Designation: C1738/C1738M – 14

Standard Practice for High-Shear Mixing of Hydraulic Cement Pastes[1]

This standard is issued under the fixed designation C1738/C1738M; 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 practice covers the high-shear mixing of hydraulic cement pastes.

1.2 The values stated in SI units or inch-pound units are to be regarded as the standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with 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:*[2]

C219 Terminology Relating to Hydraulic Cement

C305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency

C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

C1005 Specification for Reference Masses and Devices for Determining Mass and Volume for Use in the Physical Testing of Hydraulic Cements

2.2 *Non-ASTM Standard:*[3]

ANSI/API Recommended Practice 10B-2 (formerly 10B)—Recommended Practice for Testing Well Cements‖

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology C219.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *mixing, high-shear, v*—of pastes, the process of blending dry and liquid materials in a container using blades rotating axially at speeds at or above 420 rad/s [4000 rpm].

4. Summary of Practice

4.1 The practice describes the mixing of hydraulic cement paste in a high-shear mixer with a cooling jacket or other method to control the temperature of the paste. This procedure is derived from the ANSI/API standard and the following reports:

(1) R. Helmuth, L.M. Hills, D.A. Whiting, S. Bhattacharja, Abnormal Concrete Performance in the Presence of Admixtures, RP333, Portland Cement Association, Skokie, Illinois, USA, 1995, 92 pages and

(2) C. F. Ferraris, Measurement of the rheological properties of cement paste: a New Approach, Int. RILEM Conf. —The role of Admixtures in High Performance Concrete, ed. by J.G. Cabrera and R. Rivera-Villareal, Monterrey (Mexico), March 1999. pp. 333-342, or

(3) C. Ferraris, K. Obla, R. Hill, The influence of mineral admixtures on the rheology of cement paste and concrete, Cement and Concrete Research Vol. 31/2, pp. 245-255 (2001).

5. Significance and Use

5.1 This practice is useful in laboratory research on rheology of hydraulic cement systems as it has been shown to provide a paste with rheological properties similar to those obtained in a concrete from which the aggregate had been removed.[4] Mixing of paste using C305 is not satisfactory as the paste is not thoroughly mixed, due to the absence of sand. In this practice the shear imparted to the cement paste is significantly higher than in C305 and therefore it is known as high-shear mixing.

6. Apparatus

6.1 *Mixer*—Composed of an electrical motor, a mixing container and a tachometer with the motor speed controlled automatically (rheostat adjustment of speed will not be acceptable). The blades are attached to the bottom of the container

[1] This practice is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.22 on Workability.

Current edition approved April 1, 2014. Published May 2014. Originally approved in 2011. Last previous edition approved in 2013 as C1738/C1738M - 13. DOI:10.1520/C1738_C1738M-14.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] R. Helmuth, L.M. Hills, D.A. Whiting, S. Bhattacharja, Abnormal Concrete Performance in the Presence of Admixtures, RP333, Portland Cement Association, Skokie, Illinois, USA, 1995, 92 pages.

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959. United States

and rotate axially. The power of the motor shall be sufficient to ensure that the speeds of the mixer loaded with 500.0 g [1.1 lb] of cement and water shall maintain a preset rotational speed at 420 rad/s [4000 rpm] and 1047 rad/s [10 000 rpm]. The speed shall be maintained within 5 % of the preset speeds.

NOTE 1—A variable speed mixer capable of controlling the speed by a feedback loop within a range of 0 rad/s [0 rpm] to 1360 rad/s [13 000 rpm] is recommended. A mixer with a minimum of two speeds (420 rad/s [4000 rpm] and 1047 rad/s [10 000 rpm] loaded) preset either by the operator or by the manufacturer is acceptable.

6.2 *Cooling Unit*—A water bath with an outside circulating option, capable of controlling the temperature to ±1°C [±1°F] for the specified temperature range of 5-50°C [40-120°F] over the duration of the test.

6.3 *Mixing Container with the Blade Assembly*[5]—A 1-L [1 qt] container, lid and blade specifically designed for use with the mixer motor. The blade assembly shall be constructed in such a manner that the blade can be removed for weighing and changing. The blade shall be weighed initially and then periodically, replaced with a new blade when a 10 % mass loss has occurred. Replace the blade if obvious blade deformation has occurred. If the mix temperature is to be controlled by a separate cooling unit, the container shall also be equipped with a cooling system (see Note 2) that can be connected to the cooling unit.

NOTE 2—The cooling system could be either an integral part of the base of the container or a coil wrapped around the container.

6.4 *Thermometers*—A partial immersion thermometer readable 0.5°C [1°F] and accurate to ±0.5°C [± 1°F] when tested at 23°C [73°F] with a the range of 5-50°C [40-120°F].

6.5 *Cementitious Feeding System*—A feeding system, capable of adding the total quantity of cementitious material into the mixing container, within 60 s (see Note 3).

NOTE 3—A vibratory feeder or a lid mounted funnel is suitable for this purpose.

