Designation: C 1117 – 89 (Reapproved 1994)

Standard Test Method for Time of Setting of Shotcrete Mixtures by Penetration Resistance[1]

This standard is issued under the fixed designation C 1117; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the time of setting of shotcrete, either in place or in shot panels, by means of penetration resistance measurements.

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 403 Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance[2]

D 1558 Test Method for Moisture Content Penetration Resistance Relationships of Fine-Grained Soils[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *time of initial setting*—the elapsed time, after initial contact of cement and water, required for the shotcrete to reach a penetration resistance of 500 psi (3.5 MPa).

3.1.2 *time of final setting*—the elapsed time, after initial contact of cement and water, required for the shotcrete to reach a penetration resistance of 4000 psi (27.6 MPa).

4. Summary of Test Method

4.1 At regular time intervals, the resistance of the shotcrete to penetration by standard needles is measured. The penetration resistance is plotted as a function of the elapsed time, and the times of initial and final setting are determined.

5. Significance and Use

5.1 Since the setting of shotcrete is a gradual process, any definition of time of setting must necessarily be arbitrary. In this test method, the times of setting are defined in terms of the times required for the shotcrete to reach specified values of penetration resistance. This test method is an adaptation of Test Method C 403, with similar definitions for times of setting.

5.2 This test method is used for testing shotcrete in place or in prepared test panels.

5.3 This test method is applicable to normal-setting and rapid-setting shotcrete mixtures, and different testing procedures are prescribed to accommodate the two types of mixtures.

5.4 This test method is not recommended for shotcrete mixtures containing coarse aggregate with a nominal maximum size greater than ⅜ in. (9 mm). Interference by large aggregate particles can result in erratic values of penetration resistance.

5.5 This test method may be used to determine the effects of variables such as temperature, brand, type, and content of cementitious materials, mixture proportions, and admixtures upon the time of setting of shotcrete. This test method may also be used to determine compliance with time of setting requirements.

6. Apparatus

6.1 *Penetration Resistance Apparatus*—The penetration resistance apparatus shall be a spring reaction-type and graduated from 10 to 130 lbf (45 to 580 N) in increments of 2 lbf (9 N) or less; or it shall be a hydraulic reaction-type with a pressure gage having a capacity of 150 to 200 lbf (670 to 890 N) and graduated in increments of 2 lbf or less. Indications of needle loads shall be accurate to 2 lbf. Removable needles with the following bearing areas shall be provided: 1, ½, ¼, ⅒, 1/20 and 1/40 in.^{2} (645, 323, 161, 65, 32, and 16 mm^2). Each needle shank shall be scribed circumferentially at a distance 1 in. (25 mm) from the bearing area. To minimize bending, the maximum length of the 1/40-in.^{2} (16-mm^2) needle shall be 3½ in. (90 mm).

NOTE 1—A suitable apparatus is illustrated in Test Method D 1558.

[1] This specification is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregatesand is the direct responsibility of Subcommittee C09.46on Shotcrete.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.08.

7. Preparation of Specimens

7.1 Prepare shotcrete panels by using wooden or steel forms having a length and width of at least 18 in. (460 mm) and a depth of at least 3 in. (75 mm). Prepare one panel for each test condition. Construct forms with sufficient rigidity to preclude dislodging of the shotcrete because of form vibration or deformation.

NOTE 2—Wooden forms can be made using a back made from plywood that is at least ¾ in. (19 mm) thick, and the sides can be made from standard 2-by-4 lumber. Acceptable steel forms can be made of sheet material at least 3⁄16 in. (5 mm) (Number 7 gage) thick.

7.2 If wooden forms are used, wet the forms just before shotcreting and eliminate any standard water. Apply the shotcrete to the panel forms using the same equipment, personnel, and technique proposed for use or as is being used in the structure.

7.3 In-place shotcrete shall be in its as-shot condition. The minimum thickness to permit penetration resistance measurements is 3 in. (75 mm).

8. Conditioning

8.1 Store shotcrete panels within the temperature range of 68 to 77°F (20 to 25°C) or as specified by the user. To prevent excessive evaporation of water during the test, keep the panels covered with a suitable material, such as damp burlap or a tight fitting impervious cover, except when penetration tests are being made. Shield the panels from the sun.

