



Standard Specification
for



Early Stiffening of Hydraulic Cement (Paste Method)

AASHTO DESIGNATION: T 186-96¹
(ASTM DESIGNATION: C 451-89)

1. SCOPE

1.1 This test method covers the determination of early stiffening in hydraulic cement paste.

1.2 The values stated in SI units are to be regarded as the standard. The values given in the parentheses are for information only.

1.3 This standard does not purport to address all 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 AASHTO Standards:

- M 210 Apparatus for use in Measurement of Length Change of Hardened Cement Paste, Mortar, and Concrete
- R 11 Indicating Which Places of Figures Are to be Considered Significant in Specified Limiting Values
- T 127 Sampling and Acceptance of Hydraulic Cement
- T 129 Normal Consistency of Hydraulic Cement
- T 162 Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency

2.2 ASTM Standards:

- C 150 Specification for Portland Cement Concrete
- C 670 Practice for Preparing Precision Statements for Test Methods for Construction Methods
- C 1005 Specifications for Weights and Weighing Devices for Use in the Physical Testing of Hydraulic Cements
- D 1193 Specifications for Reagent Water

3. TERMINOLOGY

3.1 *Early Stiffening, n*—the early development of stiffness in the working characteristics of a portland cement paste, mortar, or concrete. Varieties include false set and flash set.

3.2 *False Set, n*—the early development of stiffness in the working characteristics of a portland-cement paste, mortar, or concrete without the evolution of much heat, which stiffness can be dispelled and plasticity regained by further mixing without addition of water; also known as “grab set,” “premature stiffening,” “hesitation set,” and “rubber set.”

3.3 *Flash Set, n*—the early development of stiffness in the working characteristics of a portland-cement paste, mortar, or concrete, usually with the evolution of considerable heat, which stiffness cannot be dispelled nor can the plasticity be regained by further mixing without addition of water; also known as “quick set.”

4. SUMMARY OF METHOD

4.1 A paste is prepared with the cement to be tested, using sufficient water to give a required initial penetration as measured by the Vicat apparatus at a stipulated time after completion of mixing. A second penetration, termed the final penetration, is measured at a later stipulated time. The ratio of final penetration to initial penetration is calculated as a percentage.

5. SIGNIFICANCE AND USE

5.1 The purpose of this test method is to determine the degree to which a cement paste develops early stiffening or to establish whether or not a cement complies with a specification limit on early stiffening.

5.2 When used for establishing compliance with a specification limit, the specification requirement is customarily stated in terms of the minimum allowable final penetration, in percent, calculated in accordance with Section 11. When used for estimating the relative tendency of a cement to manifest early stiffening, additional information of value may be obtained if the remix procedure described in Section 10 is employed. Under some conditions, a judgment may be made by comparing the behavior in the initial test and in the remix procedure to differentiate a relatively less serious and less persistent tendency to early stiffening from one that is more persistent and, consequently, more serious.

5.3 Severe false setting in a cement may cause difficulty from a placing and handling standpoint, but it is not likely

¹ Except for the use of SI units, this method agrees with ASTM C 451-89.

to cause difficulties where concrete is mixed for a longer time than usual, as usually occurs in transit mixing, or where it is remixed prior to placing or transporting, as occurs in concrete pumping operations. It is most likely to be noticeable where concrete is mixed for a short period of time in stationary mixers and transported to the forms in nonagitating equipment, such as on some paving jobs.

5.4 Cements with severe false setting usually require more water to produce the same consistency, which may be expected to result in slightly lower strengths and increased drying shrinkage.

5.5 Flash set of a severity sufficient to cause difficulties from a placing and handling standpoint usually will cause the cement to fail the requirements for time of setting in ASTM C 150.

6. APPARATUS

6.1 *Vicat Apparatus*, conforming to the requirements of T 129.

6.2 *Trowel*, having a steel blade 100 to 150 mm (4 to 6 in.) in length, with straightedge.

6.3 *Mixer, Bowl, Paddle, and Scraper*, conforming to the requirements of T 162.

6.4 *Glass Graduates*, conforming to the requirements of M 210.

6.5 *Standard Masses and Balances* shall conform to the requirements of Specification ASTM C 1005.

7. REAGENTS

7.1 *Mixing Water*—Potable water is satisfactory for routine tests. For all referee and cooperative tests, reagent water conforming to the requirements of ASTM D 1193 for Type III or Type IV grades of reagent water shall be used.

