Designation: C 398 – 98 (Reapproved 2003)

Standard Practice for Use of Hydraulic Cement Mortars in Chemical-Resistant Masonry[1]

This standard is issued under the fixed designation C 398; 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 provides recommendations for use of hydraulic cement mortars for chemical-resistant masonry construction.

1.2 *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.*

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

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 144 Specification for Aggregate for Masonry Mortar
C 150 Specification for Portland Cement
C 171 Specification for Sheet Materials for Curing Concrete
C 267 Test Method for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes
C 279 Specification for Chemical-Resistant Masonry Units
C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C 404 Specification for Aggregates for Masonry Grout
C 595 Specification for Blended Hydraulic Cements
C 904 Terminology Relating to Chemical-Resistant Nonmetallic Materials
D 226 Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
D 227 Specification for Coal-Tar Saturated Organic Felt Used in Roofing and Waterproofing

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, see Terminology C 904.

FLOORS AND CONSTRUCTION UNITS

4. Preparation of Concrete Fill or Subbase

4.1 In new construction, the surface of the concrete fill shall be free of mortar drippings, projecting joints, etc. Smooth surfaces resulting from the use of plywood forms or a steel trowel finish are not acceptable and must be given a course sandpaper profile by blasting or mechanical scarifying. The preferred finish for new concrete floors after leveling is a wood float finish, followed by a single pass metal trowel finish. The contour of the finished surface must be free of ridges and depressions, cracks, or open joints. When an old concrete surface is to be removed, it shall be cut out to provide the necessary thickness for the new setting bed and the construction unit. The surface must be clean, free of loose particles, hard, and roughened to ensure intimate bond with the new bed joint. The edges around all cut-out sections shall be maintained straight and vertical. A final finishing of the edges by hand chiseling may be necessary.

4.2 A cleavage membrane consisting of waterproof building felt as specified in Specifications D 226 and D 227, or polyethylene sheeting 0.004 in. (0.10 mm) thick is generally used over wood frame construction and is preferred for many other types of construction. It may be omitted over certain types of concrete bases of limited areas. Cleavage membrane shall have edges overlapped a nominal 2-in.

4.3 *Cleaning*—All dirt, dust, loose particles, surface laitance, and debris shall be removed from the concrete fill or subbase by vigorous brooming, vacuuming, or other means. The surface must be free of grease, oil, or wax deposits.

4.4 *Screed Strips*—Wood or metal strips shall be used to gage the thickness of the setting bed.

4.5 *Thickness of Setting Bed*—The setting bed shall be 1 to 1½ in. (25 to 38 mm) thick.

4.6 *Wetting Concrete Fill or Subbase*—Several hours before placing the setting bed, the prepared concrete surface shall be thoroughly saturated with clean water. About 1 h before

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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.

placing the topping, all surface water shall be removed with a mop or by other means.

NOTE 1—The procedure described in this paragraph does not apply to floors installed over a cleavage membrane.

4.7 *Expansion Joints*—When required, the expansion joint strips shall be located and set in position. If the expansion joints are not of the preset type, removable strips shall be set so as to keep the joints free of dirt and mortar.

5. Cement Paste Slush Coat

5.1 About 15 min before placing the setting bed, the concrete slab surface shall be given a slush coat of grout. The grout shall consist of either neat cement and water, or cement, sand, and water. The slush coat shall not be spread over such a large area that it will dry out before the setting bed is placed to cover it. The consistency of the slush coat shall be similar to that of thick cream, and its thickness shall not exceed 1⁄16 in. (1.6 mm).

NOTE 2—The procedure described in this section does not apply to floors installed over a cleavage membrane.

6. Materials and Manufacture

6.1 *Portland and Portland Blast-Furnace Slag Cements*—See Specifications C 150 and C 595. No calcium aluminate cement, lime, or admixture shall be mixed with these cements, in the mortar batch or in the mixing water.

6.2 *Calcium Aluminate Cement*—No portland or portland blast-furnace slag cements, lime, or admixture shall be mixed with this cement, in the mortar batch or in the mixing water.

