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Specification
No. 443

DEPARTMENT OF COMMERCE

BUREAU OF STANDARDS

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UNITED STATES GOVERNMENT MASTER SPECIFICATION FOR CEMENT, MASONRY

FEDERAL SPECIFICATIONS BOARD SPECIFICATION No. 443

This specification was officially promulgated by the Federal Specifications Board on October 28, 1926, for the use of the departments and independent establishments of the Government in the purchase of masonry cement.

[The latest date on which the technical requirements of this specification shall become mandatory for all departments and independent establishments of the Government is January 28, 1927. They may be put into effect, however, at any earlier date after promulgation.]

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26736°—27

I. GENERAL SPECIFICATIONS

There are no general specifications applicable to this specification.

II. TYPE AND GRADE

This specification contains requirements for a material of one type and grade only, to be used in conjunction with sand in the making of mortar for laying units of masonry construction above grade.

III. MATERIALS AND WORKMANSHIP

See Detail requirements.

IV. GENERAL REQUIREMENTS

See Detail requirements.

V. DETAIL REQUIREMENTS

1. PHYSICAL REQUIREMENTS

(*a*) FINENESS.—The residue on a standard No. 200 sieve shall not exceed 20 per cent by weight. Cement shall not be rejected for failure to meet this test if, after drying at 100° C. for one hour and resieving, it meets this requirement.

(*b*) TIME OF SETTING.—The neat cement paste, mixed to normal consistency, shall not develop initial set in less than 45 minutes as determined by the Vicat needle, or 60 minutes as determined by the Gillmore needle. Final set by either method shall be attained within 48 hours.

(*c*) SOUNDNESS.—Pats of neat cement, after being stored for seven days, one pat in laboratory air and one pat in water, shall be firm and hard and show no signs of distortion, cracking, or disintegration under both conditions of storage. Mortar-strength specimens at the time of test shall show no signs of distortion, cracking, or disintegration.

(*d*) STRENGTH.—The average compressive strength in pounds per square inch of not less than three 2-inch cubes, made of mortar composed of 1 part cement and 3 parts sand by weight, shall be not less than 175 at the age of 7 days. The average strength attained at 28 days shall not be less than that attained at 7 days.

2. REJECTION

The cement shall be rejected if it fails to meet any of the requirements of this specification. Cement remaining in storage prior to shipment for a period greater than six months after test shall be retested and shall be rejected if it fails to meet any of the requirements of this specification.

VI. METHODS OF INSPECTION, SAMPLING, AND TEST

1. TEMPERATURE

The standard temperature shall be 70° F. (21° C.). The air of the laboratory, the materials, the mixing water, the moist closet, and storage tanks shall be maintained as near as practicable at this temperature and shall not vary from it more than ±5° F.

2. FACILITIES FOR INSPECTION

Every facility shall be provided by the vendor for the necessary sampling and inspection.

3. STORAGE OF CEMENT

The cement shall be stored in a suitable weather-tight building which will protect it from dampness, and in such manner as to permit safe and easy access for proper inspection and identification of each lot.

4. SAMPLING—NUMBER AND WEIGHT OF SAMPLES

Tests may be made on individual or composite samples, as may be ordered. Each test sample shall weigh at least 5 pounds and shall represent not more than 100 barrels.

5. SHIPMENT OF SAMPLES

Samples shall be shipped and stored in air-tight, moisture-proof containers.

6. TIME FOR TESTS

At least 12 days from the time of sampling shall be allowed for the completion of the 7-day tests, and 33 days shall be allowed for the completion of the 28-day tests.

7. TREATMENT OF SAMPLES PRIOR TO TEST

Samples shall be passed through a United States Standard No. 20 sieve in order to mix the sample thoroughly, break up lumps, and remove foreign materials.

8. PHYSICAL TESTS

(*a*) Determinations of Fineness.—(1) *Apparatus.*—Wire cloth for standard No. 200 sieve shall be woven (not twilled) from brass, bronze, or other suitable wire and mounted on the frame without distortion. The joint between the cloth and frame shall be smoothly filled with solder to prevent the lodging of the cement. The sieve frames shall be circular, approximately 8 inches in diameter and about 2 inches between the top of the frame and the cloth.

