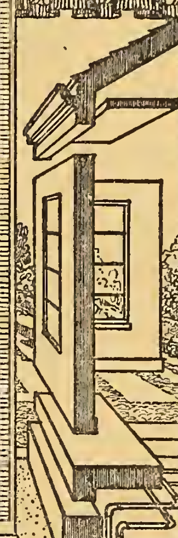
U. S. DEPARTMENT OF COMMERCE



BUILDING MATERIALS AND STRUCTURES

REPORT BMS95

Tests of Cement-Water Paints and Other Waterproofings for Unit-Masonry Walls

by

CYRUS C. FISHBURN

and DOUGLAS E. PARSONS

NATIONAL BUREAU OF STANDARDS

BUILDING MATERIALS AND STRUCTURES REPORTS

On request, the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., will place your name on a special mailing list to receive notices of new reports in this series as soon as they are issued. There will be no charge for receiving such notices.

An alternative method is to deposit with the Superintendent of Documents the sum of $5, with the request that the reports be sent to you as soon as issued, and that the cost thereof be charged against your deposit. This will provide for the mailing of the publications without delay. You will be notified when the amount of your deposit has become exhausted.

If 100 copies or more of any report are ordered at one time, a discount of 25 percent is allowed.

Send all orders and remittances to the *Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.*

The following publications in this series are available by purchase from the Superintendent of Documents at the prices indicated:

BMS1	Research on Building Materials and Structures for Use in Low-Cost Housing	10¢
BMS2	Methods of Determining the Structural Properties of Low-Cost House Constructions	10¢
BMS3	Suitability of Fiber Insulating Lath as a Plaster Base	10¢
BMS4	Accelerated Aging of Fiber Building Boards	10¢
BMS5	Structural Properties of Six Masonry Wall Constructions	15¢
BMS6	Survey of Roofing Materials in the Southeastern States	15¢
BMS7	Water Permeability of Masonry Walls	10¢
BMS8	Methods of Investigation of Surface Treatment for Corrosion Protection of Steel	10¢
BMS9	Structural Properties of the Insulated Steel Construction Company's "Frameless-Steel" Constructions for Walls, Partitions, Floors, and Roofs	10¢
BMS10	Structural Properties of One of the "Keystone Beam Steel Floor" Constructions Sponsored by the H. H. Robertson Co	10¢
BMS11	Structural Properties of the Curren Fabrihome Corporation's "Fabrihome" Constructions for Walls and Partitions	10¢
BMS12	Structural Properties of "Steelox" Constructions for Walls, Partitions, Floors, and Roofs Sponsored by Steel Buildings, Inc	15¢
BMS13	Properties of Some Fiber Building Boards of Current Manufacture	10¢
BMS14	Indentation and Recovery of Low-Cost Floor Coverings	10¢
BMS15	Structural Properties of "Wheeling Long-Span Steel Floor" Construction Sponsored by the Wheeling Corrugating Co	10¢
BMS16	Structural Properties of a "Tilecrete" Floor Construction Sponsored by Tilecrete Floors, Inc	10¢
BMS17	Sound Insulation of Wall and Floor Constructions	10¢
	Supplement to BMS17, Sound Insulation of Wall and Floor Constructions	5¢
BMS18	Structural Properties of "Pre-Fab" Constructions for Walls, Partitions, and Floors Sponsored by the Harnischfeger Corporation	10¢
BMS19	Preparation and Revision of Building Codes	15¢
BMS20	Structural Properties of "Twachtman" Constructions for Walls and Floors Sponsored by Connecticut Pre-Cast Buildings Corporation	10¢
BMS21	Structural Properties of a Concrete-Block Cavity-Wall Construction Sponsored by the National Concrete Masonry Association	10¢
BMS22	Structural Properties of "Dun-Ti-Stone" Wall Construction Sponsored by the W. E. Dunn Manufacturing Co	10¢
BMS23	Structural Properties of a Brick Cavity-Wall Construction Sponsored by the Brick Manufacturers Association of New York, Inc	10¢
BMS24	Structural Properties of a Reinforced-Brick Wall Construction and a Brick-Tile Cavity-Wall Construction Sponsored by the Structural Clay Products Institute	10¢
BMS25	Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs	15¢
BMS26	Structural Properties of "Nelson Pre-Cast Concrete Foundation" Wall Construction Sponsored by the Nelson Cement Stone Co., Inc	10¢
BMS27	Structural Properties of "Bender Steel Home" Wall Construction Sponsored by the Bender Body Co	10¢
BMS28	Backflow Prevention in Over-Rim Water Supplies	10¢
BMS29	Survey of Roofing Materials in the Northeastern States	10¢
BMS30	Structural Properties of a Wood-Frame Wall Construction Sponsored by the Douglas Fir Plywood Association	10¢
BMS31	Structural Properties of "Insulite" Wall and "Insulite" Partition Constructions Sponsored by The Insulite Co	15¢
BMS32	Structural Properties of Two Brick-Concrete-Block Wall Constructions and a Concrete-Block Wall Construction Sponsored by the National Concrete Masonry Association	10¢

