Designation: C 595M – 97
METRIC

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
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Standard Specification for Blended Hydraulic Cements [Metric][1]

This standard is issued under the fixed designation C 595M; 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.

This specification has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification pertains to five classes of blended hydraulic cements for both general and special applications, using slag or pozzolan, or both, with portland cement or portland cement clinker or slag with lime.

NOTE 1—This specification prescribes ingredients and proportions, with some performance requirements whereas Performance Specification C 1157 is a blended cement specification in which performance criteria alone govern the products and their acceptance.

1.2 For properties where values are given in both SI and non SI units, the values 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 Practice E 380, of measurements made in other units.

1.3 The text of this specification refers to notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) are not requirements of this specification.

2. Referenced Documents

2.1 *ASTM Standards:*

C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[2]
C 114 Test Methods for Chemical Analysis of Hydraulic Cement[2]
C 150 Specification for Portland Cement[2]
C 151 Test Method for Autoclave Expansion of Portland Cement[2]
C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete[3]
C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement[2]
C 185 Test Method for Air Content of Hydraulic Cement Mortar[2]
C 186 Test Method for Heat of Hydration of Hydraulic Cement[2]
C 187 Test Method for Normal Consistency of Hydraulic Cement[2]
C 188 Test Method for Density of Hydraulic Cement[2]
C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle[2]
C 204 Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus[2]
C 219 Terminology Relating to Hydraulic Cement[2]
C 226 Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement[2]
C 227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)[3]
C 265 Test Method for Calcium Sulfate in Hydrated Portland Cement Mortar[2]
C 311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete[3]
C 430 Test Method for Fineness of Hydraulic Cement by the 45-μm (No. 325) Sieve[2]
C 465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements[2]
C 563 Test Method for Optimum SO_3 in Portland Cement[2]
C 688 Specification for Functional Additions for Use in Hydraulic Cements[2]
C 821 Specification for Lime for Use with Pozzolans[2]
C 1012 Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution[2]
C 1157M Performance Specification for Blended Hydraulic Cement[2]
E 380 Practice for Use of the International System of Units (SI) (the Modern Metric System)[4]

3. Terminology

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

4. Classification

4.1 The types of blended cement covered by this specification are as follows and are intended for the uses stated.

4.2 *Portland Blast-Furnace Slag Cement*—One type with three optional provisions is covered as follows:

4.2.1 *Type IS*—Portland blast-furnace slag cement for use in general concrete construction.

4.2.2 Moderate sulfate resistance, air entrainment, or moderate heat of hydration or any combination may be specified by adding the suffixes (MS), (A), or (MH).

4.3 *Portland-Pozzolan Cement*—Two types, each with three optional provisions, are covered, as follows:

[1] This specification is under the jurisdiction of ASTM Committee C-1 on Cement and is the direct responsibility of Subcommittee C01.10 on Hydraulic Cement for General Concrete Construction.

Current edition approved Feb. 10, 1997. Published April 1997. Originally published as C 595 – 67 T. Last previous edition C 595M – 95a[ε1].

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

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

[4] *Annual Book of ASTM Standards*, Vol 14.02.

4.3.1 *Type IP*—Portland-pozzolan cement for use in general concrete construction.

4.3.2 Moderate sulfate resistance, air entrainment, or moderate heat of hydration or any combination may be specified by adding the suffixes (MS), (A), or (MH).

4.3.3 *Type P*—Portland-pozzolan cement for use in concrete construction where high strengths at early ages are not required.

4.3.4 Moderate sulfate resistance, air entrainment, or low heat of hydration or any combination is specified by adding the suffixes (MS), (A), or (LH).

4.4 *Slag Cement*—One type is covered as follows:

4.4.1 *Type S*—Slag cement for use in combination with portland cement in making concrete and in combination with hydrated lime in making masonry mortar.

4.4.2 Air entraining can be specified by adding the suffix (A).

4.5 *Pozzolan-Modified Portland Cement*—One type is covered as follows:

4.5.1 *Type I(PM)*—Pozzolan-modified portland cement for use in general concrete construction.

4.5.2 Moderate sulfate resistance, air entraining, or moderate heat of hydration, or any combination may be specified by adding the suffixes (MS), (A), or (MH).

NOTE 2—Pozzolan-modified portland cement should not be used when special characteristics attributable to the larger quantities of pozzolan in portland-pozzolan cement are desired.

4.6 *Slag-Modified Portland Cement*—One type is covered as follows:

4.6.1 *Type I(SM)*—Slag-modified portland cement for use in general concrete construction.