The average opening between the adjacent warp and the adjacent shoot wires taken separately shall be 0.0029 inch (0.074 mm) within a tolerance of ±8 per cent. The average diameter of the warp and shoot wires taken separately shall be 0.0021 inches (0.053 mm) within tolerances of −15 to +35 per cent. The maximum opening between adjacent parallel wires shall not exceed the nominal opening by more than 60 per cent.

(2) *Method.*—The test shall be made with 50 g of cement. The sieve shall be thoroughly clean and dry. The cement shall be placed on the No. 200 sieve, with pan and cover attached if desired, and shall be held in one hand in a slightly inclined position so that the sample will be well distributed over the sieve, at the same time gently striking the side about 150 times per minute against the palm of the other hand on the upstroke. The sieve shall be turned every 25 strokes about one-sixth of a revolution in the same direction. The operation shall continue until not more than 0.05 g (0.1 per cent) passes through in one minute of continuous sieving.

The essential points in the sieving operation may be summarized as follows:

1. Rotation of the sieve throughout the process.
2. Guarding against loss of material. Sieve over white paper and always tap the sieve gently.
3. A balance which will give results correct within 5 mg and sufficiently sensitive so that the rest point will be deflected at least two divisions of the scale for an added load of 5 mg.
4. Washers, shot, and slugs should never be used on the sieve.
5. Excessive humidity interferes with good sieving. It tends to decrease the percentage of cement passing the sieve, and, in general, to produce irregular results.

The fineness shall be determined from the weight of the residue on the sieve and shall be expressed as a percentage of the weight of the original sample, applying the sieve correction as determined by sieving tests made in conformity with the standard methods for these tests on a standardized cement which gives a residue of about 20 per cent on the No. 200 sieve.

A plus (+) sieve correction indicates the amount to be added to and a minus (−) sieve correction the amount to be subtracted from the per cent passing the sieve to obtain the true fineness. The per cent passing indicates the amount obtained by subtracting the per cent residue from 100. The corrections are used in reverse order when applied to the residues direct.

If mechanical sieving devices are used the cement shall not be rejected if it meets the fineness requirements when tested by the foregoing hand method.

(*b*) Mixing Cement Pastes and Mortars.—(1) *Method.*—The quantity of dry materials to be mixed at one time shall be 500 g for neat cement mixtures and 1,000 g for mortar mixtures. The proportions of cement or cement and sand shall be stated by weight in grams of the dry materials. The quantity of water shall be expressed in cubic centimeters (1 cc of water = 1 g). The dry materials shall be weighed, placed upon a nonabsorbent surface, thoroughly mixed dry if sand is used, and a crater formed in the center, into which the proper percentage of clean water shall be poured; the material on the outer edge shall be turned into the crater by the aid of a trowel. After an interval of one-half minute for the absorption of the water the operation shall be completed by continuous, vigorous mixing, squeezing and kneading with the hands for one minute. During the mixing and molding the hands shall be covered by rubber gloves.

(*c*) Normal Consistency.—(1) *Apparatus.*—The Vicat apparatus consists of a frame bearing a movable rod weighing 300 g, one end being 1 cm in diameter for a distance of 6 cm, the other having a removable needle 1 mm in diameter, 6 cm long. The rod is reversible, can be held in any desired position by a screw and has between the ends a marker which moves over a scale (graduated to millimeters) attached to the frame. The paste is held in a rigid conical ring, resting on a glass plate about 10 cm square. The ring shall be made of a noncorrodible material and shall have an inside diameter of 7 cm at the base, 6 cm at the top, and a height of 4 cm.

(2) *Method.*—In making the determination 500 g of cement, with a measured quantity of water, shall be kneaded into a paste as described in VI, (8), (*b*) and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained about 6 inches apart; the ball resting in the palm of one hand shall be pressed into the larger end of the ring held in the other hand, completely filling the ring with paste; the excess at the larger end shall then be removed neatly and smoothly by a single movement of the palm of the hand; the ring shall then be placed on its larger end on a glass plate and the excess paste at the smaller end sliced off smoothly at the top of the ring by a single oblique motion of a trowel held at a slight angle with the top of the ring, and the top smoothed, if necessary, with a few light touches of the point of the trowel. During these operations care shall be taken not to compress the paste. The paste confined in the ring, resting on the plate, shall be placed under the rod, the larger end of which shall be brought in contact with the surface of the paste; the scale shall then be read and the rod quickly released. The paste shall be of normal consistency when the rod settles to a point 10 mm below the original surface in one-half minute after being released. The apparatus shall be free from all vibrations during the test. Trial

pastes shall be made with varying percentages of water until the normal consistency is obtained. Each trial shall be made with fresh cement. The amount of water required shall be expressed in percentage by weight of the dry cement.

