HIGHWAY RESEARCH BOARD
DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH
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Wartime Road Problems

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No. 1

CURING CONCRETE PAVEMENTS
UNDER WARTIME RESTRICTIONS ON CRITICAL MATERIALS

HIGHWAY RESEARCH BOARD
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Wartime Road Problems

There are two major wartime road responsibilities; to keep the traffic essential to the war effort moving, and to bring the existing roads through the war period in as good condition as possible. Discharge of these responsibilities entails consideration of many new factors in view of the limitations on time, money, labor, equipment and use of critical materials imposed by the exigencies of the national situation. Obviously changing emphasis from devising better and more economical methods to a program within the wartime limitations of moving the wartime traffic and conserving the existing roads confronts highway engineers with many new problems and new aspects of old problems.

The Highway Research Board believes that it can be helpful by aiding in disseminating in usable form the best available information on those phases of highway technology in which common practice has not become established or in which practice must be modified during the war. To this end a series of bulletins on WARTIME ROAD PROBLEMS will be prepared by qualified committees and published by the Highway Research Board. Recommendations in these bulletins are based upon wartime restrictions and needs and are only intended for use as guides during the periods in which these conditions prevail.

This program has been endorsed by the Executive Committee of the American Association of State Highway Officials.

Suggestions for suitable subjects will be welcomed.

CURING OF CONCRETE PAVEMENTS

Need for Curing

Curing is one of the important steps in the manufacture of concrete. Even if properly designed and placed, concrete can develop its potential strength and durability only if kept under favorable temperature and moisture conditions.

Curing Practice

Methods to assure the proper curing of concrete may be divided into two general groups:

(a) Those which supply needed water throughout the hydration process and tend to maintain a uniform temperature. The methods frequently used that supply water during the hydration process are: ponding; sprinkling; spraying; application of wet burlap or cotton mats; wet earth, sand, sawdust, hay or straw.

(b) Those which only prevent loss of water with but little, if any, influence upon temperature (dark colored films tend to increase temperature variations). Curing processes that prevent loss of water consist of the application of waterproof paper or impermeable membranes.

Frequently a curing process is used that combines these two procedures; an initial curing period during which water is applied followed by application of paper or a sealing film.

Wartime Conditions

Burlap is not now available for use in curing portland cement concrete. Cotton mats and waterproof paper may still be used for this purpose although they are in the critical material class and subject to restrictions which may make them unavailable in some localities or altogether.

Bituminous materials are now not generally available in the Eastern and Central regions, and their use may be further restricted.

Other materials used in curing, including membrane curing compounds, calcium chloride and sodium silicate are obtainable.

The methods of curing available to greater or less extent under the wartime conditions and that are sanctioned by current practice are as follows:

Wet cotton mat coverings for entire curing period.

Initial wet cotton mat coverings followed by application of continuous sprinkling; ponding; coverings of wet earth, sand, sawdust, straw or hay; waterproof paper; membrane seal coats; or calcium chloride.

Seal coats of membrane compounds or waterproof paper.

Also, in lieu of initial wet coverings or seal coats the conditions of good curing may be met by keeping the surface wet by means of a fine spray of water. This method has been used but the work must be done in such a way that the surface will not be injured and will not have a chance to dry between applications. This necessitates that the spray be very fine, little more than a mist.

The methods described in the following recommended practice for curing concrete are offered as those from which selection may be made during the war emergency depending upon local conditions, the availability of particular materials and the judgment of the engineer. It is not intended to imply that all of the methods are of equal value under all conditions.

RECOMMENDED PRACTICE FOR CURING PORTLAND CEMENT CONCRETE PAVEMENT UNDER WARTIME RESTRICTIONS ON CRITICAL MATERIALS

(Also suitable for floors, walks and other like slabs)

SCOPE

1. This recommended practice covers materials and methods for curing portland cement concrete pavements through the application of wet coverings, initial water spray, liquid membrane seal coats, or waterproof paper.

MATERIALS

2. *Cotton Mats* shall conform to the requirements of the American Association of State Highway Officials "Standard Specification for Cotton Mats for Curing Concrete Pavements", designation M – 73 – 38 except that other suitable fabrics than osnaburg may be used as coverings for the mats. (See Appendix 1.)

3. *Liquid Membrane Seal Coats* shall conform to the requirements of the specification in Appendix 2.

