

DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Transportation Laboratory
P. O. Box 19128
Sacramento, California 95819



METHOD OF TEST FOR LINEAL SHRINKAGE OF SOILS (BAR METHOD)

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section H of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

This test method describes a procedure for determining lineal shrinkage (LS) of soil. Lineal shrinkage is defined as the percent of shrinkage of a soil bar when dried from its Liquid Limit to its Shrinkage Limit.

B. APPARATUS

The apparatus shall consist of the following:

1. Mold: A corrosion-resistant metal mold having compartments 127 mm long, 19.05 mm deep, and 19.05 mm wide at the top tapering to 17.48 mm at the bottom. All dimensions shall be ± 0.13 mm.
2. Evaporating Dish: A porcelain evaporating dish approximately 114.3 mm in diameter.
3. Spatula: A spatula or pill knife having a blade about 101.6 mm in length and about 19.05 mm in width.
4. Oven: An oven capable of maintaining a temperature of 105°C to 110°C.
5. Sieves: 203.2-mm diameter, full-height 2.36 mm and 425 μ m sieves.
6. Scale: A scale at least 127 mm long.
7. Containers: Milk pans approximately 215.9 mm in diameter at the bottom and approximately 88.9 mm deep for "wet" preparation of sample.

8. Pulverizing Apparatus: Either a mortar and rubber-covered pestle or a mechanical device consisting of a mortar and rubber-covered muller suitable for breaking up the aggregations of soil particles without appreciably reducing the natural size of the individual particles. Use this pulverizing apparatus for "dry" preparation of soils.

9. Stiff fiber brush for removing coatings from coarse aggregate particles.

10. Petroleum jelly for lubricating molds.

C. PREPARATION OF MOLD

Prepare the mold by thinly lubricating the inside surfaces with petroleum jelly to prevent the soil from sticking to the mold.

D. PREPARATION OF SAMPLE

Approximately 75 grams of dry material passing the 425- μ m sieve is required for this test. To ensure that all the material passing the 425 μ m sieve is included in the test sample, prepare a representative portion of the sample to obtain the required amount of material by either the "wet" or "dry" preparation method as follows:

1. Wet Preparation of Sample for Test.
 - a. Place the sample in a small container, cover with water and allow to soak for a period of 2 to 24 hours until the particle

- aggregations have become soft and broken down.
- b. Set the empty 2.36 mm sieve in the bottom of a clean milk pan and pour the liquid from the soaked sample into the sieve. Add enough water to the pan to bring the surface of the liquid approximately 12.7 mm above the mesh of the sieve.
 - c. Place a portion, not exceeding 450 grams, of the soaked material in the water on the sieve. Stir the material by hand and agitate the sieve up and down at the same time. If the material retained on the sieve contains lumps that have not slaked or disintegrated, but which can be crumbled or mashed between the thumb and finger so as to pass the sieve, crush these agglomerations and wash through the sieve into the milk pan.
 - d. After breaking up all lumps, hold the sieve above the soil and water in the pan and wash the soil retained on the sieve with a small amount of clean water. Discard the clean retained 2.36-mm sieve portion of the sample.
 - e. Continue washing portions of the soaked sample as described in paragraphs c and d into the pan until all portions of the sample have been thoroughly washed.
 - f. Repeat the procedure described in paragraphs b, c, d, and e washing the passing 2.36 mm portion over the 425 μ m sieve. Discard the clean material retained on the 425- μ m sieve.
 - g. After all of the soaked material has been washed, remove the 425 μ m sieve and set the pan containing the wash water and material passing the 425 μ m sieve aside and leave undisturbed for several hours until all of the soil particles have settled to the bottom of the pan and the water above the soil is clear.
 - h. Decant or siphon off as much of the clear water as possible. Dry the soil on a hot plate or in an oven to moisture content slightly below the liquid limit. During this drying period, stir the material frequently to prevent caking on the sides or bottom of the container. DO NOT ALLOW ANY PORTION OF THE SAMPLE TO CAKE, as this may alter the soil characteristics. If the water does not become clear in a reasonable length of time during the settling period, do not attempt to remove any water prior to partially drying the sample.
2. Dry Preparation of Sample for Test.
 - a. If the sample is moist, dry thoroughly in air or with artificial heat at a temperature not over 60°C.
 - b. Sieve the dried sample over the nested 2.36-mm and 425 μ m sieves and set aside that portion passing the 425- μ m sieve for later recombination. The 2.36-mm sieve is used to protect the 425- μ m-sieve mesh.
 - c. Remove all coatings on the larger particles retained on the 2.36 mm sieve using a stiff fiber brush. After thoroughly removing all coatings, discard the cleaned aggregate and combine the remainder of the material retained on the 2.36 mm sieve and the coatings from the cleaned aggregate with the material retained on the 425 μ m sieve.
 - d. Pulverize that portion of the sample retained on the 425 μ m sieve using the pulverizing apparatus described in paragraph 8 of Section B, Apparatus.
 - e. After pulverizing, sieve again over the 425- μ m sieve and repulverize the portion still retained.
 - f. Continue pulverizing and sieving the material retained on the 425 μ m sieve until a portion of the material retained produces no further separation of the finer material when vigorously kneaded between the palm of one hand and the thumb of the other.
 - g. Combine all portions of the sample passing the 425- μ m sieve and proceed with test.

