

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
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UNITED STATES GOVERNMENT MASTER SPECIFICATION FOR
CEMENT, PLASTIC MAGNESIA (MAGNESIA-OXYCHLORIDE)
USED AS FLOORING, BASES, WAINSCOTS, ETC.

FEDERAL SPECIFICATIONS BOARD SPECIFICATION No. 445

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 plastic magnesia cement (magnesia-oxychloride) used as flooring, bases, wainscots, etc.

[The latest date on which the technical requirements of the 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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I. GENERAL SPECIFICATIONS

There are no general specifications applicable to this specification.

II. TYPE

Plastic magnesia cement is used largely for making the so-called resilient types of flooring. The quality depends upon the proportion of the various aggregates and cement. Hence, as a floor of a certain quality may be desired it is not essential that the plastic magnesia cement should be made according to any required formula, but the manufacturer is allowed to use any combination of ingredients that will give the specified physical properties.

III. MATERIAL AND WORKMANSHIP

Plastic magnesia cement is a dry intimate mixture composed of calcined caustic magnesia, fibrous materials, finely ground inert fillers, and colors (if desired) which on gauging with a solution of magnesium chloride sets to a resilient product.

IV. GENERAL REQUIREMENTS

1. If the chloride solution fails to meet the requirements for concentration, no further tests shall be made with it nor any tests made with the dry mixture until the concentration has been corrected.

2. The principle of the tests being the determination of the quality of the finished product, the consistency used shall be that given by the vendor furnishing the dry mixture and chloride as that which will be used on the work. Hence, there shall be furnished by the contractor a statement as to the weight of chloride solution which will be used per unit weight of the dry mixture on the work.

V. DETAIL REQUIREMENTS

1. TENSILE STRENGTH

The average tensile strength of not less than three briquettes, when made and stored according to the "Method of tests," shall not be less than:

200 pounds per square inch at the end of 24 hours for the first coat.

300 pounds per square inch at the end of 7 days for the first coat.

250 pounds per square inch at the end of 24 hours for the finish coat.

350 pounds per square inch at the end of 7 days for the finish coat.

2. TRANSVERSE STRENGTH

The average transverse strength of not less than three bars ($\frac{1}{2}$ by 2 by 12 inches) when made, stored, and tested according to the "Method of tests," shall not be less than:

- 400 pounds per square inch at the end of 24 hours for the first coat.
- 700 pounds per square inch at the end of 7 days for the first coat.
- 600 pounds per square inch at the end of 24 hours for the finish coat.
- 900 pounds per square inch at the end of 7 days for the finish coat.

3. EXPANSION

The coefficient of expansion as determined on test pieces, prepared and stored according to the "Method of tests," shall lie within the following limits:

Between final set and 24 hours after final set: -0.10 per cent, $+0.15$ per cent.

Between final set and seven days after final set: -0.10 per cent, $+0.18$ per cent.

Specimens which crack or warp or separate from the scratch coat or concrete base shall be considered as having given results beyond the above limits.

4. TIME OF SET

A pat of the dry material when gauged with a solution of the chloride, as described in the "Methods of tests," shall develop on initial set in not less than one hour and a final set in not more than eight hours when determined by the Gilmore needle.

5. FINENESS

The residue on a standard 100-mesh sieve shall not exceed 30 per cent by weight for the finish coat.

6. SOUNDNESS

A pat of the dry mixture when gauged with the solution of chloride according to the "Method of tests," shall not distort, crack, check, or disintegrate in the steam test for soundness.

7. CHEMICAL LIMITS FOR MAGNESIUM CHLORIDE

The solid chloride or the salts in the liquid chloride shall meet the following requirements:

- MgCl₂, 6H₂O, not less than 97 per cent.
- CaO (as CaCl₂), not more than 2 per cent.
- SO₃ (as MgSO₄), not more than 2 per cent.
- NaCl+KCl, not more than 3 per cent.

The concentration of the solution of chloride shall not be less than 21° Baumé.

VI. METHOD OF INSPECTION AND TESTS

1. INSPECTION AND STORAGE

Such facilities shall be furnished the purchaser for careful inspection and sampling at the mill, or at the site of the work, as may be called for in the contract by the purchaser. The material shall be stored in a suitable weather-tight building which will protect it from dampness, in such manner as to permit of ready inspection and sampling. Sampling must be done within 72 hours after delivery of the materials to the site of the operation.

2. TIME FOR TESTING

Tests shall be completed within 10 days after sampling.

3. SAMPLING

(a) TESTS.—Tests may be made on individual or composite samples as may be required by the contract. Each test sample of the dry mixture shall weigh at least 15 pounds; each test sample of dry chloride shall weigh at least 4 pounds, or, if a solution is used the test sample shall weigh 15 pounds.