4. *Waterproof paper* shall comply with the requirements of the American Society for Testing Materials "Tentative Specification for Waterproof Paper for Curing Concrete", designation C 171 – 42 T. (See Appendix 3.)

5. *Calcium Chloride* shall conform to the requirements of the American Society for Testing Materials "Standard Specification for Calcium Chloride," designation D 98 – 34. (See Appendix 4.)

6. *Sodium Silicate* shall conform to the requirements of the American Society for Testing Materials "Standard Specifications for Sodium Silicate for Curing Concrete", designation C 111 – 36. (See Appendix 5.) The solution of sodium silicate and water for curing concrete pavement shall pass the test for moisture retention of "Liquid Membrane Seal Coat Material" of Appendix 2(a) and Appendix 6.

PROCEDURE

7. The engineer shall select one of the following described methods; wet coverings, membrane seal coats or waterproof paper.

Wet Coverings

8. (a) INITIAL CURING.

(a-1) *Cotton Mats.* After the final finishing operation and as soon as it is possible to do so without marring the surface the concrete shall be covered with a cotton mat.[1] During the application the cotton mat shall not be dragged over the concrete nor over mats already spread. This covering shall remain in place for not less than 6 hr. or not less than 16 hr. depending upon the type of subsequent curing as specified under 8(b) and shall be kept wet by means of a water spray fine enough that it will not damage the concrete surface.

(a-2) *Water Spray.* If cotton mats or other suitable wet coverings[1] are not available, after the final finishing operation and immediately after the free water has disappeared the surface of the concrete shall be kept wet continuously for not less than 6 hr. or not less than 16 hr. depending

[1] Burlap or other approved mats if available should be used according to this procedure. If reclaimed fabrics are used care should be taken to make sure that no materials having a deleterious effect on concrete such as sugar, molasses or wool fat are present.

upon the type of subsequent curing as specified in 8(b), by means of a water spray of such fineness and so applied that the surface will not be marred.

(b) SUBSEQUENT CURING. Following the initial period of protection with cotton mats or water spray the concrete shall be further cured by one of the following subsequent curing procedures to be approved by the engineer.

(b-1) *Cotton Mats.* The cotton mats shall be left in place and kept continuously wet after 6 hr. of initial curing until 72 hr. has elapsed since the final finishing of the concrete surface.

(b-2) *Sprinkling.* After 6 hr. of initial curing the concrete shall be kept continuously wet by sprinkling during daylight until 72 hr. has elapsed since the final finishing of the concrete surface.

(b-3) *Ponding.* After 6 hr. of initial curing the surface of the concrete shall be kept wet by ponding until 72 hr. have elapsed since the final finishing of the concrete surface.

(b-4) *Wet Earth, Sand or Sawdust.* After 6 hr. of initial curing the surface of the concrete shall be protected by not less than 1 in. of thoroughly wet earth, sand or sawdust until 72 hr. have elapsed since the final finishing of the concrete surface. The earth shall be free from large lumps.

(b-5) *Wet Straw or Hay.* After 6 hr. of initial curing a 6-in. layer of thoroughly wet straw, hay or similar material shall be placed on the surface of the concrete and kept thoroughly wet until 72 hr. have elapsed since the final finishing of the concrete surface.

(b-6) *Waterproof paper.* After 6 hr. of initial curing the surface shall be thoroughly wetted after which waterproof paper shall be applied and left in place until 72 hr. have elapsed since the final finishing of the concrete surface.

(b-7) *Non-bituminous Seal Coats.* After 6 hr. of initial curing a non-bituminous membrane seal coat shall be applied as provided in Section 9.

(b-8) *Sodium Silicate.* After 6 hr. of initial curing a sodium silicate solution shall be applied as provided in Section 9.

(b-9) *Bituminous Seal Coats.* After 16 hr. of initial curing a bituminous seal coat shall be applied as provided in Section 9.

(b-10) *Surface Application of Calcium Chloride.* After 16 hr. of initial curing the surface shall be thoroughly wetted after which 1.5 lb. of calcium chloride shall be applied uniformly to each square yard of surface.

(b-11) *Curing Concrete with Calcium Chloride Admixture.* If curing by the addition of calcium chloride to the concrete mix in accordance with the following procedure to accelerate the hardening of the concrete has been approved by the engineer, no further curing process will be required after 16 hr. of initial curing. Calcium chloride shall be added to the concrete mixture either dry or in solution as follows:

At temperatures below 80°F., 2 lb. per bag of cement.

