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Standard Test Methods for Evaluating Masonry Bond Strength[1]

This standard is issued under the fixed designation C 1357; 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.

Note—Annex A1 and Annex A2 were corrected and the year date changed on April 14, 2005.

INTRODUCTION

Bond strength between mortar and masonry units is an important physical property of masonry. Increased bond strength provides greater resistance to loads and to cracking. Bond strength therefore influences structural integrity and serviceability.

1. Scope*

1.1 These test methods cover the evaluation of flexural bond strength, normal to the bed joints, of masonry built of manufactured masonry units, as determined in accordance with Test Method C 1072. Sampling and testing procedures are referenced, and terms are defined. Two different test methods are specified, each for a different purpose:

1.1.1 The first test method is the "Test Method for Laboratory-Prepared Specimens." Its purpose is to compare the bond strengths (under the given conditions) of masonry mortars. It could be used, for example, to check the quality of mortar products after production, or to indicate the bond strength (under the given conditions) of a mortar product without requiring the product to be tested in combination with many different units. It is not intended to represent field conditions. It uses standard concrete masonry units. Mortars are batched by weight equivalents of volume proportions and are mixed to a prescribed flow. Prisms are constructed using a jig and are bag-cured.

NOTE 1—Standard fired clay masonry units are under development but are not now available. When their development is complete, they will be incorporated into these test methods.

1.1.2 The second test method is the "Test Method for Field-Prepared Specimens." Its purpose is to evaluate the bond strength (under the given conditions) of a particular unit-mortar combination, either for preconstruction evaluation of materials or for quality control purposes during construction. Mortars are batched conventionally, and the flow is not prescribed. Prisms are constructed conventionally (no jig) and are bag-cured.

1.1.3 The two test methods are not consistent, nor are they intended to be. They are intended to be used for two different purposes. To make this clear, the two methods are presented separately.

1.1.4 Appendix X1 suggests two possible criteria for assessing the bond strength values obtained using these test methods. These possible evaluation criteria are given for illustration only and are not mandatory.

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

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]

C 67 Test Methods of Sampling and Testing Brick and Structural Clay Tile

C 140 Test Methods of Sampling and Testing Concrete Masonry Units and Related Units

C 230 Specification for Flow Table for Use in Tests of Hydraulic Cement

C 270 Specification for Mortar for Unit Masonry

C 780 Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry

C 1072 Test Method for Measurement of Masonry Flexural Bond Strength

[1] These test methods are under the jurisdiction of ASTM Committee C15 on Manufactured Masonry Units and are the direct responsibility of Subcommittee C15.04 on Research.

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[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.

***A Summary of Changes section appears at the end of this standard.**

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C 1437 Test Method for Flow of Hydraulic Cement Mortar

2.2 *Other Documents:*

Building Code Requirements for Masonry Structures (ACI 530-99/ASCE 5-99/TMS 402-99)[3]

NBS Handbook 91 [4]

3. Terminology

3.1 *Definitions:*

3.1.1 *lot*, *n*—material of a given quantity of a single type, grade, class, and brand and practically of the same nominal size, color range, texture, and composition produced by a single source by virtually the same process and under essentially the same conditions.

3.1.2 *sample*, *n*—a number of specimens selected at random from a lot in which every specimen has an equal chance of being selected in every trial.

3.1.2.1 *Discussion*—It is virtually impossible to select a sample at random by exercise of human judgment alone. To avoid bias, it is necessary to select a random sample using an artificial or mechanical device such as a table of random numbers or a random number generator.

3.1.3 *specimen*, *n*—an individual piece of randomly selected material in a sample.

TEST METHOD FOR LABORATORY-PREPARED SPECIMENS

4. Summary of Test Method

4.1 This test method is for evaluating the flexural bond strength (under the given conditions) of masonry built of standard masonry units, as determined in accordance with Test Method C 1072. It uses standard concrete masonry units. Mortars are batched by weight equivalents of volume proportions and are mixed to a prescribed flow. Prisms are constructed using a jig and are bag-cured.

5. Significance and Use

5.1 This test method is intended for use in comparing the bond strengths (under the given conditions) of masonry mortars, as determined in accordance with Test Method C 1072.