(b) INDIVIDUAL SAMPLES.—If the dry mixture is delivered in bags, 1 test sample shall be taken from each 50 bags; if in barrels, 1 from each 10 barrels. If the solid chloride is used, 1 test sample shall be taken from each 5 drums or 15 bags; if a solution is used, 1 test sample shall be taken from each 10 drums.

(c) COMPOSITE SAMPLES.—If the dry mixture is delivered in bags, 1 sample shall be taken from each 10 bags and every 5 samples so taken combined to form 1 composite test sample. If in barrels, 1 sample shall be taken from each 2 barrels and every 5 samples so taken combined to form a composite test sample. If the solid chloride is used, 1 sample shall be taken from each 5 drums or 15 bags and every 3 samples so taken combined to form a composite test sample. If a solution is used, 1 sample shall be taken from each 4 drums and every 3 samples so taken combined to form a composite test sample.

(d) If the shipment represents amounts greater than 500 bags, or 150 barrels, of dry mixture, and greater than 25 drums, or 75 bags, of chloride or 50 drums of solution, it should be divided into two groups. Each group should be sampled and tested as a single shipment. Larger shipments should be divided into groups in the same ratio.

(e) Samples shall be placed, shipped, and kept during test in air-tight containers.

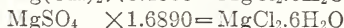
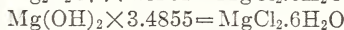
4. ANALYSIS OF COMMERCIAL MAGNESIUM CHLORIDE

(a) PRELIMINARY PROCEDURE.—Place about 10 g of the sample in a weighing bottle, stopper, and weigh accurately. Transfer the sample to a short-stem funnel placed in the neck of a 500 cc graduated flask. Replace stopper in weighing bottle and again weigh accurately to determine the weight of sample used. Dissolve the sample in distilled water (that has been well boiled to free it from carbon dioxide), allowing the solution to run into the flask; wash off funnel and stem and remove. Dilute the solution in the flask to the mark with water, stopper, and mix thoroughly.

(b) TOTAL ALKALINITY (expressed as $\text{Mg}(\text{OH})_2$).—Titrate a 100 cc aliquot of the solution with 0.1 *N* HCl solution (see Reagents), using methyl orange as an indicator. Calculate the total alkalinity to percentage of magnesium hydroxide, $\text{Mg}(\text{OH})_2$. (1 cc 0.1 *N* HCl = 0.002916 g $\text{Mg}(\text{OH})_2$.)

(c) CALCIUM (expressed as CaCl_2).—Transfer a 50 cc aliquot of the original solution to a beaker, add about 50 cc of freshly boiled water, about 5 g of NH_4Cl and a few drops of NH_4OH . Heat the solution to boiling, add slowly with stirring 20 cc of a hot saturated solution of ammonium oxalate, and continue the boiling for five minutes. Let stand from one to two hours. Filter through a 9 cm filter paper, catching the filtrate in a 250 cc graduated flask, and wash the beaker and filter two times with boiling hot water. Set the filtrate aside, place the beaker under the funnel, dissolve the precipitate by pouring about 10 cc of hot HCl (1:4) through the filter, and wash the filter several times with hot water. Add 1 g of NH_4Cl to the solution in the beaker, render just alkaline with NH_4OH , heat to boiling, and add 5 cc of a hot saturated solution of ammonium oxalate. Boil about five minutes, let stand for two hours, and filter through the original paper, catching the filtrate in the flask used in the previous filtration. Wash the beaker and filter with boiling hot water until 10 cc of the washings are not decolorized in two to three minutes after adding 0.5 cc of H_2SO_4 , heating to about 70° C., and adding two drops of 0.1 *N* KMnO_4 solution. Set the filtrate aside, place the beaker in which precipitation was made under the funnel, pierce the apex of the filter paper with a stirring rod and wash the precipitate into the beaker with a jet of hot water; pour 30 cc of warm dilute H_2SO_4 (1:4) through the filter so that the acid comes in contact with all of the paper, and wash the funnel and filter thoroughly with hot water. Dilute to about 250 cc with water, heat to about 90° C., and titrate at once with 0.1 *N* KMnO_4 solution (see Reagents) to a faint pink color not disappearing in two to three minutes (the temperature of the solution should not be below 60° C. when the end point is reached.) Calculate the total calcium to percentage of CaCl_2 (1 cc of *N* KMnO_4 = 0.00555 g CaCl_2 .)