6.6 *Timing Device*—Stop watch or other suitable timing device accurate to ±1 s when tested over a one-minute interval.

6.7 *Top-Pan Balance*—Complying with Specification C1005 having a capacity of at least of 1 kg [2 lb] and readability and accuracy of 0.01 g [$2 \cdot 10^{-5}$ lb].

6.8 *Scraper*—The scraper shall consist of a semi rigid rubber blade attached to a handle about 150 mm [6 in.] long. The blade shall be about 75 mm [3 in.] long, 50 mm [2 in.] wide, and tapered to a thin edge about 2 mm [0.08 in.] thick.

7. Temperature and Humidity

7.1 The temperature and humidity of the mixing room shall conform to the requirements of Specification C511.

7.2 The cooling unit flow rate and temperature shall be adjusted so that the temperature of the cement paste, after mixing, is within the specified range (see Note 4).

NOTE 4—Typically water temperatures of 15 ± 2°C [59 ± 4°F] are required for a cement paste temperature of 21 ± 2 °C [70 ± 4°F]. Higher or lower temperature water could be used to simulate hot or cold weather concrete. The references[4,6] provide a more detailed explanation on how to select the cooling temperature.

8. Materials and Proportioning

8.1 The materials and their proportions and quantities shall conform to the requirements contained in the particular method for which the paste is being prepared.

9. Procedure

9.1 Place the mixing container on the mixer and if applicable, connect the hoses to the cooling unit.

9.2 If using an external cooling unit, adjust the temperature to the desired temperature and turn on the water supply to the jacketed bottom of the mixing container.

9.3 If paste temperature is to be controlled by the mix water, prepare required quantity of water, at the desired temperature and maintain until needed.

9.4 *Loading of the Mixer:*

9.4.1 Add the specified quantity of dry cementitious materials in their correct proportions to the cementitious feeder.

9.4.2 Add the correct amount of water to the mixing container, cover with lid and begin mixing at the first preset speed (420 rad/s [4000 rpm]) allowing water temperature to stabilize throughout.

9.4.3 Turn off mixer and remove lid. Insert thermometer into the water being careful not to let the tip of the thermometer touch the mixing container. If the measured temperature is not correct for the desired paste temperature, perform the following, as applicable.

9.4.3.1 If using an external cooling unit, place lid on the mixing container and continue mixing at the first preset speed (420 rad/s [4000 rpm]), periodically checking the temperature, as previously described, until the water has reached the desired temperature. Adjust the cooling unit temperature, if needed.

9.4.3.2 If using mix water for temperature control, completely empty water from mixing container and replace with the required quantity of water that has been adjusted for temperature. Repeat 9.4.2 and 9.4.3 above, as needed, until the water has reached the desired temperature.

9.4.4 As soon as the water reaches the desired temperature, start mixing at the first preset speed (420 rad/s [4000 rpm]) and using the cementitious feeder, begin adding the dry materials to the mixing container. The feeding of dry materials should be uniform and completed in approximately 60 s.

9.5 *Initial Mixing:*

[5] The sole source of supply of the container and blades known to the committee at this time is (Specialty Containers manufactured by Waring Products, Torrington CT (http://www.waringproducts.com/lab)). If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. The SS510C One Liter Cool Base Container with the blade assembly is considered to conform to these requirements

[6] Taylor P.C., Johansen V.C., Graf L. A., Kozikowski R. L., Zemajtis J. Z., Ferraris C. F., "Identifying Incompatible Combinations of Concrete Materials; Volume I & II" FHWA report # FHWA-HRT-06-080, 2006 (http://www.fhwa.dot.gov/pavement/concrete/pubs/06079/ and http://www.fhwa.dot.gov/pavement/concrete/pubs/06080/index.cfm)

9.5.1 As soon as the dry material addition is complete, attach the lid to the mixing container and switch to the second preset speed (1047 rad/s [10 000 rpm]).

9.5.2 After 30 s of mixing, stop the mixer

9.5.3 *Rest Period*—Allow the paste to stand in the mixer for 150 s. During the initial 15 s of the rest period, remove the lid and using the scraper, scrape down the inside of the mixing container to incorporate any dry material into the paste that may be left on the sides of the container. Measure the temperature of the paste without touching the bottom of the mixing container. Record the temperature. Replace lid on mixing container for the duration of the rest period.

9.6 *Final Mixing*—Immediately following the rest period, start the mixer at the second preset speed (1047 rad/s [10 000 rpm]). Mix the paste at this speed for an additional 30 s (see Note 5).

NOTE 5—Other mixing speeds could be used to simulate variations in mixing of concrete.[4]

9.7 As soon as the final mixing is complete, stop the mixer and measure the temperature of the paste by moving a thermometer in and around the paste without touching the bottom of the mixing container. Record the temperature.

9.8 The paste is now ready to be used, as required.

10. Keywords

10.1 cement paste; high-shear mixing; hydraulic cement; rheology

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the ASTM website (www.astm.org/COPYRIGHT/).