5.2 This test method could be used, for example, to check one aspect of the quality of mortar products after production, or to indicate the bond potential of a mortar product without requiring the product to be tested in combination with many different units.

5.3 This test method uses controlled conditions of fabrication and curing that are not intended to represent field conditions.

5.4 This test method uses standard concrete masonry units. Mortars are batched by weight equivalents of volume proportions and are mixed to a prescribed flow. Prisms are constructed using a jig and are bag-cured.

5.5 Flexural bond strength determined by this test method shall not be interpreted as the flexural bond strength of a wall (because standard units are not used for wall construction), nor shall it be interpreted as an indication of extent of bond for purposes of water permeability evaluation.

6. Apparatus

6.1 Prism Fabrication Jig, as described in Annex A2 and shown in Fig. A2.1.

6.2 Mortar Joint Template, as described in Annex A2 and shown in Fig. A2.2.

6.3 Drop Hammer, as described in Annex A2 and shown in Fig. A2.3

6.4 Mechanical Paddle-Type Mortar Mixer, of no less than 0.6 ft^3(18L) capacity.

6.5 Flow Table, Flow Mold, and Caliper, conforming to the requirements of Specification C 230.

6.6 Cone Penetrometer, Unit Measure, Straightedge, Spatula, Tapping Stick, and Spoon, conforming to the requirements of Test Method C 780.

6.7 Bond Strength Test Apparatus, conforming to the requirements of Test Method C 1072.

7. Materials

7.1 Select representative samples of each lot of mortar materials. Each sample of material shall be of sufficient quantity to build a set of test prisms. Use standard concrete masonry units meeting the requirements of Annex A1.

7.2 Mortar materials (including water) shall be at an equilibrium temperature with laboratory air (see Section 8).

8. Temperature and Humidity

8.1 Maintain the temperature of laboratory air in the vicinity of mixing of mortar, fabrication of specimens, curing, and testing of specimens at 24 ± 9°C (75 ± 16°F)

8.2 Maintain the relative humidity of laboratory air in the vicinity of mixing of mortar, fabrication of specimens, and testing of specimens between 30 and 80 %.

9. Procedure

9.1 Fabricate a set of test prisms (any convenient number of prisms) containing a total of not less than 15 nor more than 30 mortar joints. Each prism shall have no more than 5 joints.

9.1.1 Proportion mortar materials by weights equivalent to volume proportions to be used in prism construction. Use unit weights for individual materials as given in Specification C 270. Sand shall be permitted to be used in a damp loose condition, provided that moisture content of sand is determined with reference to the oven-dried condition and batch proportions are adjusted accordingly. Record weight of ingredients (including water) added to the batch of mortar.

9.1.2 Mix mortar in a mechanical paddle-type mortar mixer. Time periods referenced below are measured from when water and cementitious materials are combined.

9.1.2.1 For standard concrete masonry units, add an estimated amount of water to the mortar to achieve a flow of 127 ± 3 determined in accordance with Test Method C 1437. Mix mortar for three minutes and determine flow. Once flow is recorded, return the material used to measure flow to the mixer. If the flow is 127 ± 3, continue mixing the batch for an additional two minutes. If the flow is less than 124, add water to the batch, mix for one minute, and determine flow. Once

[3] Available from Masonry Standards Joint Committee.

[4] Natrella, M. G., *Experimental Statistics*, National Bureau of Standards Handbook 91, U.S. Government Printing Office, August 1, 1963, pp. 2–14.

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flow is recorded, return the material used to measure flow to the mixer. If the flow is 127± 3, continue mixing the batch for one minute.

9.1.2.2 If after the one-time addition of water the flow is not 127 ± 3, discard the batch.

9.1.2.3 If the measured flow exceeds 130 at any time, discard the batch.

9.1.3 Immediately after mixing the mortar, determine its initial cone penetration in accordance with Test Method C 780. Determine the cone penetration of the mortar every 15 ± 5 minutes. If the cone penetration is less than 80 % of its initial value, discard the remaining portion of the mortar without constructing additional mortar joints.

9.1.4 Use standard concrete masonry units as defined in Annex A1. Clean the bed surface of units of dirt, loose sand, or other contaminants.

