Designation: C 1329 – 03a

Standard Specification for Mortar Cement[1]

This standard is issued under the fixed designation C 1329; 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 specification covers three types of mortar cement for use where mortar for masonry is required.

1.2 The values stated in SI units are to be regarded as the standard. Values in SI units shall be obtained by measurement in SI units or by appropriate conversion, using the Rules for Conversion and Rounding given in IEEE/ASTM SI 10, of measurements made in other units.

1.3 The text of this standard refers to notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 The following safety hazards caveat pertains only to Annex A1. *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.* (**Warning—**Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

2. Referenced Documents

2.1 *ASTM Standards:*

C 91 Specification for Masonry Cement[3]

C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[3]

C 128 Test Method for Specific Gravity and Absorption of Fine Aggregate[4]

C 140 Test Methods of Sampling and Testing Concrete Masonry Units[5]

C 151 Test Method for Autoclave Expansion of Portland Cement[3]

C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement[3]

C 185 Test Method for Air Content of Hydraulic Cement Mortar[3]

C 187 Test Method for Normal Consistency of Hydraulic Cement[3]

C 188 Test Method for Density of Hydraulic Cement[3]

C 219 Terminology Relating to Hydraulic Cement[3]

C 230/C 230M Specification for Flow Table for Use in Tests of Hydraulic Cement[3]

C 266 Test Method for Time of Setting of Hydraulic-Cement Paste by Gillmore Needles[3]

C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency[3]

C 430 Test Method for Fineness of Hydraulic Cement by the 45-μm (No. 325) Sieve[3]

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[3]

C 778 Specification for Standard Sand[3]

C 780 Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry[5]

C 1072 Test Method for Measurement of Masonry Flexural Bond Strength[5]

C 1506 Test Method for Water Retention of Hydraulic Cement-Based Mortars and Plasters[3]

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System[6]

3. Terminology

3.1 *Definitions*—Terms used in this specification are defined in Terminology C 219.

3.2 *Definition of Term Specific to This Standard:*

3.2.1 *mortar cement*—a hydraulic cement, primarily used in masonry construction, consisting of a mixture of portland or blended hydraulic cement and plasticizing materials (such as limestone or hydrated or hydraulic lime), together with other materials introduced to enhance one or more properties such as setting time, workability, water retention, and durability.

3.2.1.1 *Discussion*—Mortar cement is similar to masonry cement in use and function. However, this specification requires lower air contents and includes a flexural bond strength requirement.

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[1] This specification is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.11 on Masonry Cement.

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[2] *Annual Book of ASTM Standards*, Vol 04.01. See the section on Safety Precautions in the Manual of Cement Testing.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

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

[5] *Annual Book of ASTM Standards*, Vol 04.05.

[6] *Annual Book of ASTM Standards*, Vol 14.04.

4. Classification

4.1 Mortar cements are classified as Type N, S, or M, according to the physical requirements prescribed in Table 1.

5. Physical Properties

5.1 Mortar cement shall conform to the applicable requirements prescribed in Table 1 for its classification.

6. Sampling

6.1 At the option of the purchaser, the cement shall be sampled and tested to verify compliance with this specification, sampling and testing shall be performed in accordance with Practice C 183.

6.2 Practice C 183 is not designed for manufacturing quality control and is not required for manufacturer's certification.

7. Temperature and Humidity

7.1 The temperature and relative humidity of the air in the vicinity of the mixing slab and dry materials, molds, base plates, and mixing bowl shall conform to the requirements of Test Method C 109/C 109M.

7.2 The moist cabinet or moist room shall conform to the requirements of Specification C 511.

8. Fineness

8.1 Determine the residue on the 45-μm (No. 325) sieve in accordance with Test Method C 430.

9. Normal Consistency

9.1 Determine the normal consistency by the Vicat apparatus in accordance with Test Method C 187.

10. Autoclave Expansion

10.1 Determine the autoclave expansion in accordance with Test Method C 151. After molding, store the bars in the moist cabinet or room for 48 h ± 30 min before removal from the molds for measurement and testing in the autoclave. Calculate the difference in length of the test specimen before and after autoclaving to the nearest 0.01 % of the effective gage length, and report as the autoclave expansion of the mortar cement.

