.3.2.
- C. Liquid limit using AASHTO T 89 or ASTM D 4318.
- D. Plastic Limit and Plasticity Index using AASHTO T 90 or ASTM D 4318. Perform the plastic limit test immediately prior to the liquid limit test.
- E. Soil classification using AASHTO M 145 procedures, as modified by the Department Specifications for Geotechnical Explorations.

Prior to performing more tests submit the results to the Department for review. In this submittal recommend the testing to complete the requirements of this specification. Summarize the work by soil type. Obtain Department written acceptance before performing any additional testing. Allow 7 days to review this information.

Retain enough soil of each classification to perform the remaining tests required by this specification by combining samples if necessary.

For each soil classification found on the project, do not perform more than three complete tests required by the remaining sections of this specification.

1120.03 Lime or Lime Kiln Dust Mix Design Procedure.

A. Minimum Lime or Lime Kiln Dust Demand. Determine the minimum amount of lime or lime kiln dust required for soil stabilization using ASTM D 6276, also known as the “Eades-Grim” test. Determine the lowest percentage of lime or lime kiln dust that produces a pH of 12.4. This is the minimum lime or lime kiln dust percentage required to stabilize the soil. Record and report this value as “Minimum Lime Percentage Required for pH of 12.4.”

During the test, lime or lime kiln dust can react with moisture and carbon dioxide; careful storage is required to produce reliable results.

Not all laboratory pH-measuring devices are capable of accurate calibration to determine pH levels above 12.0. Ensure that the pH meter can manually accept a custom buffer (a buffer is a standard solution). Use only pH meters capable of accurately measuring pH levels to 14.0. Carefully calibrate the pH meter to accurately determine pH of the soil-lime-water specimens. Care must be taken to select, use, properly calibrate, clean and maintain the laboratory pH meter.

ASTM D 6276 has additional provisions for cases in which the measured laboratory pH is 12.3 or less.

B. Optimum Moisture Content (OMC). Determine the OMC of the untreated soil using the one point Proctor method, the Ohio Typical Density Curves, and S-1015.

Make a mixture of soil, lime or lime kiln dust, and water at the minimum percentage of lime or lime kiln dust as determined in Section 1120.03.A and at two and four percent lime or lime kiln dust above this amount. Thoroughly mix the soil and lime or lime kiln dust at moisture content 2-3% above the OMC of the untreated soil until the lime or lime kiln dust is consistently blended throughout the soil, as determined visually. Use a Hobart mixer or other suitable mechanical mixer. Do not use hand mixing. Seal the mixture in an airtight, moisture proof bag or container at room temperature for 20-24 hours.

Remove the soil-lime mixture from the sealed container and lightly remix for a maximum of two minutes.

For each mixture, use S-1015 to determine the OMC and maximum dry density (MDD) of the lime-treated soil using the one point Proctor method and the Ohio Typical Density Curves.

C. Unconfined Compressive Strength (UCS) Mixtures. Prepare three mixtures of lime or lime kiln dust, soil and water and one mixture of soil and water for the UCS specimens. Submit the proposed percentages to the Department for acceptance. Obtain Department written acceptance before performing any additional testing. Allow 7 days to review this information.

Make the following mixtures at the OMC determined in 1120.03.B

- 1) Mixture 1: Soil and Water.
- 2) Mixture 2: Soil, lime or lime kiln dust and water at the percentage of lime determined in 1120.03.A.
- 3) Mixture 3: Soil, lime or lime kiln dust and water at a lime percentage 2% higher than the amount determined in 1120.03.A.
- 4) Mixture 4: Soil, lime or lime kiln dust and water at a lime percentage 4% higher than the amount determined in 1120.03.A

D. UCS Specimens. Make a minimum of three UCS test specimens for each mixture prepared in 1120.03.C. Use ASTM D 5102, section 10.4.2 Procedure B. Compact the specimens at the OMC.

E. Curing. Immediately after the UCS specimens have been made, carefully and completely wrap in plastic wrap and store separately in an airtight, moisture proof bag. Cure the specimens for 7 days at 104 °F (40 °C).

1120.04 Chemical Mixture, Cement, Cement and Lime, Cement and Lime Kiln Dust Mix Design Procedure.

A. Optimum Moisture Content (OMC). Determine the OMC of the untreated soil using the one point Proctor method, the Ohio Typical Density Curves and S-1015.

When cement is specified, make mixtures of soil, cement and water at 3, 6 and 9 % cement.

When cement and lime or cement and lime kiln dust are specified, make a mixture with 3% of each type of chemical mixture in the sample. The percentage may be modified to meet the requirements in 1120.08.B.