At temperatures 80°F. to 90°F., 1.5 lb. per bag of cement.

At temperatures above 90°F., 1.0 lb. per bag of cement.

When used dry calcium chloride shall be placed in the skip of the concrete mixer with the aggregates but not in contact with the cement.

Calcium chloride solution shall be introduced into the drum of the mixer with the mixing water. The solution shall replace an equal volume of mixing water.

(CAUTION: Concrete containing calcium chloride hardens more rapidly than plain concrete.)

Membrane Seal Coats

9. If procedure under *Wet Coverings*, Section 8 is not practicable, bituminous and non-bituminous membrane seal coats are generally available for use in accordance with the following procedure.

(a) *Method.* Immediately after the free water has disappeared all exposed surfaces of the concrete shall be sealed by spraying thereon as a fine mist a uniform application of the curing material in such manner as to provide a continuous, uniform, water-impermeable film without marring the surface.

(b) *Number of Coats.* The material shall be applied in one or two separate coats as may be required for compliance with the requirement of the test for water retention, Appendices 2(a) and 6.

(c) *Rate of Application.* The rate of application shall be not less than .... nor more than .... gal. per sq. yd.

NOTE: Fill in rate of application as used on samples complying with the requirements of the test for water retention, Appendices 2(a) and 6.

Waterproof Paper

10. (a) Immediately after the final finishing operation the concrete shall be entirely covered with units of waterproof paper in such a manner that the surface will not be marred. The paper shall be lapped at least 18 in. and shall be placed and held in intimate contact with the surface covered.

(b) The waterproof paper shall remain in place for 72 hr.

Edge Protection of Pavement Slabs

11. As soon as the forms are taken up the edges shall be cured as provided for the surface or the trench left by their removal shall be filled with earth which shall be kept thoroughly wet until the end of the curing period.

AUTHORIZED REPRINT

APPENDIX 1.

Standard Specification for

COTTON MATS FOR CURING CONCRETE PAVEMENTS

American Association of State Highway Officials,
Specification M-73-38

A. Material Covered

1. These specifications cover cotton mats to be used for curing portland cement concrete pavements and bases.

B. General Requirements

2. The mats shall consist of a filling material of cotton "bat" or "bats" covered with cotton cloth and tufted or stitched to maintain the shape and stability of the unit under job conditions of handling.

C. Physical Properties

3. (a) The cotton cloth covering shall weigh not less than 6.3 ounces per square yard and shall be of the type known in the trade as "osnaburg," or the regular commercial standard with an average of 32 threads in warp and 28 threads

in filling, having a minimum average breaking strength (grab method) of 60 pounds in the warp and of 60 pounds in the filling. The weight of the osnaburg covering cloth shall not fall below the specified weight by more than 5 per cent.

(b) The raw material used in the manufacture of the cotton cloth shall be raw cotton, cotton comber waste, cotton card strip waste, or combinations thereof. The other physical characteristics of the cloth shall be equal to those in such material for industrial purposes.

4. The filling material for the mats shall be a cotton bat, or bats, made of raw cotton, cotton waste, cotton linters, or combination thereof, and shall weigh not less than 12 ounces per square yard. The batting used shall not be lower in quality than a batting made of U. S. Standard Grade No. 3 Linters.

5. (a) The cotton thread for tufting shall be not less than 4-cord No. 12s.

(b) The thread used for all sewing or stitching shall be at least equivalent in size and strength to standard 3-cord No. 30 cotton thread.

D. Dimensions

6. (a) Mats shall have a filler 5 feet 9 inches in width and shall have a flap 6 inches or more in width, consisting of an extension of two thicknesses of the covering material, extending along one longitudinal edge of the mat. The length of the mats shall be 2 feet 6 inches greater than the width of pavement slab to be cured.

(b) The length or width of the mats shall not be less than that specified by more than 2 per cent.