11. Time of Setting

11.1 Determine the time of setting by the Gillmore needle method in accordance with Test Method C 266.

12. Density

12.1 Determine the density of the mortar cement in accordance with Test Method C 188, using kerosine as the liquid. Use the density so determined in the calculation of the air content of the mortars.

13. Blended Sand

13.1 The sand shall be a blend of equal parts by weight of graded standard sand and 20–30 standard sand conforming to Specification C 778.

14. Preparation of Mortar

14.1 *Proportions for Mortar*—Mortar for air entrainment, compressive strength, and water retention tests shall be proportioned to contain 1620 g of sand and a mass of cement, in grams, as indicated in Table 2. The sand shall consist of 810 g of graded standard sand and 810 g of 20-30 standard sand (Note 1). The quantity of water, measured in millilitres, shall be such as to produce a flow of 110 ± 5 as determined by Test Method C 109/C 109M.

NOTE 1—Historically, field-mixed mortar has been proportioned by volume measured in increments or fractions of 1 ft^3. The comparable whole SI-unit volume to 1 ft^3 is 28 L. The specified mortar proportions approximate the 1:3 nominal proportions by volume, commonly specified for construction, on the basis of the following assumed mass and volume relationships:

The mass of dry sand in 28 L of loose damp sand is 36 kg.

28 L of Type N mortar cement has a mass of 32 kg.

28 L of Type S mortar cement has a mass of 34 kg.

28 L of Type M mortar cement has a mass of 36 kg.

For example, the amount of cement needed to provide a 1:3 volume proportion of cement to sand using a Type N mortar cement is calculated as follows:

$$A = 1620 \times (C/B) = 1620 \times (32/108) = 480 \quad (1)$$

TABLE 1 Physical Requirements

Mortar Cement Type	N	S	M
Fineness, residue on a 45-μm (No. 325) sieve, max, %	24	24	24
Autoclave expansion, max, %	1.0	1.0	1.0
Time of setting, Gillmore method:			
Initial set, min, not less than	120	90	90
Final set, min, not more than	1440	1440	1440
Compressive strength (average of three cubes):			
The compressive strength of mortar cubes, composed of 1 part cement and 3 parts blended sand (half graded standard sand and half standard 20–30 sand) by volume, prepared and tested in accordance with this specification, shall be equal to or higher than the values specified for the ages indicated below:			
7 days, MPa (psi)	3.5 (500)	9.0 (1300)	12.4 (1800)
28 days, MPa (psi)	6.2 (900)	14.5 (2100)	20.0 (2900)
Flexural bond strength			
28 days, min, MPa (psi)	0.5 (70)	0.7 (100)	0.8 (115)
Air content of mortar:			
Min, volume %	8	8	8
Max, volume %	17	15	15
Water retention value, min, %, of original flow	70	70	70

TABLE 2 Cement in Laboratory Batch of Mortar

Mortar Cement Type	Mass of Cement, g
N	480
S	510
M	540

where:

A = number of grams of cement to be used in the mortar with 1620 g of sand,
B = 3 × 36 = 108 kg, the mass of dry sand in 84 (or 3 × 28) L of loose damp sand, and
C = mass of Type N mortar cement per 28 L.

14.2 *Mixing of Mortars*—Mix the mortar in accordance with Practice C 305.

14.3 *Determination of Flow*—Determine the flow in accordance with Test Method C 109/C 109M.

15. Air Entrainment

15.1 *Procedure*—If the mortar has the correct flow, use a separate portion of the mortar for the determination of entrained air. Determine the mass of 400 mL of mortar in accordance with Test Method C 185.

15.2 *Calculation*—Calculate the air content of the mortar, and report it to the nearest 1 % as follows:

$$D = (W_1 + W_2 + V_w)/[(W_1/S_1) + (W_2/S_2) + V_w]\,A$$
$$= 100 - (W_m/4D) \quad (2)$$

where:

D = density of air-free mortar, g/cm^3,
W_1 = mass of cement, g,
W_2 = mass of sand, g,
V_w = mL-g of water used,
S_1 = density of cement, g/cm^3,
S_2 = density of standard sand, 2.65 g/cm^3,
A = volume percent of entrained air, and
W_m = mass of 400 mL of mortar, g.