[List continued on cover page III]

UNITED STATES DEPARTMENT OF COMMERCE · Jesse H. Jones, Secretary

NATIONAL BUREAU OF STANDARDS · Lyman J. Briggs, Director

BUILDING MATERIALS *and* STRUCTURES

REPORT BMS95

Tests of Cement-Water Paints and Other Waterproofings for Unit-Masonry Walls

by

CYRUS C. FISHBURN *and* DOUGLAS E. PARSONS

ISSUED MARCH 15, 1943

The National Bureau of Standards is a fact-finding organization; it does not "approve" any particular material or method of construction. The technical findings in this series of reports are to be construed accordingly.

UNITED STATES GOVERNMENT PRINTING OFFICE · WASHINGTON · 1943

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C. · PRICE 15 CENTS

Foreword

An extensive investigation of the water permeability of over 400 small masonry wall specimens has been concluded. The walls were tested, under conditions simulating exposure to wind-driven rain, both before and after they were subjected to artificial or outdoor weathering. Some phases of the investigation are described in BMS Reports 7, 41, 55, 76, 82, and 94. Data on the permeability of walls built of masonry units are contained in BMS Reports 7 and 82, the latter report containing information complementary to that published in BMS7. The effects of heating and cooling and of wetting and drying masonry walls, including stucco-faced walls, are described in BMS Reports 41 and 55, respectively. The effects of outdoor weathering on the permeability of masonry walls, not waterproofed, and on the durability of some waterproofings are discussed in BMS76. The permeability and weathering resistance of stucco- and gunite-faced walls are reported in BMS94 (which also contains complementary information from BMS Reports 7 and 76).

This report, the final one on the investigation, describes the effectiveness and durability of cement-water paints and of other waterproofings for unit-masonry walls, and it includes complementary information on subjects discussed in BMS Reports 7 and 76.

Lyman J. Briggs, *Director.*

Tests of Cement-Water Paints and Other Waterproofings for Unit-Masonry Walls

by CYRUS C. FISHBURN *and* DOUGLAS E. PARSONS

CONTENTS

	Page
Foreword	II
I. Introduction	2
II. Scope	2
III. Sponsors	2
IV. Wall specimens	3
1. Masonry materials	3
(a) Bricks	3
(b) Concrete units	3
(c) Mortars	3
2. Description and construction of the walls	4
3. Designation of the walls and waterproofings	4
V. Method of testing	4
1. Water-permeability test	4
(a) Apparatus and test method	4
(b) Observations	5
(c) Rating of performance	5
2. Outdoor exposure	5
VI. Cement-water paints	6
1. Materials and consistency	6
2. Method of application and curing	7
(a) Preparation of the walls for painting	7
(b) Kinds of brushes	8
(c) Application of the paints	9
(d) Curing of the coatings	10
(e) Condition of the cured paint coatings	11
3. Some factors affecting the permeability of the cement-water paint coatings	11
(a) Kind of brush	15
(b) Kind of backing and its moisture content	15
(c) Paint consistency	15
(d) Curing conditions	16
(e) Kind of paint and of admixtures	16
(f) Use of a grout coat	17
4. Effect of weathering exposure on permeability	17
5. Discussion	18
VII. Proprietary waterproofings applied to the exposed faces of the walls	19
1. Pigmented surface coatings	19
(a) Aquaplex	19
(b) Dricoat	20
(c) Drye	20
(d) Maure Brush-Tex and Plaster Special	20
VII. Proprietary waterproofings applied to the exposed faces of the walls—Continued	
1. Pigmented surface coatings—con.	
(e) Tymstone	21
(f) Varcraft	21
(g) Discussion	22
2. Colorless surface coatings	22
(a) Ampruf	23
(b) Ceremul-W	23
(c) Filporize	23
(d) Maure liquid waterproofing	24
(e) Por-fil-ite	24
(f) Sur-Ten-R	24
(g) Discussion	25
VIII. Larson Pre-Formed Waterproofing Units	25
1. Construction of the specimens	25
2. Effectiveness and durability	26
IX. Waterproofing applied to the unexposed faces of the walls	29
1. Bituminous coatings	29
(a) Asphalt	30
(b) Coal tar	31
(c) Asphalt roof coating	31
(d) Asphalt emulsion	31
(e) Bituminous plastic cement	31
(f) Discussion	32
2. Coatings of cementitious or of proprietary materials	33
(a) Portland-cement and sand brush coating	33
(b) Iron-dust (iron powder and sal ammoniac) brush coating	33
(c) Portland-cement and iron-dust brush coatings	34
(d) Portland-cement, iron-dust, and sand trowel coatings	34
(e) Mortar parging	34
(f) Armor coat	35
(g) Dricoat	35
(h) Discussion	35
X. Conclusions	36
1. Cement-water paints	36
2. Emulsified resin and oil-base paints	36
3. Colorless surface waterproofings	36
4. Joint treatments	36
5. Membrane waterproofing	37
6. Waterproofings on the inside (unexposed) faces of the walls	37