(d) **MAGNESIUM** (expressed as $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$).—Dilute the combined filtrates (from the calcium oxalate precipitations) to the mark with water, stopper, and mix thoroughly. Transfer a 100 cc aliquot of this solution to a beaker, acidify with HCl , add 10 cc of a cold saturated solution of diammonium hydrogen phosphate ($(\text{NH}_4)_2\text{HPO}_4$), boil for five minutes, cool, add NH_4OH drop by drop, with constant stirring, until the solution is alkaline and the crystallin ammonium-magnesium orthophosphate has formed. Then add 5 cc of NH_4OH (sp. gr. 0.90), stir to mix, and let stand in a cool place at least four hours, preferably overnight. Filter on an 11 cm paper and wash four or five times with dilute NH_4OH (1:19). Dissolve the precipitate in a small quantity of hot dilute HCl (1:1), catching the solution in the beaker used for the previous precipitation, wash the paper with hot water, and dilute the solution to about 100 cc with water. Add 1 cc of a cold saturated solution of $(\text{NH}_4)_2\text{HPO}_4$, and NH_4OH drop by drop, with constant stirring, until the precipitate is again formed as described; then add 5 cc of NH_4OH (sp. gr. 0.90), stir to mix, and let stand in a cool place for not less than two hours. Filter on a weighed Gooch crucible, wash with dilute NH_4OH (1:19), ignite gently at first, and finally to constant weight over a Meker burner or blast or in a muffle at a temperature (about $1,000^\circ \text{C}.$) that will not soften or melt the pyrophosphate. Cool and weigh as $\text{Mg}_2\text{P}_2\text{O}_7$. Calculate the $\text{Mg}_2\text{P}_2\text{O}_7$ to percentage of $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$. Then calculate the percentage of $\text{Mg}(\text{OH})_2$ found above to $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ and the percentage of MgSO_4 , as determined below, to $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$. Subtract the sum of these two results from the $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ calculated from the $\text{Mg}_2\text{P}_2\text{O}_7$ and report the difference as the percentage of $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ in sample.



(e) **SULPHATE** (expressed as MgSO_4).—Transfer a 100 cc aliquot of the original solution to a beaker, acidify with HCl and add 1 cc more of this acid, dilute to 250 cc with water, heat to boiling, filter if necessary, add drop by drop from a pipette 10 cc of a hot 10 per cent solution of barium chloride, and continue the boiling until the precipitate is well formed. Let stand on the steam bath for two hours, filter on paper, and wash with hot water until 5 cc of the washings give no test for chloride with 10 per cent AgNO_3 solution. Place the paper and contents in a crucible, heat so that the paper is slowly charred and consumed without flaming, ignite, cool, and weigh the BaSO_4 . Calculate to percentage of MgSO_4 ($\text{BaSO}_4 \times 0.5157 = \text{MgSO}_4$).

(f) **CHLORINE**.—Transfer a 25 cc aliquot of the solution prepared in the preliminary procedure to a 400 cc beaker, acidify with HNO_3 (see Reagents), and then add 5 cc more of this acid. Dilute with

water to about 150 cc and add from a burette or pipette an excess of 0.1 *N* AgNO₃ (see Reagents), noting the volume added (1 g of pure MgCl₂.6H₂O requires about 100 cc of 0.1 *N* AgNO₃); stir thoroughly to coagulate the precipitate, heat until hot to the touch, let settle, filter on a filter paper or on a Büchner funnel, and wash with water until the washings give no test for AgNO₃. To the combined filtrate and washings from the AgCl, add 5 cc of ferric alum indicator. (See Reagents. Upon addition of the ferric indicator no color should develop; if a reddish or yellowish color results, more of the HNO₃ is required to destroy this. The amount of HNO₃ when within reasonable limits does not affect the results.) Now titrate the excess of silver with 0.1 *N* NH₄CNS or KCNS (see Reagents), stirring thoroughly until a permanent reddish-brown color is obtained when viewed against a white background. From the volume of 0.1 *N* AgNO₃ added, subtract the AgNO₃ equivalent of the sulphocyanate used and calculate the result obtained to percentage of chlorine. The percentage of chlorine multiplied by the factor 2.8673 should give a result not smaller than that reported for MgCl₂.6H₂O. A lower result indicates that the sample contains compounds of magnesium other than the sulphate and chloride; a higher result indicates the presence of other chlorides, such as calcium, sodium, or potassium.

(g) SODIUM AND POTASSIUM (expressed as Na₂SO₄+K₂SO₄).—Transfer a 50 cc aliquot of the solution prepared in the preliminary procedure to a beaker, add 50 cc of absolute ethyl alcohol (or sufficient 95 per cent alcohol to give a solution containing 50 per cent by volume of absolute alcohol), and then add 50 cc of the alcoholic solution of ammonium carbonate (see Reagents). Stir for five minutes, allow the mixture to stand at least 20 minutes, filter on asbestos in a Gooch crucible and wash several times with the precipitant (total volume of washings should be about 50 to 60 cc). Evaporate the filtrate to dryness in a weighed platinum dish on the steam bath, drive off the ammonium salts by gentle heating, cool, add about 1 cc of water and 1 cc of dilute H₂SO₄ (1:4); again evaporate to dryness, heat gently at first and finally by means of a free flame to dull redness until fumes of sulphuric anhydride cease to come off; let cool, add about 1 g of solid ammonium carbonate, ignite as before, cool, and weigh. Repeat the ignition with solid ammonium carbonate until a constant weight is obtained. From the weight found calculate the percentage of alkali sulphates (Na₂SO₄+K₂SO₄).