16. Compressive Strength

16.1 *Test Specimens*:

16.1.1 *Molding*—Immediately after determining the flow and mass of 400 mL of mortar, return all of the mortar to the mixing bowl and remix for 15 s at the medium speed. Then mold the test specimens in accordance with Test Method C 109/C 109M, except that the elapsed time for mixing mortar, determining flow, determining air entrainment, and starting the molding of cubes shall be within 8 min.

16.1.2 *Storage*—Immediately after molding, store all test specimens in the molds on plane plates in a moist cabinet or moist room for 48 to 52 h in such a manner that the upper surfaces shall be exposed to the moist air. Then remove the cubes from the molds, and place them in the moist cabinet or moist room for 5 days in such a manner as to allow free circulation of air around at least five faces of the specimens. At the age of 7 days, immerse the cubes for the 28-day tests in saturated lime water in storage tanks of noncorrodible materials.

16.2 *Procedure*:

16.2.1 Test the cube specimens immediately after their removal from the moist cabinet or moist room for 7-day specimens, and immediately after their removal from storage water for all other specimens. If more than one specimen at a time is removed from the moist cabinet or moist room for 7-day tests, cover these cubes with a damp cloth until the time of testing.

16.2.2 The remainder of the testing procedure shall conform to Test Method C 109/C 109M.

17. Water Retention

17.1 Water retention shall be determined in accordance with the procedures in Test Method C 1506.

18. Flexural Bond Strength

18.1 Flexural bond strength shall be determined in accordance with the procedure set forth in Annex A1 of this specification.

19. Storage

19.1 The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weathertight building that will protect the cement from dampness and minimize warehouse set.

20. Inspection

20.1 Adequate facilities shall be provided to the purchaser for the necessary inspection and sampling.

20.2 All packages shall be in good condition at the time of inspection.

21. Rejection

21.1 At the option of the purchaser, the cement shall be rejected if it fails to meet any of the requirements of this specification.

21.2 At the option of the purchaser, packages more than 2 % below the mass marked thereon shall be rejected. At the option of the purchaser, the entire shipment shall be rejected if the average mass of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that marked on the packages.

21.3 At the option of the purchaser, cement remaining in storage prior to shipment for a period greater than six months after testing shall be retested and, at the option of the purchaser, shall be rejected if it fails to meet any of the requirements of this specification.

22. Manufacturer's Certification

22.1 Upon request of the purchaser in the contract or order, a manufacturer's report shall be furnished at the time of shipment stating the results of the tests made on samples of the material taken during production or transfer and certifying that the applicable requirements of this specification have been met.

23. Packaging and Package Marking

23.1 When mortar cement is delivered in packages, the brand, name of the manufacturer, type of mortar cement, and net mass of the package in kilograms (Note 2) shall be

indicated plainly thereon. Similar information shall be provided in the shipping documents accompanying the shipment of mortar cement in bulk.

NOTE 2—To facilitate the change to SI units, a standard metric package size of 32 kg for Type N, 34 kg for Type S, and 36 kg for Type M will provide convenient mass increments reasonably similar to the traditional 70–, 75–, and 80–lb packages.

24. Keywords

24.1 flexural bond strength; masonry; mortar; mortar cement

ANNEX

(Mandatory Information)

A1. TEST METHOD FOR DETERMINATION OF FLEXURAL BOND STRENGTH

A1.1 Scope

A1.1.1 This test method covers a laboratory procedure for determination of the flexural bond strength of masonry assemblies made using mortar-cement mortars and standard masonry units.

A1.2 Summary of Test Method

A1.2.1 This test method includes the following: requirements for standard concrete masonry units used in this test procedure; procedures for proportioning and mixing test mortars used in the fabrication of test prisms; procedures for fabricating, curing, and testing prism specimens; and reporting requirements.

A1.3 Significance and Use

A1.3.1 This test method provides a means for the determination of flexural bond strength values to be used to determine compliance with the bond-strength requirements of this specification.

A1.3.2 The flexural bond strength determined by this test method is not to be interpreted as the flexural bond strength of a masonry wall constructed using the same mortar cement. Flexural bond strength is not to be interpreted as an indication of the extent of bond for purposes of water permeance evaluation.