(*d*) PERCENTAGE OF WATER FOR STANDARD MORTARS.—(1) *Apparatus.*—The flow-table apparatus consists of a rigid frame with a flat circular top, so mounted on a vertical shaft that it can be raised and dropped through a fixed height by means of a rotated cam. The top shall be of noncorrodible metal, 10 inches in diameter, and with the attached shaft shall weigh 9 pounds. The mold shall be of a noncorrodible material, 4 inches in inside diameter at the base, 2¾ inches at the top, and 2 inches high.

(2) *Method.*—In making the determination the mortar shall be mixed in accordance with VI, 8 (*b*), (1), with a measured quantity of water. The table top shall be carefully wiped dry and the flow mold placed at the center and filled with mortar. In filling the mold the mortar shall not be rammed, but gently compacted to insure uniform filling. The mortar shall be smoothed off level with the top of the mold by aid of a trowel and the mold removed. Immediately the table shall be dropped through a height of one-eighth inch 30 times at the rate of 60 drops per minute. The flow is the resulting increase in diameter of the mortar mass, expressed as the percentage of the original diameter.

The mortar shall be of the standard consistency when the flow is 100 to 115. Trial mortars shall be made with varying percentages of water until the standard consistency is obtained. Each trial shall be made with fresh mortar. The quantity of water shall be expressed as a percentage of the weight of the combined dry materials.

(*e*) DETERMINATION OF THE TIME OF SETTING.—The following are alternate methods, either of which may be used as ordered:

(1) *Vicat method.*—A paste of normal consistency shall be molded in the ring, as described in VI, 8, (*c*), (1, 2), and placed under the rod, the needle end of which shall then be carefully brought in contact with the surface of the paste and the rod quickly released. The initial set shall be said to have occurred when the needle ceases to pass a point 5 mm above the glass plate in one-half minute after being released, and the final set when the needle does not sink visibly into the paste. Care shall be taken to keep the needle and plunger clean, as the collection of cement on the sides retards the penetration, while cement on the end may increase the penetration.

(2) *Gillmore method.*—A paste of normal consistency shall be made into a pat about 3 inches in diameter and one-half inch in thickness, with a flat top, on clean flat glass plates about 4 inches square, and shall be kept in moist air. In molding the pat the cement paste shall first be flattened on the glass and the pat then formed by drawing

the trowel from the outer edge toward the center, then flattening the top. The cement shall be considered to have acquired its initial set when the pat will bear, without appreciable identation, the Gillmore needle one-twelfth inch in diameter, loaded to weigh one-fourth pound. The final set has been acquired when the pat will bear, without appreciable identation, the Gillmore needle one twenty-fourth inch in diameter, loaded to weigh 1 pound. In making the test the needles shall be held in a vertical position and applied lightly to the surface of the pat. The needle ends shall be maintained in a clean condition, and shall be flat and at right angles to the axis of the rod.

(3) *Treatment of test specimens.*—The test pieces shall be kept in moist air of the damp closet during the test. The time of setting is affected not only by the percentage and temperature of the water used and the amount of kneading the paste receives, but by the temperature and humidity of the air.

(*f*) DETERMINATION OF SOUNDNESS.—*Method.*—Two pats of cement paste of normal consistency about 3 inches in diameter, one-half inch thick at the center, and tapering to a thin edge, shall be made on clean flat glass plates about 4 inches square and stored in moist air for 24 hours. One of the pats shall then be stored in the air of the laboratory and the other shall be immersed in clean water in storage tanks of noncorrodible material.

Unsoundness is usually manifested by change in volume, which causes distortion, cracking, checking, or disintegration. Pats improperly made or exposed to drying may develop what are known as shrinkage cracks within the first 24 hours. The shrinkage cracks are not an indication of unsoundness. The failure of the pats to remain on the glass or the cracking of the glass to which the pats are attached does not necessarily indicate unsoundness. Should the pat leave the plate, distortion may be detected best with a straightedge applied to the surface which was in contact with the plate, provided the glass plate was flat before test.