4.6.2 Moderate sulfate resistance, air entraining, or moderate heat of hydration, or any combination, may be specified by adding the suffixes (MS), (A), or (MH).

NOTE 3—Slag-modified portland cement should not be used when special characteristics attributable to the larger quantities of slag in portland blast-furnace slag cements are desired.

NOTE 4—A given mass of blended cement has a larger absolute volume than the same mass of portland cement. This should be taken into consideration in purchasing cements and in proportioning concrete mixtures.

5. Ordering Information

5.1 Orders for material under this specification shall include the following:

5.1.1 Specification number,

5.1.2 Type or types required,

5.1.3 Optional special properties required (see Note 2):

5.1.3.1 MS if moderate sulfate resistance is required;

5.1.3.2 MH if moderate heat of hydration is required;

5.1.3.3 LH if low heat of hydration is required, (Type P only);

5.1.3.4 A if air entraining is required;

5.1.3.5 Accelerating addition, if required;

5.1.3.6 Retarding addition, if required;

5.1.3.7 Water reducing addition, if required;

5.1.3.8 Water reducing and accelerating addition, if required; and

5.1.3.9 Water reducing and retarding addition, if required.

5.1.4 Certification, if desired (see Section 14).

NOTE 5—It is important to check for availability of various options. Some multiple options are mutually incompatible or unattainable.

6. Materials and Manufacture

6.1 *Portland Blast-Furnace Slag Cement*—The portland blast-furnace slag cement shall consist of an intimate and uniform blend (see Note 6) of portland cement and fine granulated blast-furnace slag produced either by intergrinding portland cement clinker and granulated blast-furnace slag, or by blending portland cement and finely ground granulated blast-furnace slag, or a combination of intergrinding and blending, in which the slag constituent is between 25 and 70 % of the mass of portland blast-furnace slag cement.

NOTE 6—The attainment of an intimate and uniform blend of two or more types of fine materials is difficult. Consequently, adequate equipment and controls must be provided by the manufacturer. The purchaser should assure himself of the adequacy of the blending operation.

6.2 *Air-Entraining Portland Blast-Furnace Slag Cement*—Air-entraining portland blast-furnace slag cement shall be portland blast-furnace slag cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.3 *Slag-Modified Portland Cement*—Slag-modified portland cement shall be an intimate and uniform blend of portland cement and granulated blast-furnace slag produced either by intergrinding portland cement clinker and granulated blast-furnace slag (see Note 6), by blending portland cement and finely ground granulated blast-furnace slag, or a combination of intergrinding and blending in which the slag constituent is less than 25 % of the mass of the slag-modified portland cement.

6.4 *Air-Entraining Slag-Modified Portland Cement*—Air-entraining slag-modified portland cement shall be slag-modified portland cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.5 *Blast-Furnace Slag*—Blast-Furnace slag shall be the nonmetallic product, consisting essentially of silicates and aluminosilicates of calcium and other bases, that is developed in a molten condition simultaneously with iron in a blast furnace.

6.6 *Granulated Blast-Furnace Slag*—Granulated blast-furnace slag shall be the glassy granular material formed when molten blast-furnace slag is rapidly chilled, as by immersion in water.

6.7 *Portland Cement*—See Terminology C 219. For purposes of this specification, portland cement meeting the requirements of Specification C 150 is suitable. Portland cement or other hydraulic materials, or both, containing high free lime may be used as long as the autoclave test limits for the blended cement are met.

6.8 *Portland Cement Clinker*—Portland cement clinker shall be partially fused clinker consisting primarily of hydraulic calcium silicates.

6.9 *Portland-Pozzolan Cement*—Portland-pozzolan cement shall be a hydraulic cement consisting of an intimate and uniform blend (see Note 6) of portland or portland blast-furnace slag cement and fine pozzolan produced either by

intergrinding portland cement clinker and pozzolan, by blending portland cement or portland blast-furnace slag cement and finely divided pozzolan, or a combination of intergrinding and blending, in which the pozzolan constituent is between 15 and 40 mass % of the portland-pozzolan cement.

6.10 *Air-Entraining Portland-Pozzolan Cement*—Air-entraining portland-pozzolan cement shall be portland-pozzolan cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.11 *Pozzolan-Modified Portland Cement*—Pozzolan-modified portland cement shall be an intimate and uniform blend (see Note 6) of portland cement or portland blast-furnace slag cement and fine pozzolan produced either by intergrinding portland cement clinker and pozzolan, by blending portland cement or portland blast-furnace slag cement and finely divided pozzolan, or a combination of intergrinding and blending, in which the pozzolan constituent is less than 15 mass % of the pozzolan-modified portland cement.