Reagents.—(1) *Tenth normal hydrochloric acid solution.*—To pure concentrated HCl (sp. gr. 1.19) add distilled water until the specific gravity of the solution is about 1.020. Transfer 100 cc of this solution to a graduated liter flask, dilute to the mark with water, and

mix thoroughly. Transfer 100 cc of this latter solution to a beaker, dilute with water to 300 cc, add a few drops of HNO_3 and then (gradually and with constant stirring to coagulate the precipitate) a 5 per cent solution of AgNO_3 , until no further precipitation takes place. Heat the liquid to boiling and set the whole aside (in a dark place) to cool. When completely settled, filter off the AgCl on asbestos in a Gooch crucible (previously weighed), wash thoroughly with water containing a few drops of HNO_3 to the liter and then with a little pure water. Dry first at 100°C . and then at 130 to 150°C ., cool, and weigh. From the weight of AgCl found, calculate the normality of the solution. Instead of the above procedure, the solution may be standardized against standard NaOH or KOH solution that has been standardized against Bureau of Standards benzoic acid.

(2) *Methyl orange solution.*—Dissolve 0.1 g of pure methyl orange in 100 cc of hot water, let cool, and filter off any deposited matter.

(3) *Potassium permanganate solution.*—Dissolve 3.2 g of pure potassium permanganate in a liter of distilled water, let stand 8 to 14 days, siphon off the clear solution (or filter through an asbestos filter), and standardize as follows: In a 400 cc beaker dissolve 0.40 to 0.50 g of Bureau of Standards' sodium oxalate in 250 cc of hot water (80 to 90°C .) and add 15 cc of dilute sulfuric acid (1:1). Titrate at once with the potassium permanganate solution stirring the liquid vigorously and continuously. The permanganate must not be added more rapidly than 10 to 15 cc per minute, and the last 0.5 to 1 cc must be added dropwise with particular care to allow each drop to be fully decolorized before the next is introduced. The solution should not be below 60°C . by the time the end point is reached. (Too rapid cooling may be prevented by allowing the beaker to stand on a small asbestos-covered hot plate during the titration. The use of a small thermometer as a stirring rod is most convenient.) The weight of sodium oxalate used multiplied by 0.8334 gives its iron equivalent. The permanganate solution should be kept in a glass stoppered bottle painted black to keep out light. The Fe value of the KMnO_4 multiplied by 0.995 gives the CaCl_2 value. The weight of sodium oxalate used multiplied by 0.8283 gives its CaCl_2 equivalent.

(4) *Tenth normal silver nitrate solution.*—Dissolve 17.1 g of pure AgNO_3 in distilled water, dilute to 1 liter and mix. Standardize against pure NaCl and adjust to decinormal strength, or calculate the normality and use the solution as it is.

(5) *Tenth normal sulphocyanate solution.*—Dissolve about 8 g of NH_4CNS or 10 g of KCNS in water, dilute to 1 liter, and mix. To standardize, transfer 20 cc of the 0.1 N AgNO_3 solution to a beaker, add 50 cc of water and 2 cc of the ferric alum indicator. Then add

the sulphocyanate solution from a burette, with constant stirring, until a permanent reddish-brown color is obtained. Adjust so that 1 cc of the solution will be equivalent to 1 cc of the AgNO_3 solution; or, record its value in terms of the AgNO_3 solution and use it as it is.

(6) *Pure nitric acid*.—Dilute pure concentrated HNO_3 (sp. gr. 1.42) with water until a solution is obtained containing about 50 per cent of HNO_3 , boil until perfectly colorless, and keep in the dark.

(7) *Ferric alum indicator*.—To a cold, saturated solution of ferric ammonium sulphate add sufficient pure, colorless HNO_2 to cause the disappearance of the brown color.

(8) *Alcoholic solution of ammonium carbonate*.—Mix 18 cc NH_4OH (sp. gr. 0.90), 80 cc of water, and 90 cc of absolute ethyl alcohol (or sufficient 95 per cent alcohol to give a solution containing 50 per cent by volume of absolute alcohol). Shake the solution with powdered ammonium carbonate until saturated, let stand several hours, and filter out the excess of the latter.