A1.4 Apparatus

A1.4.1 *Prism Fabrication Jig*, as shown in Fig. A1.1.

A1.4.2 *Mortar Joint Template*, as shown in Fig. A1.2.

A1.4.3 *Drop Hammer*, as shown in Fig. A1.3.

A1.4.4 *Mechanical Drum Mortar Mixer*.

A1.4.5 *Flow Table, Flow Mold, and Caliper*, conforming to the requirements of Specification C 230/C 230M.

A1.4.6 *Cone Penetrometer, Unit Measure, Straightedge, Spatula, Tapping Stick, and Spoon*, conforming to the requirements of Test Method C 780.

A1.4.7 *Bond Strength Test Apparatus*, conforming to the requirements of Test Method C 1072.

A1.5 Materials

A1.5.1 Standard masonry units shall be used for the purpose of determining the flexural bond strength properties of mortar cement mortars. The standard unit shall be in accordance with the following requirements:

A1.5.1.1 The dimensions of units shall be 92-mm (3⅝-in.) wide by 57-mm (2¼-in.) high by 194-mm (7⅝-in.) long within a tolerance of ±3 mm (⅛ in.) and shall be 100 % solid.

A1.5.1.2 The unit material shall be concrete masonry manufactured with the following material proportions by volume: 1 part portland cement to 8 parts aggregate.

TABLE A1.1 Grading of Aggregate Used in the Manufacture of Standard Concrete Masonry Units

Grading	Percent Retained by Mass
9.53 mm (⅜ in.) sieve	0
4.75 mm (No. 4) sieve	0 to 5
2.36 mm (No. 8) sieve	20 to 30
1.18 mm (No. 16) sieve	20 to 30
600 µm (No. 30) sieve	15 to 25
300 µm (No. 50) sieve	5 to 15
150 µm (No. 100) sieve	5 to 10
Pan	5 to 10

A1.5.1.3 The aggregate used in manufacture of the unit shall meet the grading requirements of Table A1.1. The bulk specific gravity determined in accordance with Test Method C 128 shall be not less than 2.6 and not more than 2.7.

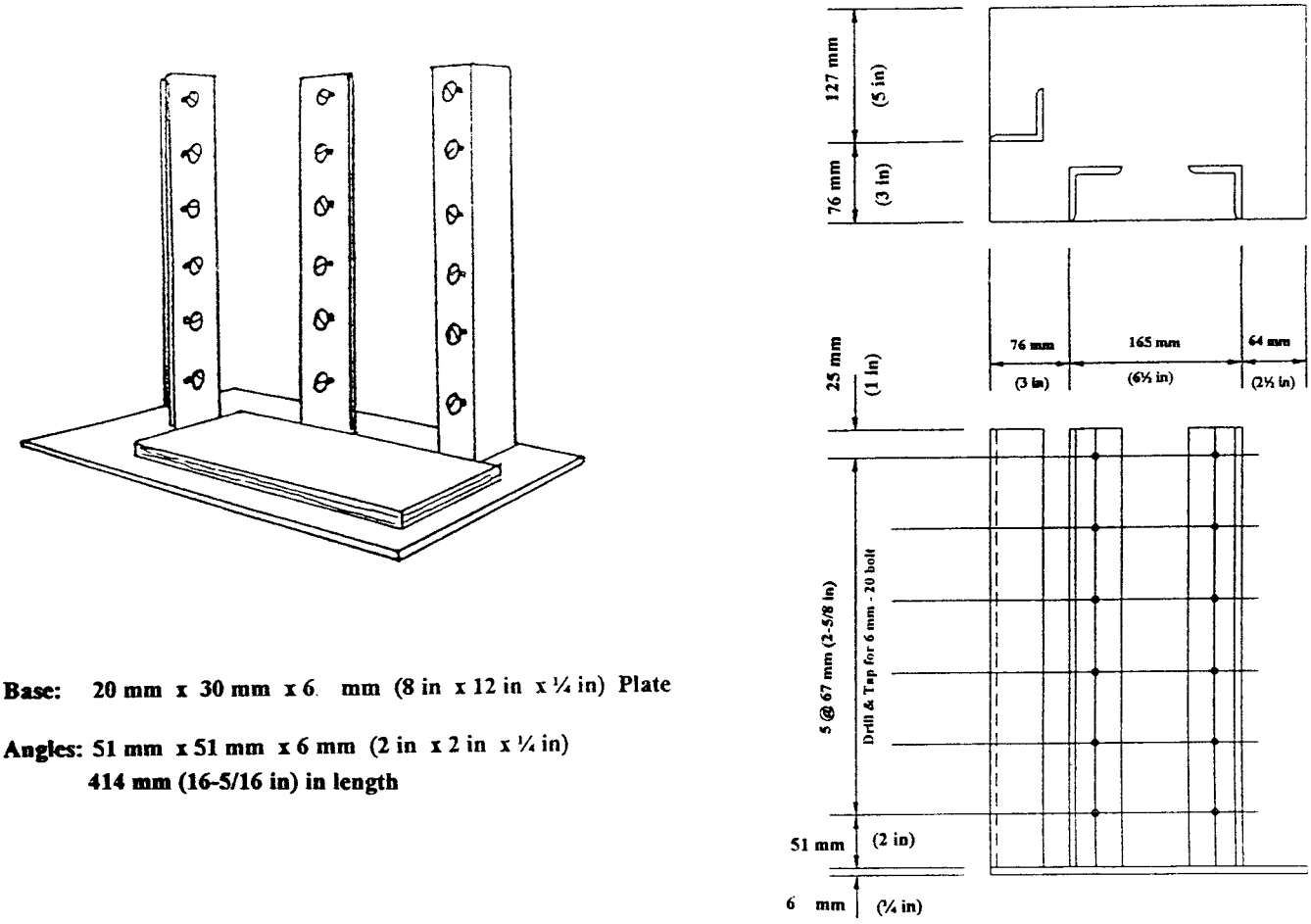
A1.5.1.4 The density of the unit shall be 2000 to 2160 kg/m^3(125 to 135 lb/ft^3).

