

## CRD-C 39-81

**TEST METHOD FOR COEFFICIENT OF  
LINEAR THERMAL EXPANSION OF CONCRETE**

**1. Scope**

1.1 This method covers the determination of the coefficient of linear thermal expansion of concrete test specimens by determinations of length change due to temperature changes. Because the thermal coefficient of concrete varies with moisture condition, being a minimum when saturated or oven dry and a maximum at about 70 percent saturated, it is important to select the relevant moisture condition for the tests to be made.

**2. Apparatus**

2.1. The apparatus shall consist of:

2.1.1 *Heating Bath* - A water bath in which concrete specimens can be maintained at a temperature of  $140 \pm 2$  F ( $60 \pm 1.1$  C) (Note 1)

2.1.2 *Cooling Bath* - A water bath in which concrete specimens can be maintained at a temperature of  $40 \pm 2$  F ( $5 \pm 1.1$  C). (Note 1)

2.1.3 *Length Comparator (Horizontal), Reference Bars, and Inserts* - As described in CRD-C 25. (Note 2)

NOTE 1-In the event that the longer storage time required to achieve temperature equilibrium is tolerable and the use of water baths is not desired, heating and cooling rooms or cabinets may be used.

NOTE 2-When laboratory molded specimens are used, strain meters that can be embedded may be used. Such meters are described in CRD-C 54.

**3. Procedure**

3.1 *General* - Tests for coefficient of linear thermal expansion require careful control ( $\pm 2$  F,  $\pm 1.1$  C) of the temperature of the specimen which is being tested for length change. Length determinations shall be conducted only when the specimens are in thermal equilibrium. Tests shall be made to determine the minimum heating and cooling periods for attainment of equilibrium by specimens of any particular size and shape. The period which shall be used will be 25 percent greater than the minimum time to insure equilib-

rium regardless of aggregate type. Further tests will be necessary to determine the maximum permissible time interval between removal of the specimen from the bath and completion of length determination when measurements are made in air. This maximum time interval shall be established so that no discernible change in length will occur during the course of the determination.

3.2 *Test Conditions* - When tests on different specimens are to be compared, the specimens must be in a comparable moisture condition and must be tested over the same temperature range. Unless other conditions are specified, it is recommended that specimens be tested in a saturated condition (immersed in water at least 48 hr before the starting of the test) and over the temperature range of 40 to 140 F (5 to 60 C). In cases where the data are to be used to evaluate dry rather than saturated concrete or where thermal coefficient over a different temperature range is required, the procedures used should be modified so that the results obtained will be most directly applicable to the pertinent conditions. Where sealed specimens are appropriately employed, the sort described in CRD-C 54 are recommended.

**4. Calculation and Report**

4.1 The coefficient of linear thermal expansion shall be calculated from the measurements by the use of the following formula:

$$C = \frac{(R_h - R_c)}{G \Delta T}$$

where:

C = coefficient of linear thermal expansion of the concrete  $10^{-6}/\text{deg F}$  (deg C),

$R_h$  = length reading at higher temperature, in. or mm,

$R_c$  = length reading at lower temperature, in. or mm,

<sup>1</sup>Tests using immersed specimens are reported in "Comparison of Methods of Test for Coefficient of Linear Thermal Expansion of Concrete," WES MP 6-108, November 1954.

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G = gage length between inserts, in. or mm, and

$\Delta T$  = difference in temperature of specimen between the two length readings, deg F or deg C.

4.2 In cases where the length change has been determined between only two temperatures, a single value will be reported. Where readings of length change have been made at various temperatures, the report should include a curve from which any significant variation in coefficient may be determined. In such cases, the coefficients for the several ranges in temperature shall be stated.

4.3 The report should include the test results calculated as indicated above, adequate information to identify the specimens tested, and information on the moisture conditions, temperatures,

and procedures used in the test

### 5. Interpretation

5.1 Powers and Brownyard<sup>2</sup> discussed the effect of moisture content on volume change of concrete during heating and cooling and stated that "from the above, it follows that the thermal coefficient of a given sample of concrete is not a constant, unless the sample is completely dry or saturated." Meyers' showed that the thermal coefficients of concrete vary over a wide range under different storage conditions as well as with the kind of concrete.

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<sup>2</sup>Powers, T. C. and Brownyard, T. L., "Studies of the Physical Properties of Hardened Portland Cement Paste," *Jour. Amer. Conc. Inst. Proc.*, Vol 43, 1947, p 988

Meyers, S. L., "Thermal Coefficient of Expansion of Portland Cement," *Ind. and Engineering Chemistry*, Vol 32, August 1940, pp 1107-1112.