6.3 *Aggregate*—The aggregate shall be in accordance with Specification C 144 or C 404, or both.

6.4 *Brick*—These mortars may be used with masonry units of brick (clay or shale) meeting the requirements of Specification C 279, and with tile masonry units. The brick shall be clean and protected from frost damage. Bricks shall be wetted several hours before laying, unless their gain in weight resulting from partial immersion flatwise in 1⁄8 in. (3 mm) of water for 1 min is less than 3⁄4 oz/30 $in.^2$ (0.11 g/cm^2) of immersed area. There shall be no free water on the bricks when laid.

6.5 *Water*—The mixing water shall be approximately neutral and shall be potable.

6.6 *Metal Reinforcing*—If reinforcing is used, it shall be welded wire fabric 2 by 2 in. (50 by 50 mm), and 16 by 16-gage (0.65 by 0.65-mm), or expanded metal reinforcing not less than 1.8 lb/yd^2 (1.0 kg/m^2).

6.7 *Expansion Joints*—When required, expansion joint compound or premolded joints shall be as specified.

7. Proportions

7.1 The setting bed shall consist of one bag of cement and 3 ft^3 (0.085 m^3) of sand (Note 3). For ordinary grouting conditions, the grout shall contain one bag of cement and 2 ft^3 (0.057 m^3) of sand (Note 3); but for thin joints where a finer sand is used the mix shall consist of one bag of cement and not more than 1 ft^3 (0.028 m^3) of fine sand.

NOTE 3—Measurements of aggregate shall be in the damp, loose condition.

7.2 The water proportions may be determined as follows: For setting beds, only enough water shall be used to produce a moist surface after the setting bed has been placed and ready for the tile or brick. Grouts to be squeegeed into joints shall be of the consistency of heavy cream. Pointing mortars shall be of such consistency that when they are pressed into a vertical joint no slump of the mortar will occur.

8. Mixing and Placing Setting Bed

8.1 All equipment shall be clean and free of other cement, lime, plaster, etc., prior to use. Each batch shall be mixed either mechanically or manually until uniform. The setting bed shall be spread and screeded until the surface is true and even in plane, either level or uniformly sloped for drainage, as specified. As large an area as can be covered with the construction units before the mortar has reached its initial set shall be placed at one operation. When more setting mortar has been placed than can be covered, the unfinished portion shall be cut back to a clean, beveled edge, removed, and discarded. Any metal reinforcement shall be placed approximately in the center of the setting bed.

9. Setting of Construction Units

9.1 A thin layer of neat cement paste 1⁄32 to 1⁄16 in. (0.8 to 1.6 mm) in thickness shall be trowelled or brushed over the setting bed. Neat cement paste 1⁄32 in. thick may also be applied to the bottom of each construction unit. The total thickness of the layer of neat cement between the construction unit, and the setting bed shall not exceed 1⁄16 in. Do not lay setting bed far in advance of setting construction unit, and in no case set them on a dry bed. Set the construction unit, before initial set has taken place. Beat the construction unit into complete and intimate contact with the plastic mortar. Set and level each construction unit immediately. Do not set large areas and then later level the construction units.

10. Grouting Construction Units

10.1 Grouting shall be done as soon as possible after the initial set has taken place in the setting bed. Force the grout or mortar into the joints by troweling or some other suitable methods to ensure a dense, void-free, flush finished joint. Do not let excess mortar or mortar scum dry and set on faces of construction units. As grouting progresses, strike excess mortar from joints and clean the faces of the construction units with clean burlap or sponges.

11. Width of Joints

11.1 Joints shall have a width of from 1⁄4 to 1⁄2 in. (6 to 13 mm), depending on the size of construction unit, in accordance with the manufacturer's recommendations.

12. Curing

12.1 It is essential that hydraulic cement mortar or grout joints be properly cured to ensure maximum retention of the mixing water. Improperly cured joints will result in soft, dusty joints with low physical properties, that is, poor tensile, flexural, and adhesion to the construction units and substrate. Water is the most effective media for curing cementitious-type

joints. Acceptable methods for curing hydraulic cement mortar or grout joints are as follows:

12.1.1 *Ponding Method*—Dikes are set up as required and sufficient water placed into the diked area. A tank or vessel may be filled with water. To prevent thermal stresses, the water should not be more than 20°F (11°C) cooler than the mortar or grout joints.

