



# Standard Specification for Expansive Hydraulic Cement<sup>1</sup>

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## 1. Scope

1.1 This specification covers hydraulic cements that expand during the early hardening period after setting.

## 2. Referenced Documents

### 2.1 ASTM Standards:

- C 33 Specification for Concrete Aggregates<sup>2</sup>
- C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)<sup>3</sup>
- C 114 Test Methods for Chemical Analysis of Hydraulic Cement<sup>3</sup>
- C 183 Practice for Sampling and the Amount of Testing of Hydraulic Cement<sup>3</sup>
- C 185 Test Method for Air Content of Hydraulic Cement Mortar<sup>3</sup>
- C 188 Test Method for Density of Hydraulic Cement<sup>3</sup>
- C 465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements<sup>3</sup>
- C 688 Specification for Functional Additions for Use in Hydraulic Cements<sup>3</sup>
- C 806 Test Method for Restrained Expansion of Expansive Cement Mortar<sup>3</sup>
- C 807 Test Method for Time of Setting of Hydraulic Cement Mortar by Modified Vicat Needle<sup>3</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 *expansive cement (K)*—an expansive cement containing anhydrous calcium aluminosulfate ( $4\text{CaO} \cdot 3\text{Al}_2\text{O}_3 \cdot \text{SO}_3$ ), calcium sulfate, and uncombined calcium oxide.

3.1.2 *expansive cement (M)*—an expansive cement containing calcium aluminate cement and calcium sulfate.

3.1.3 *expansive cement (S)*—an expansive cement containing tricalcium aluminate ( $\text{C}_3\text{A}$ ) and calcium sulfate.

3.1.4 *expansive hydraulic cement*—a cement composed essentially of hydraulic calcium silicates, calcium aluminates and calcium sulfates, which, upon being mixed with water, forms a paste that increases significantly in volume during the early hardening period occurring after setting. This volume increase is due principally to the reaction of the calcium aluminates and calcium sulfates.

3.1.5 *shrinkage-compensating concrete*—a concrete made

with an expansive cement in which the expansion, if restrained, induces compressive stresses that approximately offset tensile stresses induced by drying shrinkage.

## 4. Classification

4.1 The cement covered by this specification is suitable for use in shrinkage-compensating concrete and shall be designated as Type E-1.

NOTE 1—Three kinds of expansive cement are identified in Section 3 by the letters K, M, and S. The appropriate letter should be used as a suffix to the type designation when one of these kinds is desired. Expansive cement may also be prepared in other ways.

## 5. Ordering Information

5.1 When it is desired that an optional requirement apply or that the cement be of a particular kind, a specific request to this effect should be made by the purchaser.

## 6. Chemical Composition

6.1 Expansive cement shall conform to the requirements as to chemical composition prescribed in Table 1.

6.2 The purchaser has the option of specifying that the alkalis ( $\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$ ) shall not exceed 0.60 % (See Table 2).

NOTE 2—This limit should be specified when the cement is to be used in concrete with aggregates that may be reactive. Reference should be made to Specification C 33 for suitable criteria of deleterious reactivity.

## 7. Physical Properties

7.1 Expansive cement shall conform to the physical requirements prescribed in Table 3.

## 8. Additions

8.1 The cement covered by this specification shall contain no additions except as follows:

8.1.1 Water, or a functional addition, or both, that has been shown to meet the requirements of Specification C 688, may be added in amounts such that the limits shown in Table 1 for loss on ignition shall not be exceeded.

8.1.2 At the option of the manufacturer, processing addi-

TABLE 1 Standard Chemical Requirements

	Composition, %
Magnesium oxide (MgO), max	6.0
Insoluble residue, max	1.0
Loss on ignition, max	4.0

TABLE 2 Optional Chemical Requirements

Alkalies ( $\text{Na}_2\text{O} + 0.658 \times \text{K}_2\text{O}$ ) max, %	0.60
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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.01.