5. DENSITY OF SOLUTION

(a) *APPARATUS*.—A picnometer, Westphal balance or hydrometer may be used. As in the great majority of cases a hydrometer will be used, it should conform to the following specifications: Overall length, $8\frac{1}{2}$ inches (variance of one-fourth inch either way permissible); shot bulb, three-fourths inch in diameter; air chamber, $3\frac{9}{16}$ inches long and thirteen-sixteenths inch in diameter; take-up bulb, approximately thirteen-sixteenths inch in diameter.

6. FINENESS

(a) *APPARATUS*.—A United States standard sieve series No. 100 sieve shall be used. In this sieve the wire cloth should conform to the following requirements:

Sieve opening 0.149 mm or 0.0059 inch.

Wire diameter 0.102 mm or 0.0040 inch.

Tolerance in average opening, 6 per cent.

Tolerance in maximum opening, 40 per cent.

Tolerance in wire diameter —15 per cent to +35 per cent.

The sieve frame should be circular, about 20 cm (about 8 inches) in diameter and about 5 cm (about 2 inches) between top of the frame and the cloth.

(b) *METHODS*.—The test shall be made with 50 g of the dry mixture. This shall be placed upon the clean dry sieve pan and cover attached, and held in one hand in a slightly inclined position, so that the sample shall be well distributed over the sieve, and struck about one hundred and fifty times per minute against the palm of the other hand on the up stroke. The sieve shall be turned in the same direction every 25 strokes about one-sixth of a revolution. The operation

shall be continued until not more than 0.05 of a gram passes through in one minute of continuous sieving. The fineness shall be determined from the weight of the residue on the sieve, expressed as a percentage of the weight of the original sample. Mechanical sieving devices may be used, but rejection shall be based only upon the results of hand sieving.

7. CONSISTENCY

The principle of the tests being the determination of the quality of the finished product, the consistency used shall be that given by the vendor furnishing the dry mixture and chloride as that which will be used on the work. Hence there shall be furnished by the con-

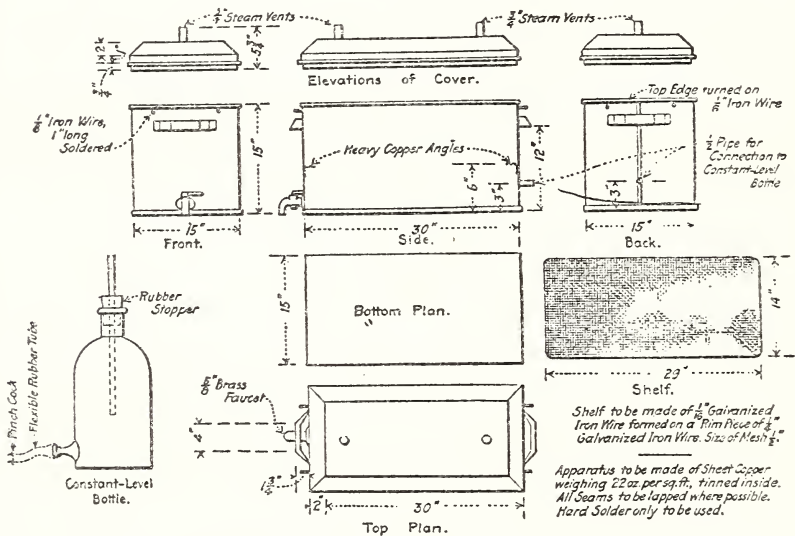


FIG. 1.—Apparatus for making soundness test of cement

tractor a statement as to the weight of chloride solution which will be used per unit weight of the dry mixture on the work. This weight converted and expressed in cubic centimeters per thousand grams of dry mixture shall be used in the testing laboratory throughout all tests.

8. MIXING DRY MIXTURE AND CHLORIDE

The quantity of dry mixture to be mixed with chloride at one time shall not exceed 2,000 g, nor be less than 300 g. The quantity of chloride solution shall be expressed in cubic centimeters. The dry material shall be weighed, placed on a nonabsorbent surface, a crater formed in the center, and the chloride solution added. The outer edge of the dry mixture shall then be turned into the crater with a trowel. After an interval of one-half minute to allow for absorption,

the operation shall be completed by a continuous mixing and kneading with the hands for one minute. During the operation the hands shall be covered with rubber gloves. The air of the laboratory during this and all other tests shall be maintained as near as practicable at 21° C. (70° F.).

9. DETERMINATION OF SOUNDNESS

(a) APPARATUS.—An apparatus similar to that shown in Figure 1, or one which will fulfill the same requirements, is recommended.

(b) METHOD.—A pat of the plastic magnesia cement mixed as above shall be made on a clean glass plate (about 4 inches square) and stored in moist air for 24 hours. The pat shall be about 3 inches in diameter, one-half inch thick at the center and tapering to a thin edge. In molding the pat the plastic magnesia cement shall be first flattened on the glass and the pat formed by drawing the trowel from the outer edge to the center. At the end of 24 hours storage it shall be placed in a loosely covered vessel in an atmosphere of steam at a temperature of not less than 98° C. for about five hours.