12.1.2 *Burlap Method*—Cover the surface to be cured with clean burlap or other suitable material and keep wet by fogging with water throughout the curing period. Cover material should be free of sizing or foreign material that could discolor, attack, hasten, or retard the curing process. New burlap, prior to use, should be thoroughly soaked and rinsed in potable water to ensure freedom from contaminants.

12.1.3 *Vapor Barrier Method*—The surface to be cured should be thoroughly wetted with spray or fog nozzles and covered with an impermeable vapor barrier. Acceptable barriers are waterproof paper, polyethylene, and polyvinyl chloride films. In hot, dry atmospheres, periodic flooding of the surface beneath the vapor barrier is required. White pigmented films should be used in hot weather. All sheet materials must conform to standard specifications for sheet materials for curing concrete, in accordance with Specification C 171.

12.1.4 *Curing Compound Method*—Liquid membrane-forming compounds can be used as curing membranes. These materials cure by retaining the water already present in the masonry components; that is, construction units, bed, and joints. Curing compounds must be applied immediately following installation of the construction unit surface in order to prevent loss of moisture due to evaporation. Sequence of application is critical. All curing compounds should conform to the requirements of standard specifications for liquid membrane-forming compounds for curing concrete in accordance with Specification C 309.

NOTE 4—**Caution:** The use of liquid membrane-forming compounds could prevent adhesion of any subsequent surface treatments desired to be applied over the construction unit surface.

12.1.5 Attention to curing ensures high-early strength. With calcium aluminate cement, sufficient curing is attained at the end of 24 h and, with portland and portland blast-furnace slag cements at the end of seven days. The installation may be placed in operation immediately following the cure period.

WALLS, LININGS, CHIMNEYS, ETC.

13. Materials and Manufacture

13.1 *Portland and Portland Blast-Furnace Slag Cements*—See 6.1.

13.2 *Calcium Aluminate Cement*—See 6.2. If additional workability is needed, from 3 to 5 lb (1.5 to 2.5 kg) of plastic fireclay may be added per bag of cement.

13.3 *Aggregates*—See 6.3.

13.4 *Brick*—See 6.4.

13.5 *Water*—See 6.5.

14. Proportions

14.1 The mortar shall consist of 1 bag of cement and not less than 2½ ft^3 (0.07 m^3) nor more than 3½ ft^3 (0.1 m^3) of sand (Note 3). An average mortar is generally considered to consist of one bag of cement and 3 ft^3 (0.085 m^3) of aggregate, measured in the damp, loose condition. Only enough water shall be used to produce a moist surface prior to laying the brick.

15. Mixing Mortar and Laying Construction Units

15.1 All equipment shall be clean and free of other cement, lime, plaster, etc., prior to use. Each batch shall be mixed either mechanically or manually until uniform. The amount of mortar mixed at one time shall not exceed the amount that the mason can use within a period of 30 min. In most cases, the mortar joints should have a width of ⅜ in. (9 mm).

15.2 Mortar shall be plastic, smooth, and workable. Periodic remixing of the mortar during use may be necessary to minimize stiffening.

15.3 All bed and head joints shall be completely filled with mortar. Bed joints are satisfactorily filled by spreading a thick bed of mortar and making a shallow furrow. Filling head joints shall be done by placing a heavy buttering of mortar on the end of the construction unit, pressing it down into the bed joint and pushing it into place so that the mortar squeezes out from the top and sides of the head joint. Mortar shall correspondingly cover the side of the construction unit, before placing as a header. The excess mortar squeezed from the joints shall be struck even with the wall and tooled at the proper time to produce a smooth concave joint. The construction units shall not be moved after initial contact with the mortar. If out of line, remove the construction unit and relay.