8. SAMPLING

8.1 When the test is part of acceptance, sample the cement in accordance with T 127.

9. CONDITIONING

9.1 The temperature of the room, dry materials, paddle, bowl, conical ring, and base plate shall be maintained between 20 and 27.5°C (68 and 81.5°F). The temperature of the mixing water shall not vary from 23.0°C (73.4°F) by more than $\pm 1.7^\circ\text{C}$ ($\pm 3^\circ\text{F}$).

9.2 The relative humidity of the laboratory shall not be less than 50 percent.

10. PROCEDURE

10.1 *Preparation of Cement Paste*—Mix 500 g of cement with sufficient water to produce a paste with an initial penetration of 32 ± 4 mm using the following procedure:

10.1.1 Place the dry paddle and the dry bowl in the mixing position in the mixer.

10.1.2 Introduce the materials for a batch into the bowl and mix in the following manner:

10.1.2.1 Place all the mixing water in the bowl.

10.1.2.2 Add the cement to the water and allow 30 seconds for the water to absorb.

10.1.2.3 Start the mixer and mix at slow speed (140 ± 5 r/min) for 30 seconds.

10.1.2.4 Stop the mixer for 15 seconds, and during this time scrape down into the batch any paste that may have collected on the sides of the bowl.

10.1.2.5 Start the mixer at medium speed (285 ± 10 r/min) and mix for 150 seconds.

10.2 *Molding Test Specimens*—Quickly form the cement paste into a ball with gloved hands. Press the ball, resting in the palm of one hand, into the larger end of the conical ring *G*, Figure 1 of T 129, held in the other hand, completely filling the ring with paste. Remove the excess at the larger end by a single movement of the palm of the hand. Place the ring on its larger end on a glass plate, *H*, and slice off the excess paste at the smaller end of the top of the ring by a single oblique stroke of a sharp-edged trowel held at a slight angle with the top of the ring. Smooth the top of the specimen, if necessary, with one

or two light touches of the pointed end of the trowel. During the operation of cutting and smoothing, take care not to compress the paste.

10.3 *Determination of Initial Penetration*—Set the paste confined in the ring resting on the glass plate, *H*, under the rod, *B*, Figure 1 of T 129 about one-third of the diameter from the edge, and the plunger end, *C*, shall be brought in contact with the surface of the paste and the tightened setscrew, *E*. Then set the movable indicator, *F*, to the upper zero mark of the scale, and release the rod exactly 20 seconds after completion of the mixing. The apparatus shall be free of all vibrations during the test. Consider the paste to have proper consistency when the rod settles to a point 32 ± 4 mm below the original surface in 30 seconds after being released. Make trial pastes with varying percentages of water until this consistency is obtained. This consistency is the initial penetration. During the 30-second interval for the initial penetration, return the excess paste to the bowl and cover the bowl and mixing paddle with a lid.

10.4 *Determination of Final Penetration*—After completion of the initial reading, remove the plunger from the paste, clean it, and reset the ring and plate in a new position. This operation shall be performed with as little disturbance as possible to the paste confined in the Vicat ring. Then bring the plunger again in contact with the surface of the paste, tighten the setscrew, and set the movable indicator to the upper zero mark of the scale. Release the plunger a second time 5 minutes after completion of the mixing period, and determine the final penetration 30 seconds after the plunger is released.

10.5 *Determination of Remix Penetration*—If the penetrations determined by the foregoing procedure show the cement to be stiffening rapidly, information as to the nature of the stiffening may be obtained by testing as follows:

10.5.1 After completing the measurement of the 5-minute penetration, immediately return the paste in the ring to the bowl.

10.5.2 Start the mixer, raise the bowl into mixing position, and remix the contents of the bowl at medium speed (285 ± 10 r/min) for 60 seconds.



10.5.3 Fill the ring and determine the penetration following the procedures specified in Sections 10.2 and 10.3.

11. CALCULATION

11.1 Calculate the percent final penetration, based on the ratio of final penetration to initial penetration, as follows:

$$P, \% = \frac{B}{A} \times 100$$

where:

P = percent final penetration,

A = initial penetration, mm, and
 B = final penetration, mm.

12. REPORT

12.1 Report the results of the test as follows:

Initial penetration	_____	mm
Final penetration	_____	mm
Percent final penetration	_____	%
Remix penetration	_____	mm

13. PRECISION AND BIAS

13.1 Interlaboratory test data for the determination of statements of precision and bias in accordance with ASTM Practice C 670 are being evaluated by ASTM Subcommittee C01.30. Statements of precision and bias will be included in a later revision of this test method.

14. KEYWORDS

14.1 Early stiffening; false set; flash set; portland cement paste.