Test Procedure for

FREEZING AND THAWING TESTS OF COMPACTED SOIL-CEMENT MIXTURE

TxDOT Designation: Tex-135-E

Effective Date: August 1999

1. SCOPE

1.1 This method determines the soil-cement losses, moisture changes, and volume changes (swell and shrinkage) produced by repeated freezing and thawing of hardened soil-cement specimens.

1.2 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 Compaction device, automatic tamper with base plate to hold 152 mm (6 in.) I.D. forming molds, equipped with 4.5 ± 0.01 kg (10 ± 0.02 lb.) ram and adjustable height of fall; striking face of ram, 43 ± 2° segment of a 74 ± 2.5 mm (2.9 ± 0.1 in.) radius circle.

2.2 Compaction mold, 152 mm I.D. +2 or -0.4 mm (6 in. I.D. [+0.0625 or -0.0156 in.]) and 216 ± 2 mm (8.5 ± 1/16 in.) height, with removable collar (Tex-905-K).

2.3 Measuring device, micrometer dial assembly for determining height of specimens, with set of standard spacer blocks.

2.4 Balance, Class G5 in accordance with Tex-901-K, minimum capacity of 16 kg (35 lb.)

2.5 Extra base plate, or other solid and unyielding surface or device.

2.6 Press, specimen ejection.

2.7 Drying oven, controlled to 110 ± 5°C (230 ± 9°F).

2.8 Metal pans, wide and shallow, for mixing and drying materials.

2.9 Carriers or trays.

2.10 Stones, circular and porous, slightly less than 152 mm (6 in.) in diameter and approximately 51 mm (2 in.) in height.
2.11 Supply of small tools, including 1.8 to 2.3 kg (4 to 5 lb.) rawhide hammer, 0.45 to 0.9 kg (1 to 2 lb.) plastic mallet, mixing pan and trowel, and level.

2.12 Freezing cabinet, capable of maintaining temperature of minus 23.3°C (-10°F) or lower.

2.13 Moist room, or suitable covered container capable of maintaining a temperature of 21 ± 2°C (70 ± 3°F) and a relative humidity of 98% to 100% for seven days.

2.14 Wire scratch brush, of 51 × 4 mm (2 × 0.167 in.) flat No. 26 gauge wire bristles assembled in 50 groups of ten bristles each and mounted to form five longitudinal rows and ten transverse rows of bristles on a 191 × 64 mm (7.5 × 2.5 in.) hardwood block.

2.15 Mechanical mixing device.

2.16 Scarifier, six-pronged ice pick, or similar apparatus, to remove the smooth compaction planes at the top of the first, second, and third layers of the specimen.

2.17 Flat pan, about 51 mm (2 in.) deep.

2.18 Pads, 6.4 mm (1/4 in.) thick, felt, blotters, sheets of plastic or similar material.

3. MATERIALS

3.1 Fresh supply of Portland cement, meeting the requirements of the Department’s Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges, Item 524.

3.2 Good quality tap water.

3.3 Material to be cement stabilized.

4. TEST RECORD FORM

4.1 Record test data on Compressive Strength Test Worksheet for Soil-Cement Mixtures and Compression Test Results.

5. PREPARING SAMPLE

5.1 Select an approximately 180-kg (400-lb.) sample of material to be treated with cement and follow Tex-101-E, Part II.
6. PROCEDURES

6.1 Dry Density of Laboratory Mixed Soil-Cement Specimens:

6.1.1 Follow the method described under Tex-113-E to determine the optimum moisture and maximum density for a soil-cement mixture containing 6% cement. The amount of cement is added as a percentage based on the dry weight of the soil.

**Note 1**—In performing this part of the test, dry mix the weighed material passing the 2.00 mm (No. 10) sieve.

6.1.2 Wet the material in accordance with Tex-113-E and stir.

6.1.3 Add cement to the material.

6.1.4 Mix thoroughly.

6.1.5 Compact each layer with a compactive effort of 1100 kN - m/mm³ (13.26 ft-lb/in.³) (50 blows per 51 mm [2 in.], using the 4.5 kg [10 lb.] ram with 457 mm [18 in.] drop).