8.2 Cure in-place shotcrete in the manner specified for the project.

9. Procedure

9.1 *Test Procedure*—Insert a needle of appropriate size, depending on the state of setting of the shotcrete, into the penetration resistance apparatus and bring the bearing surface of the needle into contact with the shotcrete surface. Hold the apparatus perpendicular to the shotcrete surface during the measurement. Gradually and uniformly apply a force on the apparatus until the needle penetrates the shotcrete to a depth of 1 ± 1⁄16 in. (25 ± 1.5 mm) as indicated by the scribe mark. The time required to penetrate to the 1-in. (25-mm) depth shall be approximately 10 s. Record the force required to produce the 1-in. (25-mm) penetration and the elapsed time after initial contact of cement and water. Calculate the penetration resistance by dividing the recorded force by the bearing area of the needle, and record the penetration resistance.

9.2 *Plotting Results*—Prepare a graph with penetration resistance as the ordinate and elapsed time as the abscissa. For the ordinate, use a scale such that 500 psi (3.5 MPa) is represented by not less than ½ in. (13 mm). For the abscissa, use a scale such that the final setting time is represented by not less than 3 in. (75 mm). Use this graph to plot the development of penetration resistance as a function of elapsed time.

NOTE 3—The plot of penetration resistance (average or individual values) versus elapsed time provides information on the rate of setting. The plot can be used to choose times for subsequent tests and it can assist in identifying spurious test results. Therefore, it is recommended that the data be plotted as they are being accumulated.

9.3 *Testing Times*:

9.3.1 Perform additional penetration tests at regular time intervals as indicated in 9.3.2 and 9.3.3. If an abnormally high penetration resistance is obtained because of interference with a large aggregate particle, repeat the test and disregard the spurious result. The clear distance between needle impressions shall be at least two diameters of the needle being used but not less than 1 in. (25 mm).

9.3.2 For normal-setting mixtures and normal temperatures, perform penetration tests at 10-min intervals. A test consists of obtaining the average of three penetration resistance measurements conducted in succession. Perform the first test after an elapsed time from initial contact of cement and water of 15 min or earlier if needed. Calculate and record the average penetration resistance at each time interval. Plot the average penetration resistance and elapsed time on the graph.

9.3.3 For rapid-setting mixtures or high temperatures, begin performing individual tests as soon as practicable, and make subsequent tests at times dependent on the rate of setting. This may require performing tests at time intervals of 1 min or less. For extremely rapid-setting mixtures, it may not be possible to perform penetration tests prior to initial setting. Record the individual test results. Plot penetration resistance and elapsed time on the graph.

9.4 *Number of Readings*—Not less than six average or individual penetration resistance determinations shall be made in each time of setting test. The time intervals between average or individual penetration resistance determinations shall be such as to give a satisfactory curve of penetration resistance versus elapsed time, as indicated by equally spaced points. For normal-setting mixtures, continue the tests until an average penetration resistance greater than 4000 psi (27.6 MPa) is reached. For rapid-setting mixtures, continue testing until three consecutive individual tests indicate penetration resistances greater than 4000 psi (27.6 MPa).

9.5 *Test Conditions*—Record the ambient temperature at the start and finish of each time of setting test.

10. Calculation

10.1 For each variable and condition of shotcrete specified in Section 8, plot the average or individual values of penetration resistance versus the elapsed time. For each plot, draw a best-fitting smooth curve through the data points.

10.2 For each curve, determine the times of initial and final setting as the times when the penetration resistance equals 500 psi (3.5 MPa) and 4000 psi (27.6 MPa), respectively. Record the setting times in hours and minutes to the nearest 5 min for normal-setting mixtures and to the nearest 1 min for rapid-setting mixtures.

11. Report

11.1 *Data on Shotcrete Mixture*—The report shall include the following information:

11.1.1 Type and proportions of cementitious materials, fine aggregate, coarse aggregate, (including maximum size and grading of aggregate), and the ratio of net water content to cement content;

11.1.2 Name, type, and percentage, by weight of cement of any addition or admixture used; and

11.1.3 The test date and the ambient temperature during the test period.

11.2 *Time of Setting Results*—The report shall include the following information:

11.2.1 A plot of average or individual values of penetration resistance versus elapsed time for each time of setting test, and

11.2.2 The times of initial and final setting for each test, reported in hours and minutes to the nearest 5 min for normal-setting mixtures and to the nearest 1 min for rapid-setting mixtures.

12. Precision and Bias

12.1 *Precision*—There are insufficient data at this time to support a statement of precision for this test method. A statement will be prepared after sufficient data have been obtained and analyzed.

12.2 *Bias*—The bias of this test method cannot be determined because time of setting can only be defined in terms of this test method.