9.1.5 Fabricate prism specimens as described in Annex A2.

9.1.6 Cure prism specimens in accordance with Annex A2.

9.2 Conduct bond-wrench tests on prism specimens.

9.2.1 Test the prisms in the same facility where they were built.

9.2.2 Test masonry prisms in accordance with the requirements of Test Method C 1072 except as otherwise provided in this test method.

NOTE 2—When test ages other than 28 days are specified, the general relationship between the strength at the specified test age and that at 28 days is generally established by test. That relationship may vary with different materials and curing conditions.

10. Report

10.1 Identify mortar materials and units tested, including as applicable the manufacturer's name, brand name, type, grade, source of sample, date sampled, and date tested.

10.2 List unit dimensions, number of joints per prism, and number of prisms per set of specimens.

10.3 Include the following in the report:

10.3.1 Weight of ingredients (including water) added to the batch of mortar.

10.3.2 Flow or cone penetrometer reading of mortar used to construct prisms.

10.3.3 Flexural bond strength test results for each joint of the test specimens. Mean, standard deviation, and test age for each set of test specimens.

11. Precision and Bias

11.1 *Precision*—Published data are not available for within-laboratory variability of this test method. Published data (Hedstrom,[5] Melander[6]) obtained under conditions almost identical with those of this test method show within-batch coefficients of variation varying between 10 % and 25 % for 30-joint samples of selected portland cement-lime mortars and masonry cement mortars. Because only one sample of each mortar was tested in each laboratory, sufficient data are not available to establish repeatability for this test method. Interlaboratory testing is now planned to determine the reproducibility of this test method. It is the intent of this committee to develop precision values within 5 years from the date of issuance of this test method.

11.2 *Bias*—No information can be presented on the bias of this test method because no test having an accepted reference value is available.

TEST METHOD FOR FIELD-PREPARED SPECIMENS

12. Summary of Test Method

12.1 This test method is for evaluating the flexural bond strength (under the given conditions) of masonry built of conventional masonry units, as determined in accordance with Test Method C 1072. Mortars are batched conventionally, and their flow is not prescribed. Prisms are constructed conventionally (no jig) and are bag-cured.

13. Significance and Use

13.1 This test method is intended for evaluation of flexural bond strength (under the given conditions) between mortar and units, as determined in accordance with Test Method C 1072.

13.2 The purpose of this test method is to evaluate the bond strength (under the given conditions) of a particular unit-mortar combination, either for preconstruction evaluation of materials or for quality control purposes during construction. Preconstruction field tests may be used to provide information on the potential performance of a mortar-unit combination under field conditions of fabrication and workmanship (but not curing). Construction field tests may be used as a quality control measure to ensure that performance criteria established in preconstruction tests are being met.

13.3 Flexural bond strength determined by this test method shall not be interpreted as the flexural bond strength of a wall constructed of the same material, nor shall it be interpreted as an indication of extent of bond for purposes of water permeability evaluation. However, if effects of construction conditions, specimen size, workmanship, and curing conditions are taken into account, the results may be used to estimate the flexural strength of a wall.

14. Sampling

14.1 Select representative samples of each lot of masonry materials intended for use in construction. Each sample of material shall be of sufficient quantity to build a set of test prisms. A lot of each material shall consist of not less than the following quantities:

14.1.1 4000 of each type of masonry unit,

14.1.2 15 bags of each type of cement (or the equivalent bulk quantity),

14.1.3 15 bags of lime (or the equivalent bulk quantity),

14.1.4 3 yd^3 of sand, and

14.1.5 If mortar is delivered in bulk, 3 yd^3 of mortar.

[5] Hedstrom, E. G., Tarhini, K. M., Thomas, R. D., Dubovoy, V. S., Klingner, R. E., and Cook, R. A., "Flexural Bond Strength of Concrete Masonry Prisms Using Portland Cement and Hydrated Lime Mortars," *Masonry Society Journal*, Vol 9, No. 2, February 1991.

[6] Melander, J. M., Ghosh, S. K., Dubovoy, V. S., Hedstrom, E. G., and Klingner, R. E., "Flexural Bond Strength of Concrete Masonry Prisms Using Masonry Cement Mortars," *Masonry: Design and Construction, Problems and Repair, ASTM STP 1180*, ASTM, 1993.

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