E. Construction of Mats

7. The covering material for each surface of the mat shall consist of two widths of cloth joined by a lapped seam or by a seam formed by superimposing the two widths and uniting them by one row of stitches. If the seam is of the latter type, the edges shall be on the inside of the finished mat. The cotton filling material in the form of a bat or bats shall be held in place between the coverings by sewing or tufting all around the periphery of the mat within 1 inch of each of the four edges of the filler, and by sewing or quilting longitudinally at intervals not greater than 4 inches, or by tufting at intervals, both longitudinally and transversely, not greater than 3 inches. The sewing or tufting shall be sufficiently loose to permit substantially all of the surface of the mat to come in contact with a flat surface when in use, but not so loose as to permit the filling material to shift. The flap shall be constructed by sewing the upper and lower coverings together longitudinally within 1 inch of the outer edge of the flap. Along the edge of the mat opposite the flap, the filling material shall be within 1 inch of the edges of the covering material, and the covering material shall be sewn together so as to enclose the filling material. The ends of the mats shall be finished by running an additional seam (i.e., a seam in addition to the seam holding the filling material in place) across the mats. This seam shall not be closer to the seam holding the filling material in place than $\frac{1}{4}$ inch and not closer to the end of either covering than $\frac{1}{2}$ inch, unless the ends of the mat are finished with an overlying or whip stitch or in a manner which will not leave a raw edge. All longitudinal sewing or quilting shall average at least three stitches per inch and shall have not less than five stitches in any 2 inches. All other sewing shall average six stitches per inch and shall have not less than nine stitches in any 2 inches.

F. Packing

8. Mats shall be rolled or packaged in such manner as to insure their acceptance by a common or other carrier for safe transportation at lowest rates, to the point of delivery.

APPENDIX 2.

Recommended Specification for

LIQUID MEMBRANE SEAL COAT MATERIAL

(*a*) ***Moisture Retention.*** The liquid membrane seal coat curing material when tested in accordance with the method prescribed in the "Tentative Method of Test for Efficiency of Materials for Curing Concrete", American Society for Testing Materials C 156 – 40 T (Appendix 6) shall provide a film which will retain within the specimen at the end of 3 days at least 85 per cent of the original water used in the mix.

NOTE.—85 per cent is considered the lowest permissible limit. Some films will retain over 90 per cent. When such are available their use is recommended.

(*b*) ***Consistency.*** The curing material shall be of such consistency that it can be applied to the concrete as a fine mist by means of an atomizing nozzle.

(*c*) ***Character of Film.*** The curing material shall form a continuous coherent film when applied at the specified rate and when dry the covering shall be continuous, flexible and without breaks or pinholes.

(*d*) ***Reaction with Concrete.*** The liquid membrane curing material shall be of such nature as not to react deleteriously with the wet concrete.

NOTE.—Any tendency of a liquid membrane material to injure the surface may be determined by means of a simple hardness test such as that described in Appendix 7. In case such a test cannot be made an approximate idea of the effect may be secured by scratching the surface with a knife, screwdriver, etc.

Any softening of the concrete revealed in this way should be considered sufficient cause for rejection of the material unless it can be shown that it has been used with satisfactory results.

(*e*) ***Delivery of Material.*** The liquid membrane curing compound shall be delivered to the job in the manufacturer's original container clearly labeled to show the name of the manufacturer and the contents. It shall be in all respects the same as the sample tested.

(*f*) ***Color of Non-bituminous Membrane Seal Coats.*** The compound shall produce no darkening in color of the natural concrete. It shall, however, be of such nature or so treated that the film will be distinctly visible for at least 4 hours after application.

APPENDIX 3.

Tentative Specifications for

WATERPROOF PAPER FOR CURING CONCRETE[1]

A.S.T.M. Designation: C 171 - 42 T

ISSUED, 1942.[2]

This Tentative Standard of the American Society for Testing Materials is, under its Regulations, subject to annual revision. Suggestions for revision should be addressed to the Society, 260 S. Broad St., Philadelphia, Pa.

Scope

1. These specifications cover waterproof paper intended for use as a curing material for portland cement concrete.

General Requirements

2. Waterproof paper shall consist of two sheets of plain kraft paper cemented together with a bituminous material in which are embedded cords or strands of fiber running in both directions of the paper, not more than $1\frac{1}{4}$ in. apart. The paper shall be light in color, shall be free of visible defects, and shall have a uniform appearance. It shall be sufficiently strong and tough to permit its use under the conditions existing on highway and structural work without tearing or otherwise becoming unfit for the use for which it is intended.

