CRD-C 38-73

METHOD OF TEST FOR TEMPERATURE RISE IN CONCRETE

1. Scope

1.1 This method covers a procedure for determining the temperature rise in concrete under adiabatic conditions primarily due to heat liberated on hydration of cement.

2. Apparatus

2.1 The apparatus used shall consist of:

2.1.1 Cabinet.- An insulated cabinet with heating elements and fans.

2.1.2 Room.- A controlled temperature room capable of maintaining any selected temperature within the range of 35 to 135 F (2 to 58 C), and also of automatic variation to maintain a constant difference of 0 to 10 F (0 to 6 C) between the room temperature and the temperature in the insulated cabinet, which is situated within the room.

2.1.3 Control Apparatus.- The temperature control apparatus (Fig. 1) shall consist of the following:

2.1.3.1 An electronic indicating potentiometer accurate to ±0.3 F (0.2 C) to control the temperature of the room, and

2.1.3.2 a d-c amplifier, a magnetic amplifier, and an electronic recording potentiometer with an 11-in. (279-mm) scale having a range of -0.4 to +0.4 F (-0.2 to +0.2 C), with least division of 0.004 F (0.002 C). These three instruments act in combination and are actuated by unbalance in a resistance bridge, one leg of which represents concrete specimen temperature and another of which represents cabinet temperature. They shall be capable of maintaining cabinet air temperature the same as specimen temperature or slightly higher or lower than specimen temperature as may be necessary for the adjustments described in Paragraph 3.10. Accuracy of control shall be ±0.004 F (±0.002 C).

2.1.4 Recording Apparatus.- The temperature measuring and recording apparatus (Fig. 1) shall consist of the following:

2.1.4.1 An electronic recording potentiometer accurate to ±0.3 F (±0.2 C),

2.1.4.2 a precision resistance bridge, the least dial division of which is 0.0001 ohm,

2.1.4.3 an electronic null indicator,

2.1.4.4 ten precision resistance thermometers, and

2.1.4.5 five iron-constantan thermocouples.

2.1.5 Jacket.- A sheet metal jacket (Fig. 2) to hold insulation material around the specimen container. The jacket shall be 34 in. (864 mm) in diameter and 36 in. (914 mm) high; its bottom shall be covered on the inside with polystyrene insulation 2 in. (51 mm) thick.

2.1.6 Specimen Container.- A sheet metal specimen container, 30 in. (762 mm) in diameter and 30 in. (762 mm) high, with a 1/2-in. (13-mm)-flange at the top. A strap (1/8 by 1 in.) (3.2 by 25 mm) shall extend diametrically across the inside of the container at the top. The strap shall have five 1/2-in.- (13-mm-) diameter holes, one at the midpoint and two on either side at 2 and 12 in. (50 and 305 mm) from the midpoint.

2.1.7 Specimen Container Cover.- A specimen container cover of sheet metal with holes corresponding to the holes in the strap (subpara 2.1.6). Airtight packing glands shall be brazed or soldered in place on the container cover over the five holes. The packing glands shall be of a size suitable for tightening on the shafts of the resistance thermometers which will pass through the holes (para 3).

3. Test Procedure

3.1 Calibration.- The ten resistance thermometers, which shall be permanently wired to a terminal strip within the cabinet, shall be calibrated, by clipping the leads, to read to ±0.005 F (±0.003 C) at three constant temperatures covering the expected range of the adiabatic temperature-rise test. For this purpose the

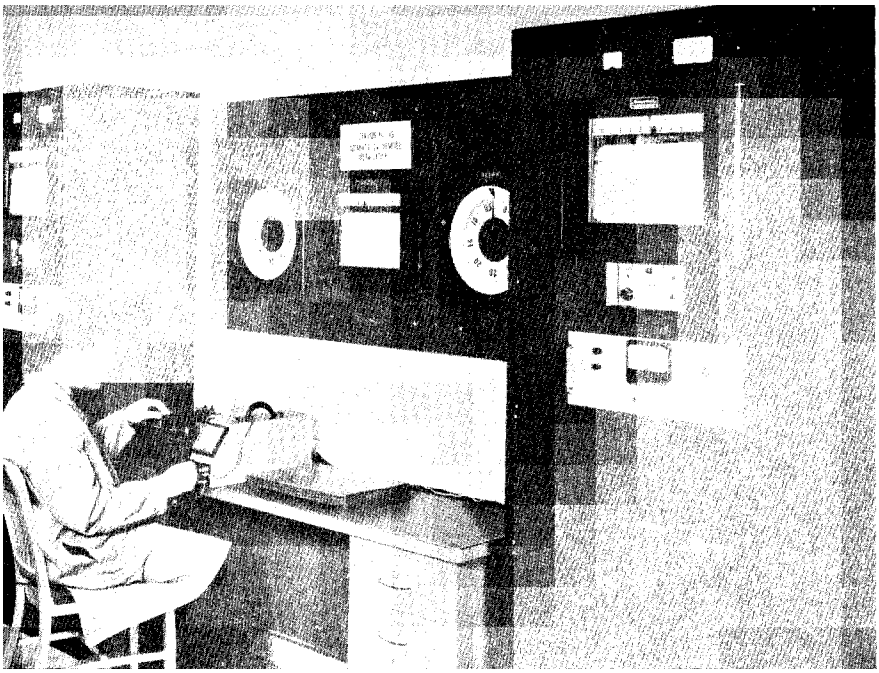

Fig. 1. Temperature control and measuring equipment for two adiabatic calorimeters

Fig. 2. Preparing mass concrete specimen for temperature-rise test; jacket and positioning of thermometers in specimen are shown

thermometers shall be taped together and tested in a vacuum flask located within the cabinet. During the calibration, air currents shall be excluded from the vacuum flask by use of packing material at the top. When the calibration of all thermometers is within ±0.005 F (±0.003 C) of the average, each thermometer's remaining deviation from the average shall be used as a correction for that thermometer.