15.4 It is customary to lay the construction units 1½ to 2 in. (37 to 50 mm) away from the structural substrate or wall. Spacing is maintained by the use of spacer blocks. After joints have set, the space between the structural wall and construction unit lining is filled with a poured grout backing (Grout ratio is one part portland cement to two parts mortar sand, and is the consistency of a thick soupy mix). The grout backing is not poured behind more than two or three construction unit courses at any one time. The pour is terminated at ½ the height of the last course. The cold joint between successive grout pours should not coincide with the bed joint of any given course.

15.5 *Construction Units Laid Solid in PC Mortar*—All bed, head and backing joints shall be filled completely with mortar. A thick layer of mortar is spread as the bed joint and a shallow furrow formed by dragging the point of the trowel through the mortar. The substrate or wall is covered with a thick trowel coat of mortar. The construction unit is then evenly buttered on all sides that are to be bonded to the construction unit previously laid and the structural substrate. The construction unit is then placed into position by forcing the construction unit into the trowel coat of mortar on the substrate and bed joint approximately 1 in. (25 mm) away from the head joint. Press the construction unit firmly against the backing joint and slide the construction unit into position so that mortar is forced from all joints, that is, back, bed, and head. Sliding the construction unit ensures complete mortar coverage of all mortared surfaces. The excess mortar squeezed from the joints shall be cut off even withthe face of the construction unit. Joints can be struck at the proper time to produce smooth, concave joints. Do not

move the construction unit after it has been properly placed into position. If out of line, remove the construction unit and relay.

15.6 When the mean daily temperature is below 40°F (5°C), hydraulic cement mortars and construction unit shall be preheated so that mixing, placing, and setting is done at a temperature of not less than 55°F (13°C). A temperature of 55°F (13°C) shall be maintained for three days throughout the body of the masonry, including all corners, by means of enclosures, insulation, or heating, and the masonry protected from freezing for an additional three days. Flue gases shall not be allowed to come in contact with the masonry and unvented heaters shall not be used.

15.7 When the mean daily temperature is above 40°F (5°C), but when there is a possibility of freezing weather, the masonry shall be sufficiently protected by enclosures, insulation, or heating to prevent freezing for at least 48 h.

15.8 The total curing period of seven days shall be lengthened by one day for each of the seven days that the mean daily temperature is below 50°F (10°C).

15.9 Bricks shall not be set in hydraulic cement mortars at material temperatures above 90°F (32°C). When atmospheric temperatures exceed this limit and material temperatures are 85°F (29°C) or higher, the mortar ingredients and brick shall be cooled before use sufficient to lower their initial temperature by 5 Fahrenheit degrees (3 Celsius degrees) for each 5 Fahrenheit degrees (3 Celsius degrees) or fraction thereof that air temperature exceeds 90°F (32°C). Smaller areas than normal shall be set at a time, and curing should begin as quickly as possible. When there is a wind, windbreaks should be used if possible to prevent excessive evaporation before curing can begin. Artificial shade shall also be used where necessary to protect masonry from direct sunlight.

16. Curing

16.1 See 12.1.

TABLE 1 Chemical Resistance of Mortars[A]

Aqueous Solution	Portland Cement	Portland Blast-Furnace Slag Cement	Calcium Aluminate Cement
Sodium, potassium, calcium, and magnesium sulfates	N[B]	N	G
Other neutral salts	G[C]	G	G
Sodium and potassium hydroxides	G	G	N
Calcium and magnesium hydroxides	G	G	G
Dilute sulfuric acid (pH 4 to 7)	N	N	G
Other dilute acids and acid salts (pH 4 to 7)	N	N	L[D]
Hypochlorite (Na and Ca)	G	G	L

[A] Specific recommendations should be obtained from the manufacturer.
[B] N = not recommended.
[C] G = generally recommended.
[D] L = limited use.

17. Chemical Resistance

17.1 The chemical resistance of these mortars may be determined by Test Method C 267. A general guide for chemical resistance of the following cements when used in aqueous solutions is shown in Table 1 for room temperature service.

18. Keywords

18.1 chemical-resistant brick; hydraulic cement mortars