A1.5.1.5 The unit shall be cured in a 100 % relative humidity environment at 60 ± 6°C (140 ± 10°F) at atmospheric pressure for 10 to 20 h. Additional curing, under covered atmospheric conditions, shall continue for at least 28 days. The unit shall be loose stacked in the cube (separated by a 12-mm (½-in.) gap) to allow air to circulate during drying.

A1.5.1.6 At the time of fabricating the prisms, the units shall have a 25 to 35 % of total absorption when tested in accordance with Test Methods C 140.

A1.5.1.7 During manufacturing of the standard masonry unit, precaution shall be exercised to prevent contamination of the surfaces of the unit by a mold release agent.

A1.5.1.8 Upon delivery, units shall be protected from any outside contamination by means of covering with stretch wrapping or shrink wrapping. At seven days prior to use, units to be used shall be stored under conditions of laboratory temperature and humiduty. The units shall not be wetted or surface treated prior to or during prism fabrication.



NOTE 1—Base: 20 by 30 by 6.0-mm (8 by 12 by ¼-in.) plate. Angles: 51 by 51 by 6 mm (2 by 2 by ¼ in.), 414 mm (16 5⁄16 in.) in length.

FIG. A1.1 Jig Used in Prism Fabrication

A1.6 Procedure

A1.6.1 Mortar shall be prepared in accordance with the following:

A1.6.1.1 Sand shall be a blend of an equal mass of graded standard sand and standard 20–30 µm sand conforming to Specification C 778. Mortar shall be proportioned to contain a mass of cement in kg equal to 0.20 times the net mass in kg printed on the bag and 22.0 kg of sand.

A1.6.1.2 Mortar materials shall be mixed in a paddle-type mortar mixer of no less than 18 L (0.6 ft^3) capacity for 5 min.

A1.6.1.3 Mortar flow shall be determined in accordance with Test Method C 109/C 109M. Water shall be adjusted until flow of 125 ± 5 is achieved. The flow shall be determined on mortar mixed 3 min after all of the ingredients are added to the mixer. If the flow meets the required consistency, the batch (including material used to determine flow) shall be mixed for the remaining 2 mins. If the flow is less than 120, additional water is not prohibited from being added to the batch (including material used to determine flow) and mixed for 1 min. If the flow then meets the required consistency, the batch (including material used to determine flow) shall be mixed for the remaining minute. If after the one-time addition of water the flow does not meet the required consistency, the batch shall be discarded. Whenever the measured flow exceeds 130 the batch shall be discarded.

