
Standard Method of Test for

Coefficient of Thermal Expansion of Hydraulic Cement Concrete

AASHTO Designation: TP 60-00 (2007)¹



1. SCOPE

- 1.1. This test method covers determination of the coefficient of thermal expansion (CTE) of hydraulic cement concrete cores and cylinders. Since it is known that the degree of saturation of concrete influences its measured coefficient of thermal expansion, the moisture condition of the concrete specimens must be controlled. For this test procedure, the specimens must be in a saturated condition.
- 1.2. The values stated in SI units shall be regarded as the standard.

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- R 39, Making and Curing Concrete Test Specimens in the Laboratory
 - T 23, Making and Curing Concrete Test Specimens in the Field
 - T 24, Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

3. SUMMARY OF TEST METHOD

- 3.1. This method determines the CTE of a cylindrical concrete specimen, maintained in a saturated condition, by measuring the length change of the specimen due to a specified temperature change. The measured length change is corrected for any change in length of the measuring apparatus (previously determined), and the CTE is then calculated by dividing the corrected length change by the temperature change and then the specimen length, as described in the section on calculations.

4. SIGNIFICANCE AND USE

- 4.1. Measurement of the CTE permits assessment of the potential for length/volume change of concrete due to a uniform temperature change and of the potential deformation of a concrete structure due to a temperature gradient through the concrete. As an example, for pavement slabs on grade, uniform temperature change will affect the openings at joints, and a temperature gradient through the thickness of these same slabs will produce curling of the slabs. Using the results of this test, better estimates of slab movement and stress development due to temperature change can be obtained.

5. APPARATUS

- 5.1. *Concrete Saw*—Capable of sawing the ends of a cylindrical specimen perpendicular to the axis and parallel to each other.
- 5.2. *Balance*—A scale or balance having a capacity of 20 kg (44 lb) and an accurateness of 0.1 percent over its range.
- 5.3. *Caliper*—Comparator or other suitable device to measure the specimen length to the nearest 0.1 mm (0.004 in.).
- 5.4. *Water Bath*—A controlled-temperature water bath with a temperature range of 10 to 50°C (50 to 122°F), capable of controlling the temperature to 0.1°C (0.2°F).
- 5.5. *Support Frame*—A rigid support frame for the specimen to be used during length change measurement. The frame should be designed to have minimal influence on the length change measurements obtained during the test and should support the specimen such that the specimen is allowed to freely adjust to any change in temperature. A suitable support frame is described in detail in Appendix X1.
- 5.6. *Temperature Measuring Devices*—Four submersible temperature measuring devices with a resolution of 0.1°C (0.2°F) and an accurateness of 0.2°C (0.4°F).
- 5.7. *Gauge*—A submersible LVDT gauge head with excitation source and digital readout, with a minimum resolution of 0.00025 mm (0.00001 in.), and a range suitable for the test (for ease in setting up the apparatus, a range of ± 3 mm (0.1 in.) has been found practical) (Note 1).
- Note 1**—Linear variable differential transformers (LVDTs) with the appropriate associated electronic actuating and indicating apparatus appear to give the best results with respect to stability, sensitivity, and reliability. Multichannel recording of outputs has been found to be practical and efficient. As an alternative, a data logger can be used to excite the LVDT and record the LVDT and both temperature and time outputs. The data can be stored directly in a personal computer for graphing of test results.
- 5.8. *Micrometer*—A micrometer or other suitable device for calibrating the LVDT over the range to be used in the test and with a minimum resolution of 0.00025 mm (0.00001 in.).

6. TEST SPECIMENS

- 6.1. Test specimens shall consist of drilled 100-mm (4-in.) nominal diameter cores sampled from the concrete structure being evaluated or 100-mm (4-in.) nominal diameter cylinders. Cores shall be obtained in accordance with T 24. Cylinders shall be cast in accordance with T 23 or R 39. The specimens shall be sawed perpendicular to the axis at a suitable length. A length of 180 ± 2 mm (7.0 ± 0.1 in.) has been found acceptable. The standard reference material used for calibration (see Appendix X2) shall be the same length as the test specimen so that the frame does not have to be adjusted between calibration and testing. The sawed ends shall be flat and parallel.

7. PROCEDURE

- 7.1. *Specimen Conditioning*—The specimens shall be conditioned by submersion in saturated limewater at $23 \pm 2^{\circ}\text{C}$ ($73 \pm 4^{\circ}\text{F}$) for not less than 48 hours and until two successive weighings of the surface-dried sample at intervals of 24 hours show an increase in weight of less than 0.5 percent. A surface-dried sample is obtained by removing the surface moisture with a towel.
- 7.2. *Testing Procedure:*
- 7.2.1. Place the measuring apparatus, with the LVDT attached, in the water bath and fill the bath with cold tap water. Place the four temperature sensors in the bath at locations that will provide an average temperature for the bath as a whole. To avoid any sticking at the points of contact with the specimen, put a very thin film of silicon grease on the end of the support buttons and the LVDT tip.
- 7.2.2. Remove the specimen from the saturation tank and measure its length at room temperature to the nearest 0.1 mm (0.004 in.). After measuring the length, place the specimen in the measuring apparatus located in the controlled-temperature bath, making sure that the lower end of the specimen is firmly seated against the support buttons and that the LVDT tip is seated against the upper end of the specimen (Note 2).
- Note 2**—The desired range of travel is the linear range of the LVDT over which it has been calibrated. The LVDT travel during the test should remain well within this range to ensure accurate results.
- 7.2.3. Set the temperature of the water bath to $10 \pm 1^{\circ}\text{C}$ ($50 \pm 2^{\circ}\text{F}$). When the bath reaches this temperature, allow the bath to remain at this temperature until thermal equilibrium of the specimen has been reached, as indicated by consistent readings of the LVDT to the nearest 0.00025 mm (0.00001 in.) taken every 10 minutes over a one-half hour period. Also at this time, check that the specimen is firmly seated against the support buttons, as confirmed by the LVDT reading.
- 7.2.4. Record the temperature readings from the four sensors to the nearest 0.1°C (0.2°F). Record the LVDT reading to the nearest 0.00025 mm (0.00001 in.). These are the initial readings.
- 7.2.5. Set the temperature of the water bath to $50 \pm 1^{\circ}\text{C}$ ($122 \pm 2^{\circ}\text{F}$). Once the bath has reached $50 \pm 1^{\circ}\text{C}$ ($122 \pm 2^{\circ}\text{F}$), allow the bath to remain at this temperature until thermal equilibrium of the specimen has been reached, as indicated by consistent readings of the LVDT to the nearest 0.00025 mm (0.00001 in.) taken every 10 minutes over a one-half hour period.
- 7.2.6. Record the temperature readings from the four sensors to the nearest 0.1°C (0.2°F). Record the LVDT reading to the nearest 0.00025 mm (0.00001 in.). These are the second readings.
- 7.2.7. Set the temperature of the water bath to $10 \pm 1^{\circ}\text{C}$ ($50 \pm 2^{\circ}\text{F}$). When the bath reaches this temperature, allow the bath to remain at this temperature until thermal equilibrium of the specimen has been reached, as indicated by consistent readings of the LVDT to the nearest 0.00025 mm (0.00001 in.) taken every 10 minutes over a one-half hour period.
- 7.2.8. Record the temperature readings from the four sensors to the nearest 0.1°C (0.2°F). Record the LVDT reading to the nearest 0.00025 mm (0.00001 in.). These are the final readings.