Impermeability

3. Mortar specimens, when covered with the paper to be tested and tested in accordance with the Tentative Method of Test for Efficiency of Materials for Curing Concrete (A.S.T.M. Designation: C 156) of the American Society for Testing Materials,[3] shall not show a moisture loss greater than 10 per cent of the original mixing water used. In the test the paper shall be placed on the mortar specimen immediately after molding and shall remain in place for three days.

Tensile Strength

4. The paper shall conform to the following requirements as to tensile strength:

		Machine Direction	Cross Direction
Tensile strength, lb. per in. of width	dry	50	30
	wet	20	10

Tensile Strength Test

Apparatus

5. The testing machine shall consist of the following:

(*a*) *Clamps.*—Two clamps whose centers shall be in the same plane parallel with the direction of motion of the stressing clamp and so aligned that they will hold the test specimen in one plane.

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

[2] Accepted by the Society at annual meeting, June, 1942.

[3] 1940 Supplement to Book of A.S.T.M. Standards, Part II, p. 264.

(*b*) *Pendulum.*—A pendulum so attached to one clamp as to accurately balance the load applied to the test specimen.

(*c*) *Scale.*—A device attached to the pendulum to indicate on a graduated scale the breaking load of the test specimen. The scale shall be graduated in weight units which may be read to an accuracy of not less than 0.2 per cent of the total reading.

(*d*) *Loading Device.*—A means of moving the stressing clamp at a uniform rate. The capacity of the machine shall be such that the tensile strength of the paper to be tested will be not greater than 90 per cent nor less than 10 per cent of the capacity of the machine. The machine shall preferably be power driven.

Calibration of Apparatus

6. The testing machine shall be accurately leveled in both of the principal directions. The stressing clamp shall be displaced or removed and accurate weights corresponding to various divisions of the scale markings shall be suspended from the pendulum actuating clamp. The weights shall be held at the start and released slowly so that the pendulum is actuated at a rate similar to that specified in Section 9 (*b*), and other conditions shall be as nearly as possible the same as when a specimen is being tested. A record shall be made of deviations from the scale readings and corresponding corrections shall be made in the test results. The machine shall be calibrated at intervals of not more than 30 days.

Test Specimens

7. Specimens for test shall be cut accurately, and not less than ten from each principal direction of the paper shall be so selected as to be representative of the sample. The specimens shall be cut exactly 2 in. in width and the edges shall be clean-cut and parallel.

Conditioning

8. (*a*) Specimens to be tested dry shall be preconditioned in air maintained at a temperature between 70 and 75 F. and at a relative humidity of 50 per cent, for a period of 12 hr. prior to testing.

(*b*) Specimens to be tested wet shall be immersed in water having a temperature between 70 and 75 F., for a period of 1 hr. immediately prior to testing.

Procedure

9. (*a*) All tensile strength tests shall be made in an atmosphere maintained at a temperature of 70 to 75 F. and at a relative humidity of 50 per cent.

(*b*) The distance between the jaws of the testing machine at the beginning of the test shall be 7 in. The test specimen shall be firmly clamped squarely in the jaws of the clamps and the stressing jaw then operated at a speed of 12 $\pm$ 2 in. per min. until the specimen breaks. The breaking load shall be recorded to the nearest 2 per cent of the total indicated reading. Not less than ten specimens cut in each principal direction of the paper shall be tested. All readings obtained when the paper breaks at or in the jaws shall be rejected.

Report

10. The tensile strength results in pounds per inch of width shall be reported to the nearest 2 per cent of the total reading. The average, maximum, and minimum tensile strengths for each of the principal directions of the paper shall be reported.

APPENDIX 4.

Standard Specifications for

CALCIUM CHLORIDE[1]

A.S.T.M. Designation: D 98 – 34

ADOPTED, 1934.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 98; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover calcium chloride to be used for road purposes, acceleration of concrete, and curing of concrete.

Chemical Composition

2. The calcium chloride shall conform to the following requirements as to chemical composition:

Calcium chloride, $CaCl_2$ (anhydrous), min., per cent	77
Magnesium chloride, $MgCl_2$, max., per cent	0.5
Total alkali chlorides, max., per cent	2.0
Other impurities, max., per cent	1.0

Grading

3. The calcium chloride shall be in the form of flakes and when tested by means of laboratory sieves[3] shall conform to the following requirements:

Passing a $\frac{3}{8}$-in. sieve	100 per cent
Retained on a $\frac{1}{4}$-in. sieve, max	20 per cent
Passing an 840-micron (No. 20) sieve, max	10 per cent

Packing and Marking

4. The calcium chloride shall be delivered in moistureproof bags or sacks containing approximately 100 lb. each, or in airtight steel drums weighing not more than 450 lb. each The name of the manufacturer, the lot number, the approximate net weight, and the percentage of calcium chloride guaranteed by the manufacturer shall be legibly marked on each container.