A1.6.1.4 The initial cone penetration shall be determined in accordance with Test Method C 780, immediately after mixing the mortar. Mortar shall not be used when the cone penetration is less than 80 % of the initial cone penetration value.

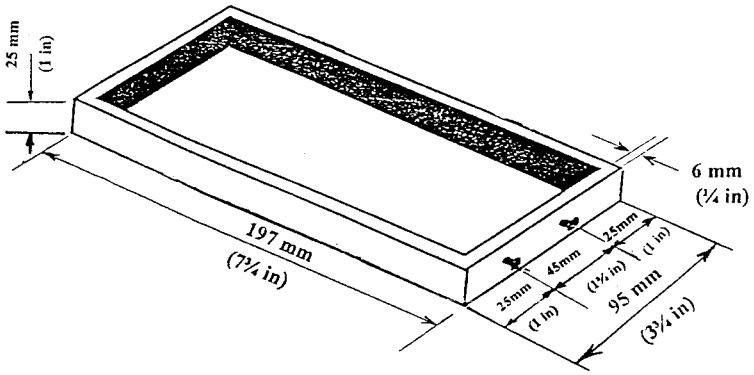
A1.6.2 Test specimens shall consist of a set of prisms such that 30 mortar joints are fabricated for testing. Prism specimens shall be not more than six units in height.

A1.6.3 Fabricate the test specimens as follows:

A1.6.3.1 Each prism shall be built in an opened moisture-tight bag that is large enough to enclose and seal the completed prism. Set the first unit of each prism on a 12-mm (½-in.) plywood pallet in an alignment jig, as shown in Fig. A1.1.

A1.6.3.2 Place the mortar template shown in Fig. A1.2 on the unit so that the mortar bed depth prior to compaction is 12 mm (½ in.). Place the mortar in the template, and strike off excess mortar with a straight edge.

A1.6.3.3 Remove the template, and immediately place the next unit on the mortar bed in contact with the three alignment bolts for that course using a bulls-eye level to ensure uniform initial contact of the unit surface and bed mortar. Carefully



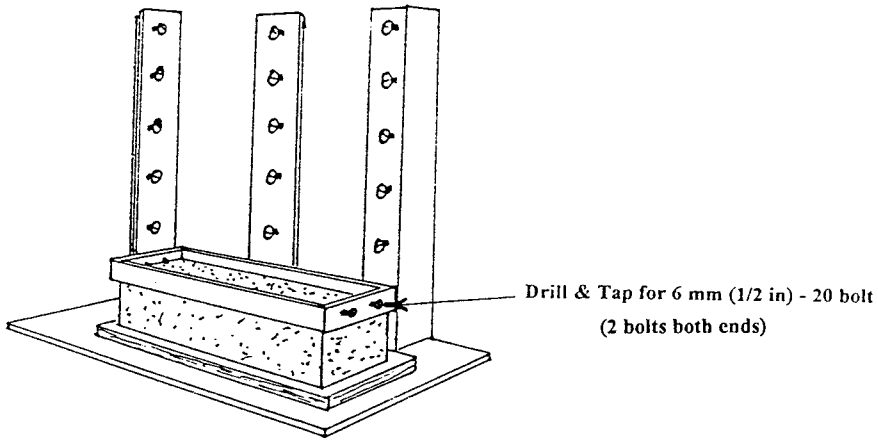


FIG. A1.2 Mortar Template Used in Prism Fabrication

position the drop hammer apparatus shown in Fig. A1.3 on top of the unit, and drop its 1.8 kg (4 lb), round end down, once from a height of 38 mm (1.5 in.).

A1.6.3.4 Repeat the steps given in A1.6.3.2 and A1.6.3.3 until the prisms are complete.

A1.6.3.5 Joints shall be cut flush after the prism is completely built. The joints shall not be tooled.

A1.6.3.6 Place two masonry units of the type used to construct the prism upon the top course 1 h ± 15 min after the completion of construction.