6.1.6 Scarify the tops of the first three layers to remove smooth compaction planes before placing and compacting succeeding layers. This scarification should form grooves at right angles to each other, approximately 3 mm (0.125 in.) wide and 3 mm (0.125 in.) deep, and approximately 6 mm (0.25 in.) apart.

6.1.7 Begin molding a specimen at 6% cement using the optimum moisture determined in Section 6.1.1. The percent molding water would be varied slightly as the percent cement is increased or decreased to mold nearer optimum moisture without running a new M-D curve for each percentage of cement.

- % Cement Increase = difference in cement content between curve and other cement contents
- % Molding Water = % optimum from M-D curve + 0.25 (% cement increase).

**Note 2**—Perform a new M-D curve for each percentage of cement if desired.

6.1.8 Mold three specimens at 6% cement and optimum moisture for later testing.

6.1.9 Weigh and record one specimen as molded and place in an oven at 110 ± 5°C (230 ± 9°F) for at least twelve hours or to constant mass (weight).

6.1.10 Calculate the percentage of moisture to check against design moisture content.

6.1.11 Weigh each compacted specimen with mold.

6.1.12 Then remove the mold and calculate the oven-dry density of one specimen in kg/m³ (lb./ft.³) to check against design density.

6.1.13 Identify one specimen as No. 1, along with other needed identification marks, and use this specimen to obtain data on moisture and volume changes during the test.
Identify the second specimen as No. 2, along with other needed identification marks, and use this specimen to obtain data on soil-cement losses during the freeze-thaw test.

Determine the average circumference and height of the No. 1 specimen and calculate its volume.

Place the molded specimens, in rectangular pans suitable for capillary wetting, in the moist room for a period of seven days. The specimens should be exposed to high humidity but protected from free water spray during curing.

Weigh and measure the No. 1 specimen at the end of the seven-day storage period to provide data for calculating its moisture content and volume.

Note 3—It is important that all height and diameter measurements be accurate to within 0.25 in. and be taken at the same points on the specimen at all times.

Using the percent molding water from Section 6.1.3, mold two additional sets of specimens—one at 4% cement, and one at 8% cement. Each of these sets should have specimens numbered 1 and 2 to be handled as described above. These, plus the No. 1 and No. 2 specimens at 6% cement, form a complete set.

Level the top surface of each specimen and measure before centering specimens over porous stones before removing specimens from the molds by means of a small press.

Place a card on each specimen showing the laboratory identification number and the percent of cement.

Note 4—If compressive strength information is desired, three additional samples at each cement content should be molded.

In calculating the actual dry density of laboratory mixed soil-cement specimens, the dry mass of material is the total mass of the oven-dry soil in the specimen. The amount of moisture should be the weight of hygroscopic moisture in the soil plus the amount of water added. Road-mixed, wetted materials and soil-cement cores should have moisture and density determined from the oven-dry masses.

Freezing and Thawing:

At the end of the seven day storage in the moist room, place water-saturated felt pads, blotters, or sheets of plastic, no more than 6 mm (0.25 in.) thick, between the specimens and the porous stones.

Place the assembly in a freezing cabinet having a constant temperature not warmer than minus 23.3°C (-10°F) for 24 hours and remove.

Weigh and measure all No. 1 specimens (volume and moisture change specimens) of each cement content.

Replace the assembly in the moist room or a suitable covered container having a temperature of 21 ± 2°C (70 ± 3°F) and a relative humidity of 98% to 100% for 23 hours and remove.
6.2.4.1 Free potable water should be made available to the absorbent pads under the specimens to permit the specimens to absorb water by capillary action during the thawing period. (Use pans and porous stones as in Tex-117-E.)

6.2.5 Weigh and measure all of the No. 1 specimens after each thawing period.

6.2.6 Give the three No. 2 specimens (soil-cement loss specimens) two firm strokes on all areas with the wire scratch brush.

6.2.7 Hold the brush with the long axis parallel to the longitudinal axis of the specimen.

6.2.8 Apply these strokes to the full height and width of the specimen with a firm stroke corresponding to approximately 1.4 kg (3 lbs.) force. Eighteen to twenty vertical brush strokes are required to cover the sides of the specimen twice and four strokes are required on each end.