10. DETERMINATION OF THE TIME OF SET

(a) APPARATUS.—The time of set shall be determined by the Gilmore needles (see fig. 2).

(b) METHOD.—The pat which has been prepared for the determination of soundness may be used, provided its surface has been flattened for an area of about 1½ inches in diameter. The plastic magnesia cement shall be considered to have acquired its initial set when the pat will bear without any indentation the Gilmore needle one-twelfth inch in diameter, loaded to weigh one-fourth pound. Final set has been acquired when the pat will bear without any indentation the Gilmore needle one-twenty-fourth inch in diameter loaded to weigh 1 pound. Care should be taken to apply the needles in a vertical position on the flattened surface of the pat.

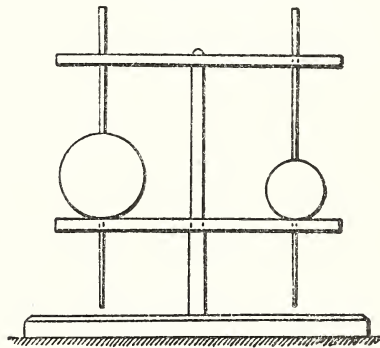


FIG. 2.—Gilmore needles

11. TENSILE STRENGTH

(a) FORM OF TEST PIECE.—The standard form of test piece is that used in testing Portland cement.

(b) MAKING THE TEST PIECE.—Immediately after mixing, as described in Section VI, 8 above, the plastic magnesia cement shall be

placed in the molds, pressed in firmly with the thumbs and smoothed off with the trowel without any ramming. The mold shall then be turned over and placed upon a heavy glass plate and more plastic magnesia cement added, and the operation repeated as before.

(c) STORAGE OF TEST PIECES.—During the first 24 hours the filled molds shall be tightly covered with a glass plate. At the end of this period the specimen shall be removed and stored in the air until broken. During the air storage the specimens shall be so placed that the air may have free access to them.

(d) TESTING.—Tests may be made with any standard briquette machine acceptable to the purchaser of the cement. The bearing surface of the clips of the machine and the briquettes should be free from grains of sand or dirt. The briquettes should be carefully centered and the load applied continuously at the rate of 600 pounds per minute. The testing machines should be frequently calibrated in order to determine their accuracy.

(e) FAULTY BRIQUETTES.—Briquettes that are manifestly faulty, or which give strengths differing more than 15 per cent from the average of test pieces made from the same sample and broken at the same time, shall not be considered in determining the tensile strength.

12. TRANSVERSE STRENGTH

(a) FORM OF TEST PIECE.—Any mold which will permit of making a test piece $\frac{1}{2}$ by 2 by 12 inches is satisfactory. Such a mold is shown in Figure 3.

(b) MAKING THE TEST PIECE.—The plastic magnesia cement after mixing as described in Section VI, 8 should be spread along the length of the mold and worked by the trowel into the corners. Somewhat more than that needed to fill the molds should be used, and the excess struck off by not more than three strokes of the trowel forward and three backward over the full length of the mold. Further troweling should not be done, as excessive troweling materially changes the surface of the test piece.

(c) STORAGE OF TEST PIECE.—The test piece shall be stored in the air of the laboratory for the 24 hours following making and should be removed from the mold at the end of this period and stored on edge supported at two points only. Each test piece should be at least 1 inch from the neighboring test pieces.

(d) TESTING.—A suitable testing machine for this purpose is not yet produced by testing-machine manufacturers. Figure 4 shows a homemade type which can readily be made in any shop and will serve the purpose. Figure 5 shows a more elaborate but far more satisfactory machine.

In testing, the test piece should be supported on roller bearings 10 inches apart. The load shall be applied midway between these

bearings through a knife-edge upon that surface which was lowermost in the mold.

After breaking the test pieces should be carefully measured for thickness to the nearest 0.02 inch. The transverse strength (modulus of rupture) shall be calculated from the formula

