CRD-C 36-73

METHOD OF TEST FOR THERMAL DIFFUSIVITY OF CONCRETE

1. Scope

1.1 This method of test outlines a procedure for determining the thermal diffusivity of concrete. The thermal diffusivity is equal to the thermal conductivity divided by the heat capacity per unit volume and may be used as an index of the facility with which the material will undergo temperature change.

Note. - A method for determining the thermal diffusivity of 8-cu-ft (0.0227-m^3) cube specimens of mass concrete is given in CRD-C 37.

2. Apparatus

2.1 The apparatus shall consist of:

2.1.1 Bath. - A heating bath in which concrete cylinders can be raised to uniform high temperature (212 F, 100 C).

2.1.2 Diffusion Chamber.- A diffusion chamber containing running cold water.

2.1.3 Temperature Indicating or Recording Instrument.- Consisting of iron-constantan thermocouples, Type K Potentiometer, ice bath, standard cell, galvanometer, switch, and storage battery; or thermocouples and suitable recording potentiometer.

2.1.4 Timer. - Timer capable of indicating minutes and seconds.

3. Procedure

3.1 Preparation of Specimen. - The test specimen shall be a 6- by 12-in. (152- by 305-mm) cylinder (for other shapes and sizes, see Sec. 5). If molded, shall be made in accordance with the applicable provisions of CRD-C s 10 and 49 and shall contain a thermocouple placed at the center of mass. If prepared from a hardened concrete core, shall contain a similarly placed thermocouple inserted in an axially drilled hole 3/8 in. (9.5 mm) in diameter which has been subsequently grouted. Molded specimens shall be moist-cured for 28 days prior to testing.

3.2 Heating. - Each specimen shall be heated to the same temperature by continuous immersion in boiling water until the temperature of the center is 212 F (100 C). The specimen shall then be transferred to a bath of running cold water, and suspended in the bath so that the entire surface of the specimen is in contact with the water. The temperature of the cold water shall be determined by means of another thermocouple.

3.3 Cooling.- The cooling history of the specimen shall be obtained from readings of the temperature of the interior of the specimen at 1-min intervals from the time the temperature difference between the center and the water is 120 F (67 C) until the temperature difference between the center and water is 8 F (4 C). The data shall be recorded. Two such cooling histories shall be obtained for each test specimen, and the calculated diffusivities shall check within ± 0.002 ft^2/h ($0.0052 \times 10^{-5} m^2/s$).

4. Calculations

4.1 The temperature difference in degrees F shall be plotted against the time in minutes on a semilogarithmic scale. The best possible straight line shall then be drawn through the points so obtained. A typical graph is shown in Fig. 1. The time elapsed between the temperature difference of 80 F (44 C) and 20 F (11 C) shall be read from the graph, and this value inserted in equation (1) below, from which the thermal diffusivity shall be calculated:

$$\alpha = 0.812278/(t_1 - t_2)$$

where:

α = thermal diffusivity, ft^2/hr (Note),

$(t_1 - t_2)$ = elapsed time between temperature differences 80 F (44 C) and 20 F (11 C), minutes, and

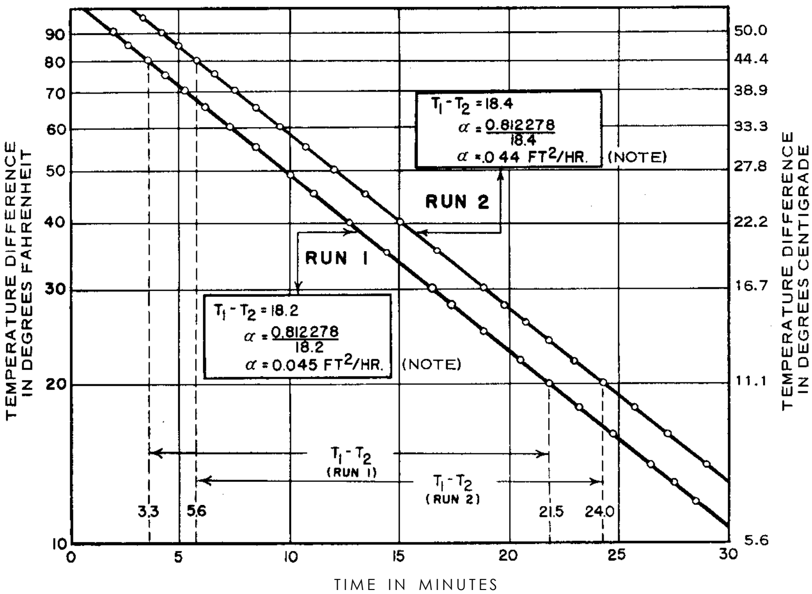

Fig. 1. Calculation of thermal diffusivity of a concrete cylinder

0.812278 = numerical factor applicable to 6- by 12-in. (152-by 305-mm) cylinder.

Note. - The SI equivalent of ft^2/h is m^2/s; ft^2/h x 2.580640 E-05 = m^2/s.

5. Specimens of Other Sizes and Shapes

5.1 The method given above is directly applicable to a 6- by 12-in. (152- by 305-mm) cylinder. Specimens of other sizes and shapes may be treated in the manner described below.

5.2 The thermal diffusivity of a specimen of regular shape is, to a first approximation:

$$\alpha = M/(t_2 - t_1)$$

where:

α = thermal diffusivity, ft^2/hr (Note),

M = a factor depending on the size and shape of the specimen, and

t_1, t_2 = times at which the center of the specimen reaches any specified temperature differences, min.

5.3 For a prism,

$$M = \frac{60 \ln(T_1/T_2)}{\pi^2\left(\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{c^2}\right)}$$

where:

$\ln(T_1/T_2)$ = natural logarithm of the temperature difference ratio,

T_1, T_2 = temperature differences at times t_1 and t_2, deg F, and

a, b, c = dimensions of prism, ft.

5.4 For a cylinder,

$$M = \frac{60 \ln(T_1/T_2)}{\left(\frac{5.783}{r^2} + \frac{\pi^2}{l^2}\right)}$$

where:

$\ln(T_1/T_2)$ = natural logarithm, as above,

r = radius of cylinder, ft, and

l = length of cylinder, ft.

5.5 For specimens whose minimum dimension is more than 3 in. (76 mm), this approximate calculation will yield the required accuracy. For smaller specimens or when more precise determinations are desired, reference may be made to Heat Conduction, by L. R. and A. C. Ingersoll, and O. J. Zobel, McGraw-Hill Book Company, Inc., 1948, pp. 183-185 and appended tables. Charts which may be used are also found in Williamson and Adams, Phys. Rev. XIV, p. 99 (1919) and Heat Transmission, W. H. McAdams, McGraw-Hill Book Company, Inc., 1942, pp. 27-44.