



Standard Test Method for The Laboratory Determination of the Time of Setting of Hydraulic-Cement Mortars Containing Additives for Shotcrete by the Use of Gillmore Needles¹

This standard is issued under the fixed designation C 1398; 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.

ε¹ NOTE—Title, Section 2, and 4.4 editorially corrected January 2001.

1. Scope

1.1 This is a laboratory test method that covers the determination of the time of setting of hydraulic-cement mortars containing additives for shotcrete for comparison with control mixes containing no additives or to compare the performance of shotcrete mixtures which contain additives that produce rapid setting or rapid stiffening of shotcrete.

1.2 The values stated in SI units (see IEEE/ASTM SI 10) are the standard.

1.3 *This standard may involve hazardous materials, operations, and equipment. 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 150 Specification for Portland Cement²

C 185 Test Method for Air Content of Hydraulic Cement Mortar

C 266 Test Method for Time of Setting of Hydraulic Cement Paste by Gillmore Needles²

C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency²

C 490 Practice for use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar and Concrete²

C 778 Specification for Standard Sand²

C 1005 Specification for Masses and Devices for Determining Mass for Use in the Physical Testing of Hydraulic Cements²

C 1141 Specification for Admixtures for Shotcrete³

D 1193 Specification for Reagent Water⁴

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System⁵

3. Summary of Test Method

3.1 A mortar consisting of the sand, hydraulic cement, and water to be tested is proportioned by mass. The appropriate admixture or admixtures are added and a specimen is prepared from the mortar and tested for time of setting by means of Gillmore initial and final needles. A time of setting determination is then made for initial and final time of setting for each specimen. The time of setting shall be compared to a treated control mixture to demonstrate the effect of the admixture if such a comparison is the purpose of the study.

4. Significance and Use

4.1 The performance of an admixture for shotcrete in the field varies with the composition of the hydraulic cement and sand combination. Since this test method involves the determination of time of setting of a particular combination of hydraulic cement, sand and an admixture, it therefore provides information on the suitability for use of that particular combination in the field.

4.2 The time of setting of the combination established in the laboratory does not necessarily indicate the time of setting this combination will produce in actual shotcreting in the field.

4.3 This method is used to determine the effect on time of setting of mortars containing admixtures as compared to a control mortar.

4.4 The test method is used for comparison in laboratory pre-evaluation studies to demonstrate the effect of shotcrete admixtures in mortar compared with plain mortar and can be used to demonstrate or compare the performance of shotcrete admixtures which produce rapid setting or rapid rheological stiffening of shotcrete.

4.5 The test method is used to evaluate the relative performance of more than one shotcrete admixture for comparison of performance.

¹ This practice is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C 09.46 on Shotcrete.

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² Annual Book of ASTM Standards, Vol 04.01.

³ Annual Book of ASTM Standards, Vol 04.02.

⁴ Annual Book of ASTM Standards, Vol 11.01.

⁵ Annual Book of ASTM Standards, Vol 14.02.

4.6 The test method is used to determine or verify that no adverse effects on setting time may be experienced with the use of admixtures that are not intended to accelerate or are used to produce stiffening of shotcrete mixtures.

4.7 Although specific environmental conditions are indicated, the testing environment can be varied to simulate the performance of admixtures in mortars at different temperatures. Such variations are reported as indicated in Section 10.

5. Apparatus

5.1 *Trowel*, having a steel blade 100 to 150 mm (4 to 6 in.) in length with a straight edge.

5.2 *Mixer, Bowl, Paddle with Scraper*, shall conform to the requirements of Practice C 305.

5.3 *Glass Graduates*, shall conform to the requirements of Practice C 490.

5.4 *Scales and Weights*, shall conform to the requirements of Specification C 1005.

5.5 *Disposable, Round, Plastic Petri Dishes*, 15 mm by 100 mm (1/2 in. high by 4 in.)

5.6 *Gillmore Needles*, shall conform to the requirements of Test Method C 266.

5.7 *Spoon*—a metal restaurant spoon as described in Test Method C 185.

5.8 *Stopwatch*.

6. Materials

6.1 *Mixing Water*—Potable water is satisfactory for routine tests. For referee and cooperative tests, use reagent water conforming to the requirements for Type II or Type IV of Specification D 1193.

6.2 *Fine Aggregate*. Use 20-30 sand in conformance with the requirements of Specification C 778.

6.3 *Portland cement* conforming to the requirements of Specification C 150.

6.4 *Accelerating shotcrete*, admixtures conforming to the requirements of Specification C 1141.

7. Conditioning

7.1 The temperature of the room, dry materials, paddle, bowl, and disposable plastic petri dishes shall be maintained between 20 and 28 °C (68 and 82 °F). The temperature of the mixing water shall not vary from $23^{\circ} \pm 2^{\circ}\text{C}$ ($73.5^{\circ} \pm 3.5^{\circ}\text{F}$).