Note 5—This pressure is measured by:
- clamping a specimen in a vertical position on the edge of a platform scale and zero the scale and
- applying vertical brushing strokes to the specimen and note the force necessary to register approximately 1.36 kg (3 lb.)

6.2.9 Turn the specimens end over end before they are replaced on the water-saturated pads.

6.2.10 The steps described above constitute one cycle (48 hours) of freezing and thawing.

6.2.10.1 Again, place the specimens in the freezing cabinet and continue the procedure for 12 cycles.

Note 6—Mass determinations of No. 2 specimens before and after brushing are usually made at the end of each cycle. Some specimens made of silty and clayey soils tend to scale on sides and ends, particularly after about the sixth cycle of test. Remove this scale with a sharp-pointed instrument, since regular brushing may not be effective.

6.2.10.2 The No. 1 specimen of each cement content may be discontinued prior to 12 cycles, if measurements become inaccurate due to soil-cement loss of the No. 2 specimen.

Note 7—If it is not possible to run the cycles continuously because of Sundays, holidays, or for any other reason, hold the specimens in the freezing cabinet during the layover period.

6.2.11 After 12 cycles of test, break down the No. 1 specimens, dry to constant mass at 110°C (230°F), and weigh to determine the oven-dry weight.

6.2.12 Calculate volume and moisture changes of specimen No. 1 and the soil-cement losses of specimen No. 2 after the prescribed 12 cycles of the freeze thaw test.
7. **CALCULATIONS**

7.1 Calculate the difference between the volume of specimens No. 1 at the time of molding and subsequent volumes as percentage of the original volume:

\[
\% \text{ of Original Volume} = \frac{(O_v - F_v)}{O_v} \times 100
\]

Where:
- \(O_v\) = Original Volume
- \(F_v\) = Final Volume.

7.2 Calculate the moisture content of specimens No. 1 at the time of molding and subsequent moisture contents as a percentage of the original oven-dry weight of specimen:

\[
\% \text{ of Original Oven Dry Weight of Specimen} = \frac{(W_o - W_f)}{W_o} \times 100
\]

Where:
- \(W_o\) = Dry weight
- \(W_f\) = Molding weight or surface dry weight during test.

7.3 Correct the oven-dry mass of specimen No. 2 for water that has reacted with the cement and soil during the test and is retained in the specimen at 110°C (230°F):

\[
\text{Corrected Oven Dry Mass} = 100 \left( \frac{A}{B} \right)
\]

Where:
- \(A\) = oven-dry weight after drying at 110°C (230°F)
- \(B\) = percentage of water retained in specimen plus 100.

The percentage of water retained in specimens No. 2 after drying for use in the above formula can be assumed equal to the water retained in corresponding specimen No. 1.

7.4 Calculate the soil-cement loss of specimens No. 2 as a percentage of the original oven-dry mass of the specimen, where:

\[
\text{Soil Cement Loss} = 100 \left( \frac{C - D}{C} \right)
\]

Where:
- \(C\) = original calculated oven-dry mass
- \(D\) = final corrected oven-dry mass.

8. **REPORT**

8.1 The designed optimum moisture and maximum density of the molded specimens.
8.2 The moisture content and density obtained in molded specimens. Good laboratory practice permits the following tolerances between design factors and those obtained in the molded specimens:

- Moisture content ± 1%
- Density ± 48 kg/m³ (3 lb./ft.³)

8.3 The designed cement content, in percent, of the molded specimens.

8.4 The maximum volume change, in percent, and maximum moisture content during test of specimens No. 1.

8.5 The soil-cement loss, in percent, of specimens No. 2.

9. CLASSIFICATION OF SOILS AND SOIL-AGGREGATE MIXTURES

9.1 The following percent loss recommendations by the Portland Cement Association (PCA) have been considered satisfactory to insure durable soil-cement pavements that resist leaching of the cement and degrading of the pavement structure:

- Soil Groups A-1, A-2-4, A-2-5, and A-3, not over 14%
- Soil Groups A-2-6, A-2-7, A-4, and A-5, not over 10%
- Soil Groups A-6 and A-7, not over 7%.

9.2 AASHTO has established a classification system for Soils and Soil-Aggregate Mixtures.