**TABLE 3 Physical Requirements**

Time of setting, min, minutes	75
Air content, max, vol %	12.0
<i>Restrained expansion of mortar:</i>	
7-day expansion:	
min, %	0.04
max, %	0.10
28-day, percentage of 7-day expansion, max	115
<i>Compressive strength, min:</i>	
7-day, psi(MPa)	2100(14.7)
28-day, psi(MPa)	3500(24.5)

tions may be used in the manufacture of the cement, provided such materials in the amounts used have been shown to be not harmful in accordance with Specification C 465.

## 9. Test Methods

9.1 The cement shall be sampled and the properties enumerated in this specification shall be determined in accordance with the following methods:

9.1.1 *Sampling*—Practice C 183.

9.1.2 *Chemical Analysis*—Test Methods C 114.

9.1.3 *Time of Setting*—Test Method C 807.

9.1.4 *Air Content*—Test Method C 185, using the actual specific gravity of the cement if it differs from 3.15 by more than 0.05 in calculating the air content.

9.1.5 *Restrained Expansion of Mortar*—Test Method C 806.

9.1.6 *Compressive Strength*—Test Method C 109/C 109M, except that a water-cement ratio of 0.500 shall be used, the specimens shall be covered with a polyethylene sheet or other suitable material for preventing loss or gain of moisture at the surface of the specimens during the moist storage period in the molds, and the specimens shall remain in the molds for 3 days.

9.1.7 *Density*—Test Method C 188.

## 10. Inspection

10.1 Every facility shall be provided the purchaser for careful inspection and sampling of the finished cement. The finished cement may be inspected and sampled either at the mill or at the site of the work, as may be specified by the purchaser. The following periods from time of sampling shall be allowed for completion of testing:

7-day test	12 days
28-day test	33 days

10.2 The manufacturer shall provide suitable facilities to enable the inspector to check the intergrinding or blending operation used to produce cement by either means. The plant facilities for intergrinding or blending and inspection shall be adequate to ensure compliance with the provisions of this specification.

## 11. Rejection

11.1 The cement may be rejected if it fails to meet any of

the requirements of this specification.

11.2 Cement remaining in bulk storage at the mill prior to shipment for a period greater than 6 months or cement in bags in local storage in the hands of a vendor for more than 3 months, after completion of the tests, may be retested for expansion and may be rejected if it fails to conform to the requirements of this specification for expansion.

11.3 Packages more than 2 % below the net weight marked thereon, may be rejected. Also, if the average net weight of packages in any shipment, as shown by weighing 50 packages at random, is less than that marked on the packages, the entire shipment may be rejected.

## 12. Certification

12.1 At the request of the purchaser, the manufacturer shall state in writing the composition of a finished cement.

12.2 The composition of any cement shall conform to that shown in the statement of the manufacturer within the following tolerances:

	Tolerance, ± %
Silicon dioxide (SiO <sub>2</sub> )	3
Aluminum oxide (Al <sub>2</sub> O <sub>3</sub> )	2
Calcium oxide (CaO)	3

12.3 At the request of the purchaser, the manufacturer shall state in writing the nature, amount, and identity of any processing or functional addition that may have been used. Also, if requested, the manufacturer shall supply test data showing compliance of any processing addition with the provisions of Specification C 465, and any functional addition with the provisions of Specification C 688.

12.4 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material during production was tested in accordance with this specification together with a report of the test results shall be furnished at the time of shipment.

## 13. Packaging and Package Marking

13.1 When the cement is delivered in packages, the words "expansive cement," the type, the kind (if the cement is one of the three kinds defined in Section 3), the name and brand of the manufacturer, and the net weight shall be plainly marked on each package. Similar information shall be provided in the shipping documents accompanying the shipment of packaged or bulk cement. All packages shall be in good condition at the time of inspection.

## 14. Storage

14.1 The cement shall be stored in a manner such 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.

## 15. Keywords

15.1 calcium aluminate; calcium aluminosulfate; calcium oxide; calcium silicate; calcium sulfate; cement; expansive; hydraulic; shrinkage-compensated; tricalcium aluminate