3.2 Positioning of Thermometers.- The resistance thermometers shall be positioned as follows: one suspended in the air of the cabinet, two on opposite sides inside the jacket, two on opposite sides outside the specimen container, and five (Fig. 2) inside the specimen container. The five thermometers placed in the specimen container shall be threaded through the holes in the cover, passed through the holes in the strap across the top of the container, and held in place during

placement of concrete by wooden straps near the top. Except for the air thermometer, all the thermometers shall be positioned in a straight line passing diametrically through the midplane of the specimen container.

3.3 Insulation.- The jacket shall be placed on a warehouse dolly in such a position that it will be in the approximate center of the cabinet when the dolly is rolled into the cabinet. The specimen container shall be placed inside the jacket, the annular space filled with expanded vermiculite insulation (ASTM Designation: C 516, Type 2), and the whole assembly allowed to remain overnight in the calorimeter room, which shall be maintained at approximately the expected casting temperature.

3.4 Room Temperature Adjustment.- The next day the approximate casting temperature shall be determined as soon as possible, and the room temperature shall be adjusted to agree closely with the casting temperature. Room temperature will later be adjusted and controlled as prescribed in Subparagraph 3.8 below. The door of the cabinet shall remain open during casting of the specimen.

3.5 Specimen.- The specimen shall be made from a single 11.9 ft^3 (0.3 m^3) batch of concrete, made in accordance with the applicable provisions of CRD-C's 10 and 49, shall be placed and vibrated in three layers in the specimen container to form a cylindrical specimen 30 in. (762 mm) in diameter and approximately 29 in. (737 mm) in height.

3.6 Temperature Balancing.- When the precision thermometers are covered with concrete during the placement of the specimen, the difference between concrete temperature and room temperature shall be noted and reduced promptly by manual control of room temperature so that the difference shall be no more than ±0.4 F (±0.2 C), the total range of the control potentiometer, which operates in an indicating, rather than a control, capacity during this step of the procedure. This type of control is possible, and necessary, only during the time the door of the cabinet is open.

3.7 Sealing Specimen.- Immediately after the concrete has been placed (subpara 3.5 above) and vibrated, the cover shall be soldered in place and the packing glands tightened; it is essential that the specimen container, cover, and packing glands be vaportight. One thermocouple shall be taped against the metal cover near the center, two suspended in air within the cabinet, and two suspended in air in the controlled temperature room; of these, one at each location shall be connected to the electronic recording potentiometer and one at each air location shall be connected to the electronic indicating potentiometer used to control room air temperature.

3.8 Final Insulation.- Expanded vermiculite insulation shall be placed on top of the specimen container to a depth of about 3 in. (76 mm). The total amount of vermiculite used on the sides (Sec. 3.3) and top shall be 120 ± 20 lb (54 ± 9 kg). The test assembly shall be rolled into the cabinet, and the door closed. The temperature of the room shall then be lowered to and thereafter controlled at a temperature about 10 F (6 C) below cabinet temperature.

3.9 Temperature Recording.- The temperatures indicated by the ten precision thermometers, as measured by means of the precision bridge, shall be recorded as soon as the thermometers are covered, again after 1 hr and after 2 hr, and thence daily (during workdays) for 28 days. The air thermometer and the central concrete thermometer are normally connected to the automatic cabinet air temperature control, forming two legs of the resistance bridge network, Paragraph 2.1.3.2. They may, however, be be switched to the precision bridge for their temperatures to be read.

3.10 Temperature Control Adjustment.- The temperature of the concrete for the record and for control adjustment purposes shall be the average of four temperatures, two of which are the temperatures of the thermometers that are 2 in. (51 mm) distant from the center of the specimen and two of which are the temperatures of the thermometers that

are 12 in. (305 mm) distant from the center. The controls shall be adjusted to initiate compensation for any difference between the concrete temperature so obtained and the temperature of the air as represented by the average temperature of the two thermometers that are located inside the metal jacket. The adjustment is accomplished either by moving the pointer of the recording potentiometer, Paragraph 2.1.3.2, or by varying resistors that are placed for this purpose in series with the air and concrete resistance thermometers. The difference noted on the casting day may be ignored; but beginning the first day after casting, adjustments shall be made as necessary on each workday, and a cumulative record of the difference kept. The accumulated difference at the end of the test should not be more than ±0.02 F (±0.01 C).

3.11 Correction for Heat Loss.- The temperature rise at any time shall be increased by 4.0 percent to account for the heat loss to the insulation (Note).

Note.- This correction is based on approximate calculations involving heat capacities and the ratio of inside area to total area of the container.

4. Report

4.1 The report shall contain relevant data on aggregates and mixture proportions, and a table and plot of the corrected temperature-rise data.