Inspection

5. Every facility shall be provided the purchaser should he elect to have his representative sample the material at the plant. If the purchaser decides to sample the material after delivery it is understood that a 3 per cent variation in content of $CaCl_2$ from the chemical composition prescribed in Section 2 shall be permissible.

Rejection

6. The calcium chloride shall be rejected if it fails to conform to any of the requirements of these specifications, and if it has become caked or sticky in the containers before opening.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Prior to adoption as standard, these specifications were published as tentative from 1921 to 1934, being revised in 1922, 1930, 1933, and 1934. Editorially revised and rearranged in 1939.

[3] Detailed requirements for these sieves are given in the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, see 1939 Book of A.S.T.M. Standards, Parts II and III.

APPENDIX 5.

Standard Specifications for

SODIUM SILICATE FOR CURING CONCRETE[1]

A.S.T.M. Designation: C 111 – 36

ADOPTED, 1936.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation C 111; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover sodium silicate suitable for application to the surface of concrete for the purpose of preventing moisture loss during curing.

Properties and Tests

2. (*a*) The sodium silicate shall have a density of not less than 42.25° Baumé at 60 F. (15.5 C.).

(*b*) The ratio of sodium oxide, Na_2O, to silica, SiO_2, shall be 1 Na_2O to not less than 3.2 SiO_2.

Packing and Marking

3. The sodium silicate shall be delivered on the job in containers of suitable size and of a type which will not cause any deterioration of the product prior to its application to the concrete. The name of the manufacturer, the actual net weight, and the manufacturer's grade designation shall be plainly marked on each container.

Inspection and Sampling

4. Sodium silicate may be sampled for purpose of tests either at the plant prior to delivery or on the site of the work, at the option of the purchaser. At least one sample from each 500 gal. shall be taken to determine compliance with these specifications.

Rejection

5. The sodium silicate shall be rejected if it fails to meet any of the requirements of these specifications.

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

[2] Prior to adoption as standard, these specifications were published as tentative from 1934 to 1936. Editorially revised and rearranged in 1939.

APPENDIX 6.

Tentative Method of Test for

EFFICIENCY OF MATERIALS FOR CURING CONCRETE[1]

A.S.T.M. Designation: C 156 - 40 T

ISSUED, 1940.[2]

This Tentative Standard of the American Society for Testing Materials is, under its Regulations, subject to annual revision. Suggestions for revision should be addressed to the Society, 260 S. Broad St., Philadelphia, Pa.

Scope

1. This method is intended for laboratory use in testing the efficiency of materials for curing concrete.

Apparatus

2. *Molds.*—Molds shall be made of metal and shall be watertight. They shall be rigidly constructed so as not to distort when the specimens are handled at early ages. The molds shall be approximately $2\frac{1}{2}$ in. in depth ($\frac{1}{2}$ in. deeper than the thickness of the specimen) in order to allow for proper sealing of the curing material, and the sides shall be beveled in order that the specimens may be readily removed.

Test Specimens

3. Test specimens shall be approximately 6 in. in width by 12 in. in length by 2 in. in thickness.

Proportioning and Mixing Mortar

4. (*a*) *Proportioning.*—The mortar for making the test specimens shall be of plastic consistency and gaged to a definite water-cement ratio. The proportions of cement and sand shall be determined by adding to a paste having a water-cement ratio of 0.40 by weight, a sufficient quantity of saturated, surface-dried sand (Note 1) to produce a flow of 50 per cent as measured on the 10-in. flow table using thirty $\frac{1}{8}$-in. drops in 30 sec. (Note 2).