7.2 The relative humidity of the laboratory shall be 50 % \pm 5 %.

7.3 The test area shall be free of airflow and drafts.

8. Mixing Procedure – Dry-Mix Shotcrete

8.1 *Preparation of the control mortar*—Proportion 200 g of cement, 400 g of standard 20–30 sand, with 70 mL (w/c = 0.35) water following the mixing procedure for cement mortars described in 8.2 except without the addition of admixture.

8.2 *Preparation of Mortar Containing Admixtures*:

8.2.1 *Mortar with non-liquid*—Proportion the sand and cement as in 8.1. Add the prescribed amount of nonliquid admixture to the mixing bowl with the dry sand and cement.

8.2.2 *Mortar with liquid admixtures*—Proportion the sand and cement as in 8.1 adding the mixture to the mixing bowl. Add mixing water to the prescribed amount of admixture to

obtain a volume of 70 mL. This solution is added to the mortar as described in 8.3.3.

8.3 *Mixing of Mortar*— The mixing shall be done in the mechanical mixer as follows:

8.3.1 Place the appropriate dry materials in the mixing bowls, as in 8.2.1 or 8.2.2 and hand mix them with a spoon until a homogeneous mixture is achieved.

8.3.2 Position the bowl in the mixer and set the paddle in place.

8.3.3 With the mixer operating at medium speed, add 70 mL of mixing water to the non-liquid admixture as in 8.2.1 or 70 mL of mixing water and liquid admixture as in 8.2.2, start the stopwatch when the water contacts the dry mixture in the bowl. Mix for 10s.

8.4 *Preparation of Test Specimens*:

8.4.1 Stop the mixer and immediately remove the bowl from the mixer. With a spoon, quickly fill the plastic petri dish, and with the trowel, using the flat surface, cover three quarters of the dish surface and press straight down forcing the excess out of the remaining uncovered quarter. Draw the straight edge of the trowel across the surface in one motion.

9. Mixing Procedure – Wet-Mix Shotcrete

9.1 *Preparation of control mortar*—mix 200 g of cement and 400 g of standard 20–30 sand, with 70 mL of water (w/c = 0.35) following the mixing procedure for cement mortars described in 9.2 except without the addition of admixture.

9.2 *Preparation of Mortar Containing Admixtures*—Use a mechanical mixer as follows,

9.2.1 Place the sand and cement in the dry bowl, and hand mix the material with a spoon for a few seconds or until a homogeneous mixture is produced.

9.2.2 Position the bowl in the mixer, and set the paddle in place.

9.2.3 With the mixer operating at a slow speed add the entire quantity of mixing water within 15 s and continue mixing for 1 min, starting the stopwatch and timing from the first addition of water.

9.2.4 Stop the mixer, quickly scrape down the sides of the mixing bowl with the rubber scraper. Restart the mixer and mix for 15 s.

9.2.5 Stop the mixer, change to a medium speed. Start the mixer and quickly add the specified amount of admixture, continue mixing the mortar for 10 s.

9.3 *Preparation of Test Specimens*

9.3.1 Stop the mixer and immediately remove the bowl from the mixer. With a spoon, quickly fill the plastic petri dish, and with a trowel using the flat surface, cover three quarters of the dish surface and press straight down forcing the excess out of the remaining uncovered quarter. Draw the straight edge of the trowel across the surface in one motion.

10. Time of Setting Determination

10.1 After filling the plastic petri dish, immediately place the initial Gillmore needle in contact with surface of the mortar near the center of the dish. Release the needle. The mortar has reached time of setting when the surface will bear, without appreciable indentation, the initial Gillmore needle. The difference in hours, minutes, and seconds between the time of

contact of the mortar with the liquid admixture, and the time at which the initial Gillmore needle makes no appreciable indentation is the initial time of setting.

10.2 Use the final Gillmore needle to determine the final time of setting, following the same procedure. For dry-mix shotcrete, the difference in hours, minutes, and seconds between the time of contact of the mortar and mixing water, and the time at which the final Gillmore needle makes no appreciable indentation is the final time of setting. For wet-mix shotcrete, the difference, in hours, minutes, and seconds between the time of contact of the mortar with the added liquid admixture, and the time at which the final Gillmore needle makes no appreciable indentation is the final time of setting.

NOTE 1—When using admixtures that cause rapid rheological stiffening, prolonging the time of mixing or, not starting the Gillmore needle testing immediately may result in erroneous results in the determination of initial time of setting.

11. Report

11.1 Report the following information:

11.1.1 The times of initial and final setting in hours, minutes, and seconds for both the control specimen and specimen that was treated with admixtures if desired,

- 11.1.2 Brand and type of cement,
- 11.1.3 Brand and type of admixture,
- 11.1.4 Admixture dose,
- 11.1.5 Mix Temperature,
- 11.1.6 Room Temperature, and
- 11.1.7 Room Humidity.

12. Precision and Bias

12.1 It is not practical to specify the precision of this test method for measuring time of setting because test data are unavailable. A statement will be included at such time that sufficient test data have been obtained and analyzed.

12.2 The procedure in this test method has no bias because the value of time of setting of mortars is defined in terms of this test method.

13. Keywords

13.1 admixture; dry-mix shotcrete; mortar; quick-setting accelerating admixture; shotcrete; time of setting; wet-mix shotcrete

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