A1.6.3.7 Identify all test specimens using a water-resistant marker.

A1.6.3.8 Draw and seal the moisture-tight bag around the prism.

A1.6.3.9 Cure all test specimens for 28 days. Two days prior to testing, remove the moisture-tight bag and continue curing in the laboratory air, maintained at a temperature of 24 ± 9°C (75 ± 16°F), with a relative humidity between 30 and 70 %.

A1.6.4 Determine the flexural bond strength of the test specimens in accordance with the procedure outlined in Test Method C 1072.

A1.7 Calculation

A1.7.1 Calculate the modulus of rupture of each mortar joint as follows:

$$f_r = \frac{6(PL + P_1L_1)}{bd^2} - \frac{(P + P_1)}{bd}$$

where:

f_r = modulus of rupture, MPa (psi),
P = maximum applied load, N (lbf),
P_1 = weight of loading arm, N (lbf),
L = distance from center of prism to loading point, mm (in.),
L_1 = distance from center of prism to centroid of loading arm, mm (in.),
b = average width of cross section of failure surface, mm (in.), and
d = average thickness of cross section of failure surface, mm (in.).

A1.7.2 The flexural bond strength of mortar cement shall be determined as the average modulus of rupture of 30 joints minus 1.28 times the standard deviation of the sample, which yields a value that a mortar joint's modulus of rupture will equal or exceed 9 out of 10 times.

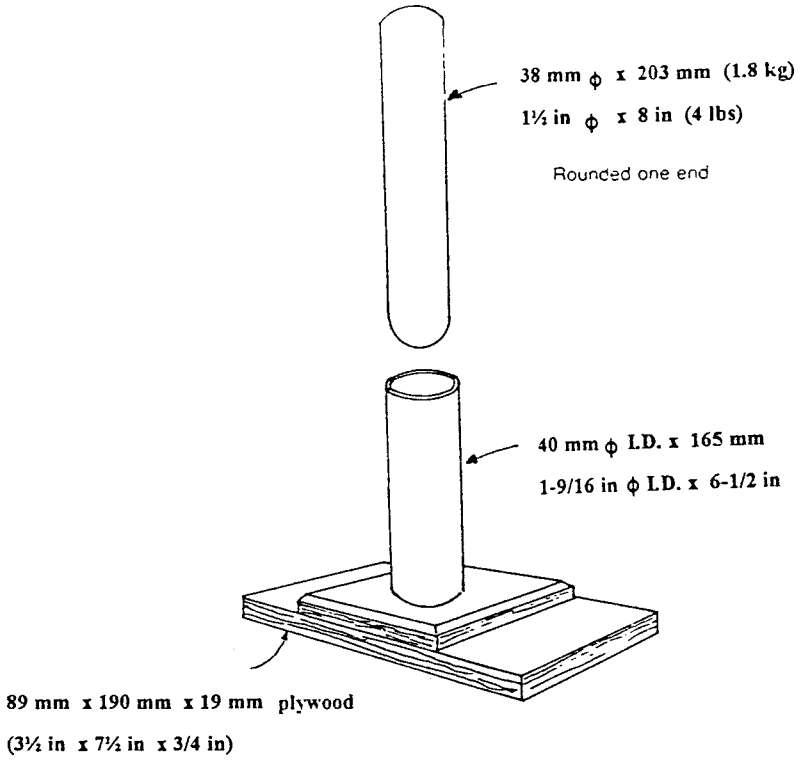


FIG. A1.3 Drop Hammer Used in Prism Fabrication

A1.8 Report

A1.8.1 Include the name of the manufacturer of the mortar cement being evaluated, place of manufacture, type of mortar cement, date of testing, laboratory name, and names of laboratory staff in the report.

A1.8.2 Report the mortar flow and initial cone penetration.

A1.8.3 Identify the prism and joint tested. Report the maximum applied test load and the modulus of rupture.

A1.8.4 Report the standard deviation for all 30 joints tested.

A1.8.5 Report the flexural bond strength of the mortar cement as determined in accordance with A1.7.2.

A1.9 Precision and Bias

A1.9.1 Insufficient data are currently available for a precision and bias statement.

A1.10 Keywords

A1.10.1 flexural bond strength; mortar cement; standard concrete masonry unit