$$MR = \frac{3}{2} \frac{WL}{BD^2}$$

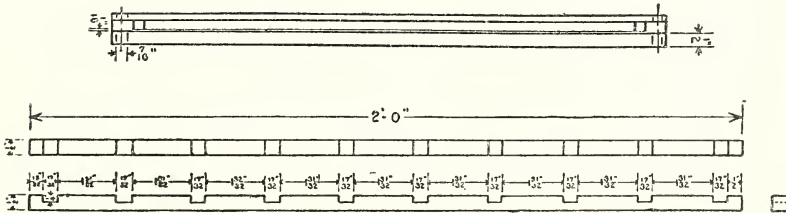
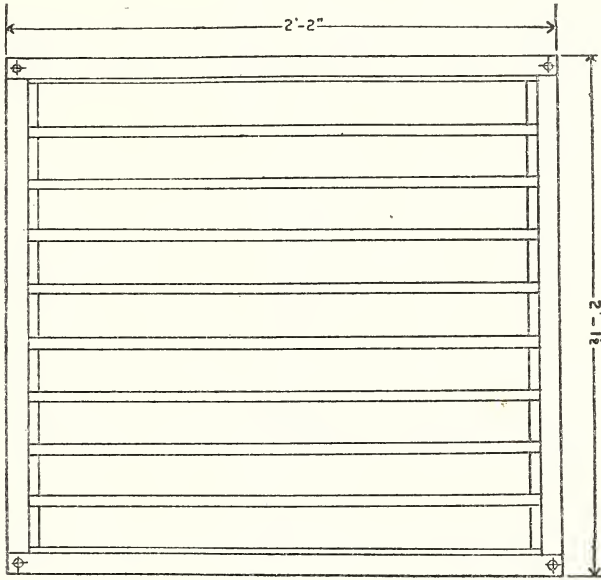


Fig. 3.—Mold for transverse strength test pieces

wherein

- W = the breaking load,
- L = the length between supports = 10 inches,
- B = the width of the bar = 2 inches,
- D = the thickness of the bar, measured to the nearest 0.02 inch.

Hence for a length of 10 inches and a breadth of 2 inches the transverse strength is equal to seven and one-half times the breaking

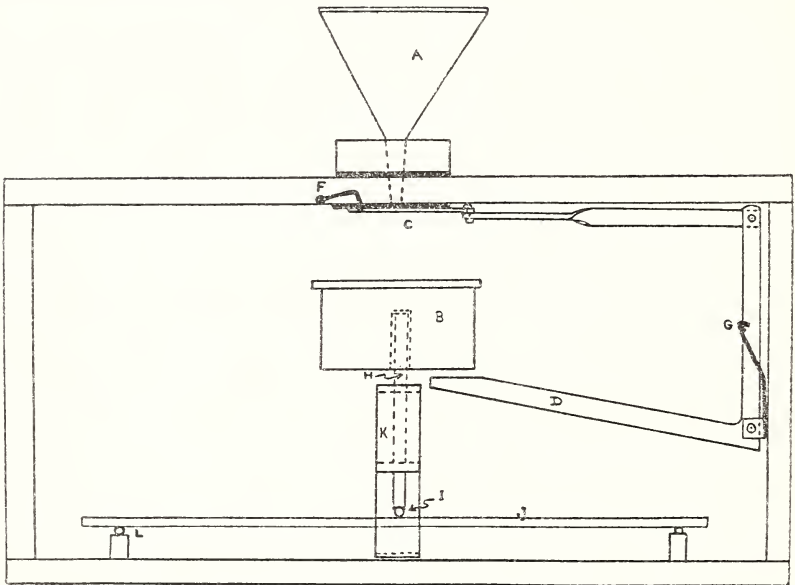


FIG. 4.—A readily made type of transverse testing machine

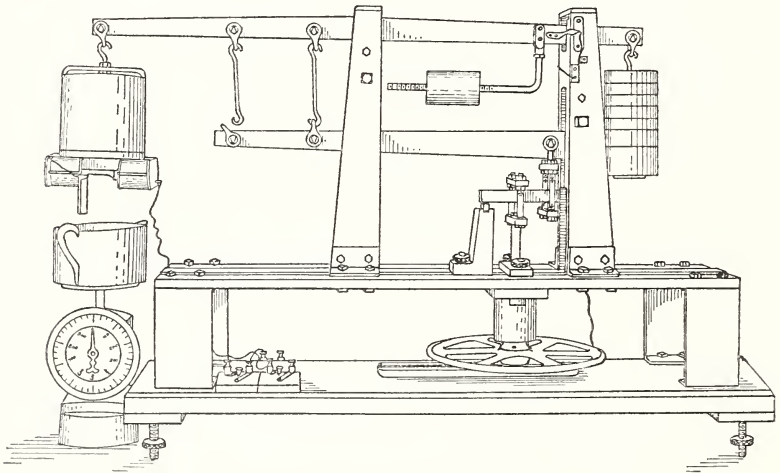


FIG. 5.—Transverse testing machine

load, divided by the square of the thickness. The need of careful measurement of the thickness is hence evident.

13. COEFFICIENT OF EXPANSION

(a) APPARATUS.—Any suitable device for measuring lengths of approximately 10 inches which may be read to 0.001 inch can be used. A suitable type of instrument is the Berry gauge or a similar type as shown in Figure 6.