E. TEST PROCEDURE

1. Using the evaporating dish, thoroughly mix a representative portion of the prepared passing 425- μm sieve material with water. Use a sufficient amount of material to completely fill the 19.05-mm x 19.05 mm x 127-mm mold.
 - a. If dry material is used, pour about 80 ml of water, more for a clay type and less for a sandy type material, into the evaporating dish. Add the dry soil slowly and mix thoroughly with the water until a consistency slightly more fluid than the liquid limit is reached.
 - b. If damp or wet soil is used, place a representative portion of the prepared soil in the dish, add water slowly, and mix thoroughly until the proper consistency is reached.

The importance of thorough and uniform mixing of the sample with water cannot be over-emphasized. Clay soils do not readily mix with water and a great deal of manipulation is therefore required.
2. Test to determine when the proper consistency for molding is reached by shaping the sample into a smooth layer about 12.7 mm thick on the bottom or side of the evaporating dish. Place a liquid limit grooving tool, blunt pencil, or stick on the dish and draw it through the sample to form a V-groove.
 - a. If the material just flows into and closes the groove at the bottom of its own accord, the sample is at the proper consistency for molding.
 - b. If a light jarring is necessary to cause the material to close in the groove, add more water and again, thoroughly mix the sample to uniform consistency. Retest until proper consistency for molding is reached.
 - c. If the material is obviously too wet, add more of the prepared soil, mix thoroughly, and retest until proper consistency for molding is reached.
3. Immediately after the soil has been brought to a uniform and proper consistency for molding, work the sample evenly into the lubricated

mold, jarring the mold frequently to assist in the removal of any entrapped air bubbles. "Spading" the material in the mold with the spatula will also help to remove the entrapped air. As soon as the mold has been properly filled, strike off the excess and smooth the soil down level with the top of the mold.

4. Air-dry the specimen until the color of the soil changes slightly. Setting the mold in strong sunlight or a minimum distance of one third of a meter below a heat lamp will accelerate the air-drying. This initial air-drying will minimize cracking of the bar.
5. After air drying the soil bar, place the mold in an oven at a temperature not exceeding 110°C.
6. When the soil bar is dry or when constant length is obtained, cool to room temperature, then carefully remove the soil bar from the mold and place it with one side laying on a flat surface.
7. Measure and record as "L₁" the chord distance between the corners of the convex surface of the soil bar to the nearest 0.25-~~mm~~, i.e. the straight-line distance between the extremities of the longest arc formed by the soil bar. If the soil bar is not curved, measure and record as "L₁" the distance between the upper corners at each end of the soil bar.
8. Turn the soil bar over, measure and record as "L₂" the corresponding distance on that side.

**California Test 228
2000**

F. CALCULATIONS

Calculate the percent lineal shrinkage (LS) to the nearest whole percentage point as follows:

$$LS = ((L_w - L_d)/L_w) \times 100$$
$$= 100 - 0.3937(L_1 + L_2)$$

Where:

L_w = Wet length of soil bar = 127 mm and

L_d = $1/2 (L_1 + L_2)$

G. PRECAUTIONS

1. If a soil bar breaks during the oven drying, this may indicate insufficient air drying prior to placing in the oven. Fit all of the individual pieces of the fractured bar together as accurately and tightly as possible before making the specified measurements.
2. If one of the corners of the soil bar becomes chipped off and cannot be fitted back, estimate the required chord length to the nearest 0.25-mm.

H. SAFETY AND HEALTH

Soils and waters may contain bacteria and/or organisms, which can be harmful to one's health. Please be sure to clearly identify those soils and water, which may contain contaminates. The wearing of dust masks and protective gloves when handling materials is advised.

This method does not purport to address all the safety problems associated with its use.

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans' Laboratory Safety Manual.

Users of this method do so at their own risk.

REFERENCES:
Soils Manual, U.S. Engineering Office,
Galveston, Texas, February, 1942
Soil Testing Procedure, Texas Highway
Department, 1953
AASHTO Designation T 87 and T 146

End of Text (4 Pages) on California Test 228