(*g*) COMPRESSION TESTS.—(1) *Form of test piece.*—The form of test piece used shall be a 2-inch cube. The molds shall be made of a noncorrodible metal and have sufficient material in the sides to prevent spreading during molding. Molds shall be oiled with a mineral oil before using.

(2) *Molding of test pieces.*—Immediately after mixing in accordance with the methods for mixing cement pastes and mortars, the standard mortar shall be placed in the cube molds which rest on plane nonabsorbent plates. The molds shall be filled heaping full without compacting. Then the mortar shall be gently worked into the molds with the thumbs, using only sufficient effort to insure uniform filling of the molds. Additional mortar shall be heaped above

the molds and smoothed off with a trowel. The molds and plates shall then be turned over upon plane nonabsorbent plates oiled with mineral oil, the first plates removed, and the operation of heaping, thumbing, and smoothing off repeated. No ramming or tamping shall be used, nor any troweling in excess of that required to smooth off the specimen.

(3) *Storage of test pieces.*—Apparatus.—The moist closet may consist of a soapstone, slate, or concrete box, or a wooden box lined with metal. The interior wall surfaces of all closets shall be covered with felt or wicking, kept wet. The bottom of the moist closet shall be covered with water to a depth of at least 2 inches.

Method.—All test pieces, immediately after molding, shall be kept in the molds on plane plates in the moist closet for from 20 to 24 hours in such a manner that the upper surfaces shall be exposed to the moist air. The tubes shall then be removed from the molds and placed in the air of the laboratory for 6 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 the cubes for the 28-day tests shall be immersed in clean water in storage tanks of noncorrodible materials.

(4) *Testing of cubes.*—The tests may be made with any of the various types of machines acceptable to the office purchasing the cement. Those faces of the cube which have been in contact with the sides of the molds when molding shall be placed in contact with the surfaces through which the compression is applied. A spherical-seated bearing block shall be used between the lower face of the cube and the bed of the testing machine. The center of the sphere shall lie in that surface of the bearing block which is in contact with the cube, and the radius of the sphere shall be 1½ inches. The cube shall be carefully centered on the upper plate of the bearing block, and the two shall be slowly rotated as the head of the machine is brought to a bearing on the test piece. Cushioning materials shall not be used.

The load shall be applied uniformly and without shock. The moving head of the testing machine shall travel at the rate of approximately 0.05 inch per minute when the machine is running idle.

The 28-day specimens shall be tested as soon as they are removed from the water.

(5) *Computation of strength.*—The total load indicated by the testing machine at failure of the test piece shall be recorded and the unit compressive strength calculated in pounds per square inch of the cross-sectional area of the cube.

Cubes that are manifestly faulty, or which give strengths differing by more than 15 per cent from the average value of all test pieces

made from the same sample and tested at the same period, shall not be considered in determining the compressive strength.

(6) *Standard sand.*—The sand to be used shall be natural sand from Ottawa, Ill., screened to pass a No. 20 sieve and be retained on a No. 30 sieve. This sand may be obtained from Ottawa Silica Co., Ottawa, Ill.

This sand, having passed the No. 20 sieve, shall be considered standard when not more than 5 per cent passes the No. 30 sieve after one minute continuous sieving of a 100 g sample.

The sieves shall conform to the same requirements as for the No. 200 sieves, except that the average openings and wire diameters shall be as follows, in accordance with "Standard specifications for sieves," Bureau of Standards Letter Circular 74, April 15, 1924.

Sieve No.	Sieve opening	Wire diameter	Tolerance in average opening	Tolerance in wire diameter	Tolerance in maximum opening
	Inches	*Inches*	*Per cent*	*Per cent*	*Per cent*
20	0.0331	0.0165	±5	−15 to +30	25
30	.0232	.0130	±5	−15 to +30	25

VII. PACKING AND MARKING

The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer and the net weight plainly marked thereon. All packages shall be in good condition at the time of inspection.

Packages varying more than 5 per cent from the marked weight may be rejected; and if the average weight of packages in any shipment as shown by weighing 50 packages taken at random is less than that marked the entire lot represented shall be rejected.

VIII. NOTES

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