6.12 *Air-Entraining Pozzolan-Modified Portland Cement*—Air-entraining pozzolan-modified portland cement shall be pozzolan-modified portland cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.13 *Pozzolan*—Pozzolan shall be a siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value but which will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

6.14 *Slag Cement*—Slag cement shall be hydraulic cement consisting mostly of an intimate and uniform blend (see Note 6) of granulated blast-furnace slag and portland cement, or hydrated lime, or both, in which the slag constituent is at least 70 % of the mass of the slag cement.

6.15 *Air-Entraining Slag Cement*—Air-entraining slag cement shall be slag cement to which sufficient air-entraining addition has been added so that the resulting product complies with the air content of mortar requirements.

6.16 *Hydrated Lime*—Hydrated lime used as part of a blended cement shall meet the requirements of Specification C 821, except that when interground in the production process there shall be no minimum fineness requirement.

6.17 *Air-Entraining Addition*—When air-entraining cement is specified, an addition meeting the requirements of Specification C 226 shall be used.

6.18 When processing additions are used in the manufacture of cement, they shall have been shown to meet the requirements of Specification C 465 in the amounts used or greater, (see Section 14.2).

6.19 When functional additions (used at the sole option of the purchaser, and in amounts not to exceed 0.50 % by mass of the cement) are used they shall have been shown to meet the requirements of Specification C 688 when tested with the cement to be used, in the amount used or greater, (see Section 14.2 and Note 7).

NOTE 7—The 0.50 % by mass is an arbitrarily selected value.

6.20 *Other Additions*—The cement covered by this specification shall contain no additions except as provided for above except that water or calcium sulfate (see Terminology C 219), or both, may be added in amounts so that the limits shown in Table 1 for sulfate reported as SO_3 and loss on ignition are not exceeded.

TABLE 1 Chemical Requirements

Cement Type	I(SM), I(SM)-A, IS, IS-A	S,SA	I(PM), I(PM)-A, P, PA, IP, IP-A
Magnesium oxide (MgO), max, %	...	...	6.0
Sulfur reported as sulfate (SO_3), max, %[B]	3.0	4.0	4.0
Sulfide sulfur (S), max, %	2.0	2.0	...
Insoluble residue, max, %	1.0	1.0	...
Loss on ignition, max, %	3.0	4.0	5.0
Water-soluble alkali, max, %	...	0.03[A]	...

[A] Applicable only when the cement is specified to be nonstaining to limestone. The amount and nature of the staining material in limestone vary with the stone. The alkali in any cement may, therefore, induce markedly different staining on different stone, even though the stone may have come apparently from the same source. The amount of alkali permitted by the specification should not cause stain unless stone high in staining material has been used, or unless insufficient means have been used to prevent infiltration of water into the masonry.

[B] When it has been demonstrated by Test Method C 563 that the optimum SO_3 exceeds a value 0.5 % less than the specification limit, an additional amount of SO_3 is permissible provided that, when the cement with the additional calcium sulfate is tested by Test Method C 265, the calcium sulfate in the hydrated mortar at 24 ± ¼ h, expressed as SO_3, does not exceed 0.50 g/L. When the manufacturer supplies cement under this provision, he will, upon request, supply supporting data to the purchaser.

7. Chemical Composition

7.1 Cement of the type specified shall conform to the applicable chemical requirements prescribed in Table 1.

7.2 If the purchaser has requested the manufacturer to state in writing the composition of the blended cement purchased, the composition of the cement furnished shall conform to that shown in the statement within the following tolerances (see Note 8).

	Tolerance, ± %
Silicon dioxide (SiO_2)	3
Aluminum oxide (Al_2O_3)	2
Calcium oxide (CaO)	3

NOTE 8—This means that if the manufacturer's statement of the composition says "SiO_2: 32 %," the cement when analyzed, shall be found to contain between 29 and 35 % SiO_2.

8. Physical Properties

8.1 *Blended Cement*—Blended cement of the type specified shall conform to the applicable physical requirements prescribed in Table 2.

8.2 *Pozzolan or Slag*—Pozzolan or slag that is to be blended with cement shall be tested in the same state of subdivision as that in which it is to be blended. Pozzolan shall conform to the fineness requirement and the pozzolanic activity requirement of Table 3. Slag that is to be used for slag-modified portland cements shall conform to the slag activity requirement of Table 3. Such pozzolan or slag that is to be interground with portland cement clinker shall, before testing for conformance with requirements of Table 3, be ground in the laboratory to a fineness at which it is believed to be present in the finished cement. It is the manufacturer's responsibility to decide on the fineness at which the testing is to be carried out, and when requested to do so by a