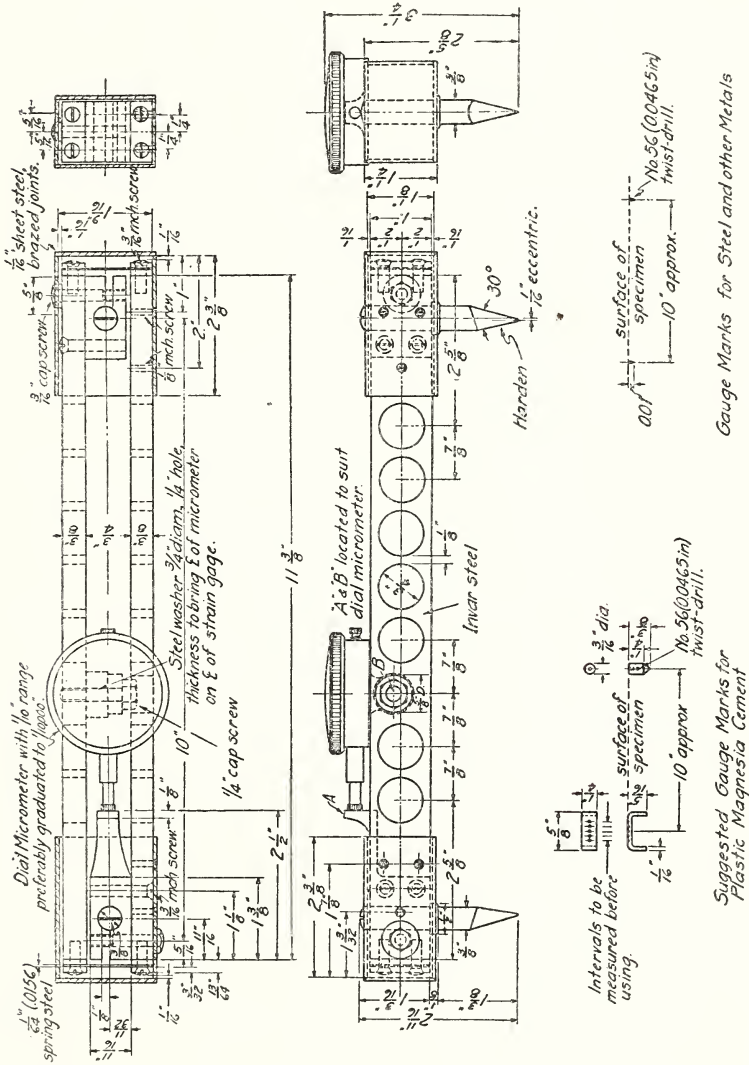


FIG. 6.—An instrument for measuring length change

(b) TEST PIECE.—Plastic magnesia flooring during hardening frequently shows apparently excessive changes in volume. However, it has been noted that the same plastic magnesia cement used in covering old wooden floors or concrete does not show any cracking,

buckling, or noticeable volume changes. Hence the following procedure is given for preparing the test piece for coefficient of expansion:

Bars approximately 1 by 2 by 12 inches should be made of 1:3 Portland cement sand mortar with a roughened top surface, such as may be obtained by brushing before set with a broom. These to permit of easy handling should be reinforced lengthwise, midway between top and bottom, with about three No. 16-gauge iron wires. After storage for two weeks in a damp atmosphere they should be stored in the air for six weeks before use. Upon the rough surface of the bars after such aging should be placed the plastic magnesia cement, using as a binding material a cream of magnesite and chloride. The plastic magnesia cement should be prepared as given in Section VI, 8 and should be applied in a thickness of about one-fourth inch for each coat of two-coat work. The finish coat should be applied to the first coat 24 hours after the first has been applied. If intended for one coat work the plastic magnesia cement should be applied in a thickness of one-half inch. The surface should be smoothed with not more than three forward and three backward passes of the trowel, after which gauge marks of the type suggested in Figure 6 should be placed approximately 10 inches apart.

(c) MAKING MEASUREMENTS.—The initial measurements with the gauge should be made at the time of final set, as determined by the Gilmore needle on the expansion test piece. Several readings should be made on each bar and should check each other to within one-half of the smallest division of the dial. The second measurement should be made at the end of 24 hours and the third at the end of 7 days after the first reading. Before making any measurements the length of the standard bar furnished with the instrument should be determined. The difference between the dial reading for the plastic magnesia cement bar and that for the standard bar represents the amount the former is longer or shorter (depending upon whether the difference is positive or negative) than 10 inches.

VII. PACKING AND MARKING

The dry mixture shall be delivered in suitable containers with brand or manufacturer's name plainly marked thereon. The chloride, if in the solid form, may be delivered in original containers. If delivered in the liquid form it should be in such containers as can be readily delivered without spilling, and permit of sealing after sampling and during the testing.

VIII. NOTES