The above percentages are based on the maximum dry weight of the soil.

Thoroughly mix the chemically-treated soil at moisture content 2-3% above the OMC of the untreated soil until the cement is consistently blended throughout the soil, as determined visually. Use a Hobart mixer or other suitable mechanical mixer. Do not use hand mixing.

For each mixture, use S-1015 to determine the OMC and maximum dry density (MDD) of the chemically-treated soil using the one point Proctor method and the Ohio Typical Density Curves.

B. Unconfined Compressive Strength (UCS) Specimens. Make a minimum of three UCS test specimens for each mixture prepared in 1120.04.A. Use ASTM D 1633 Test Method A. Compact the specimens at the OMC.

C. Curing. Immediately after the UCS specimens have been made, carefully and completely wrap in plastic wrap and store separately in an airtight, moisture proof bag. Cure the specimens for 7 days at an ambient temperature of 70 °F (21 °C).

1120.05 Moisture Conditioning. After curing, moisture condition the specimens by capillary soaking prior to UCS testing. Do the following:

- A. Remove the UCS specimens from the airtight bag, and remove the plastic wrap.
- B. Use a caliper and/or pi-tape to measure the height and circumference of the specimens.
- C. Record and average at least three vertical and circumferential readings each time.
- D. Wrap the specimens with a damp, absorptive fabric.
- E. Within a flat container, place each wrapped specimen on a porous stone.
- F. Add water to the container until the water level is near the top of the stone and in contact with the absorptive fabric, but not in direct contact with the UCS specimen.
- G. Allow the capillary soak process to occur for 24 hours (\pm 1 hour), then remove the UCS specimens and proceed to the next step.

1120.06 Expansion Testing. After the soaking is complete but prior to the UCS testing measure the height and circumference again. Calculate the volume change between the initial (dry) condition and the soaked condition. Report this change as a percentage. Notify the Department if this measurement exceeds 1.5%. Further testing using ASTM D 3877 may be required. The ASTM D 3877 work is extra work and will be paid for under 109.05.

1120.07 UCS of the Cured and Moisture Conditioned Specimens.

- A. Determine, calculate and report the UCS of each specimen in accordance with the following:
 - 1) For Lime or Lime Kiln Dust, ASTM D 5102, sections 13 and 14.
 - 2) For Cement, Cement and Lime, Cement and Lime Kiln Dust, ASTM D 1633.
- B. Determine and report the average UCS for the individual mixtures.
- C. Report the UCS in pounds per square inch (MPa).

1120.08 Minimum Chemical Mixture Content for Soil Stabilization.

- A. For Lime or Lime Kiln Dust: Recommend the minimum lime or lime kiln dust percentage that increases the 8-day compressive strength by 50 psi (0.35 MPa) over Mixture 1 in 1120.03.C.1 and has a minimum 8-day compressive strength of 100 psi (0.70 MPa) for lime and 150 psi (1.0 MPa) for lime kiln dust. Add 1% lime or lime kiln dust to this percentage for use in the field.
- B. For Cement, Cement and Lime, Cement and Lime Kiln Dust: Recommend the minimum cement or chemical mixture percentage that increases the 8-day compressive strength by 50 psi (0.35 MPa) over the untreated soil and has a minimum 8-day compressive strength of 150 psi (1.0 MPa). Add 1% cement to this percentage for use in the field. If cement and lime or cement and lime kiln dust are used add a 0.5 % of each chemical to this percentage for use in the field.

If the average UCS does not meet 1120.08.A or B, then contact the Department.

1120.09 Field Verification of the Mix Design. After the soil and chemical(s) are mixed according to 205.04.B or 206.05.B, sample the mixture to ensure it meets the design strengths in 1120.08. Take three samples randomly every 15,000 cubic yards (11,500 cubic meters) of soil mixture.

- A. For Lime or Lime Kiln Dust: Perform procedures detailed in sections 1120.03.B through 1120.03.E and 1120.05 through 1120.07 on each sample taken.
- B. For Cement, Cement and Lime, Cement and Lime Kiln Dust: Perform procedures detailed in sections 1120.04.B through 1120.07 on each sample taken.

Report these values to the Department.

1120.10 Reports and Final Report. Report the information in 1120.02 and 1120.03.C for acceptance prior to any additional testing. Submit interim reports as required throughout the construction and as requested by the Department. Submit a summary report for each construction season. Submit a final report with all the project information. Summarize in the final report the information required in sections 1120.02, 1120.03, 1120.04, 1120.06, 1120.07, 1120.08 and 1120.09.