NOTE 1.—In order to control the mortar proportions within reasonable limits, a siliceous sand graded approximately as follows shall be used:

Sieve	Percentage Passing
No. 4 (4760-micron)	100
No. 16 (1190-micron)	60
No. 50 (297-micron)	15
No. 100 (149-micron)	2

NOTE 2.—The flow test is described in the Standard Method of Test for Flow of Portland-Cement Concrete by Use of the Flow Table (A.S.T.M. Designation: C 124) of the American Society for Testing Materials.[3]

(*b*) *Mixing.*—Cement and water in quantities which will give a water-cement ratio of 0.40 by weight shall be placed in an appropriate vessel and the cement permitted to absorb water for 1 min. The materials shall then be mixed with a spoon into a smooth paste. Saturated, surface-dried sand from a

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

[2] Accepted by the Society at annual meeting, June, 1940.

[3] 1939 Book of A.S.T.M. Standards, Part II, p. 337.

sample of known weight shall be added to the mixture until the mortar appears to be of the desired consistency. Final mixing shall be accomplished by continuous squeezing and kneading with the hands for 2 min. Rubber gloves shall be worn during the mixing operation.

Molding Specimens

5. The entire batch of mortar shall be placed in the mold and puddled with the gloved finger. It shall then be struck off with a wooden template.

Storage of Specimens

6. Immediately after molding, the mold and the specimen shall be weighed to the nearest gram and placed in an atmosphere maintained at a temperature of 100 ± 5 F. and at a relative humidity controlled within the limits of 30 to 35 per cent.[4] Means shall be provided for circulating the air.

Procedure

7. (*a*) *Application of Curing Material.*—After a storage period in the curing cabinet corresponding to the time the concrete in the field would be exposed without curing, the specimens shall be removed from the cabinet and weighed. The curing material shall then be applied in accordance with the established specification for that method of curing. After each treatment or stage of treatment the specimen shall be weighed and returned to the curing cabinet. During the period when a specimen is being subjected to wet curing, it is not necessary to maintain the humidity constant in the curing cabinet. Wetted burlap or curing blanket shall be kept constantly wet, either by frequent applications of water or by having the covering extend beyond the edge of the container into a pan of water. When other than wet curing methods are used, the curing materials shall be applied to the surface of the specimen in a uniform layer and in the manner and quantity specified for use in the field. In order to prevent moisture loss except through the curing medium, the edges of the specimens shall be sealed to the sides of the pans with heavy bitumen. In the case of paper or other coverings which are not kept wet by continuous or intermittent applications of water, an additional seal shall be applied to the top of the covering where it contacts the sides of the pans.

(*b*) *Determination of Loss in Weight.*—Weighings shall be made 3 hr. after application of the curing material and daily for the duration of the test. In determining these losses in weight, corrections shall be made for the change in weight of the curing material. These corrections, when necessary, shall be made by coating metal plates of the same area as the top of the test specimens with the same quantity of curing material and placing them in the curing cabinet with the test specimens. Subsequent weighings will determine the proper corrections. At the end of the curing period, the specimens shall be removed from the curing cabinet and the final loss in weight determined. When calculating the loss in weight, the original weight shall be taken as the weight of the free water in the specimen immediately after molding. The moisture loss shall be expressed as a percentage of this weight.

[4] The atmospheric conditions specified may be obtained by the use of an incubator similar to the type commonly employed for hatching eggs.

APPENDIX 7.

Suggested Surface Wear Test for
EFFECT OF MEMBRANE COATINGS ON QUALITY OF CONCRETE

The surface of the specimen to be tested is masked out with a rubber pad except for a 4-in. circle which is left exposed.

The exposed surface is subjected to a blast of steel grit using 80-lb. air pressure with the nozzle of the gun held 12 in. from the specimen in a plane making an angle of 90 deg. with the plane of the specimen. The nozzle has an opening of $\frac{3}{8}$-in. Number 14 steel grit (100 per cent passing the No. 14 sieve and 100 per cent retained on the No. 40 sieve) is fed into the gun at the rate of $4\frac{1}{2}$ lb. per min. The test is continued for 1 min. on concrete specimens and for 2 min. on mortar specimens. The loss in weight is taken as a measure of the surface hardness.

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WARTIME ROAD PROBLEMS

No. 1. Curing Concrete Pavements Under Wartime Restrictions on Critical Materials.

No. 2. Design of Highway Guards.

No. 3. Design of Concrete Pavements Requiring a Minimum of Steel.

IN PREPARATION

Road Stabilization.

Compaction of Soil.

Maintenance Methods for Preventing and Correcting the Pumping Action of Concrete Pavement Slabs.