ABSTRACT

One hundred thirty-one small highly permeable masonry wall specimens built of concrete blocks or of bricks were treated with cement-water paints or with other waterproofings. The effectiveness of the treatments was measured by comparing the permeability of the walls, before and after treatment, when they were subjected to conditions simulating wind-driven rain. The durability of some treatments was observed by again testing the specimens after they had been weathered outdoors.

The cement-water paints were effective waterproofings and could be applied to the best advantage on the walls of concrete blocks with stiff, rather than soft, brushes. The admixture of fine sand to the paint for the first coat applied to the coarse-textured concrete block increased the effectiveness and durability of the paints. Thick paint films resulting from the application of excessive amounts of paint were effective when first applied, but they were much less durable than thinner coatings. The permeability of the paint films of average thickness was lower after weathering than before.

The colorless waterproofings were generally ineffective. Only one of the colorless waterproofings was satisfactory when first applied, but it was not durable and was much more permeable than the best cement-water paint treatments. The data confirm results previously obtained, which indicate that the only effective and durable method of waterproofing brick walls without changing their appearance was by repointing or grouting of the face joints.

A series of built-in waterproof membranes was an effective waterproofing for brick walls if the leakage through the facing was drained out of the wall through weep holes at the bottom.

The bituminous coatings applied to the inside faces of the walls were ineffective as waterproofings.

I. INTRODUCTION

The effectiveness and durability of waterproofings applied to small walls built of masonry units are also discussed in previous publications[1] of the National Bureau of Standards. Although some of the walls described in those papers were given surface treatments, applied to the exposed faces, most of the tests were made on walls that were not waterproofed. This paper describes the effectiveness and durability of the cement-water paints and of other waterproofings applied to a second group of wall specimens. The complementary data published in BMS7 and BMS76 are discussed briefly in this paper, which therefore contains practically all the information on waterproofing that was obtained from the tests on both groups of walls.

[1] Building Materials and Structures Reports BMS7, Water Permeability of Masonry Walls, and BMS76, Effect of Outdoor Exposure on the Water Permeability of Masonry Walls.

II. SCOPE

Forty-five different waterproofings were tested. The treatments of the exposed faces of the walls included 9 pigmented and 6 colorless proprietary materials and 16 laboratory-prepared cement-water paints. The waterproofings applied to the back (unexposed) faces of the walls were five bituminous treatments, two pigmented proprietary materials, and six cementitious coatings prepared with or without the addition of powdered iron and sal ammoniac. One built-in bituminous membrane waterproofing was also tested. The number of proprietary waterproofings tested was limited by the scope of the investigation and was relatively very small in comparison with the considerable number in use.

The effectiveness of the surface waterproofings was determined from permeability tests made on the walls before and after treatment, and the durability of some of them was observed by additional permeability tests made after the walls had been stored outdoors. The effectiveness of a built-in membrane waterproofing was measured by comparing the performances of walls with and without the membrane.

III. SPONSORS

The construction and waterproofing of most of the walls were sponsored by the Government agencies that collaborated with the Bureau in the investigation. Some proprietary waterproofings were sponsored by the makers, who furnished the materials and labor for the walls and supervised the application of the waterproofings to the specimens. These sponsors were:

Armor Laboratories, Inc., Los Angeles, Calif.; sponsors of "Armor Coat."

Brisk Waterproofing Co. Inc., New York, N. Y.; sponsors of Larson "Pre-formed Waterproofing Units."

Maure Corporation, New York, N. Y.; sponsors of Maure "Brush-Tex", "Liquid Waterproofing", and "Plaster Special."

Pal-Verd, Inc., Chicago, Ill.; sponsors of "Sur-Ten R."

Tymstone Studio, Chicago, Ill.; sponsors of "Tymstone."

All the tests were made by the Bureau.

IV. WALL SPECIMENS

1. Masonry Materials

(a) *Bricks*

The dimensions and physical properties of the bricks are given in table 1; their general characteristics are listed below.

Brick c, a dry-pressed, highly absorptive unit with a high rate of absorption.

Brick b, a side-cut, shale unit.

Brick r, an end-cut, shale unit of special shape containing five horizontal cored holes and known as Munlock brick.[2]

Brick s, a stiff-mud, moulded brick.

Brick t, a side-cut, surface clay brick containing three 1-in. cored holes.

[2] The Munlock brick are illustrated in figures 2 and 3 of Building Materials and Structures Report BMS82, Water Permeability of Walls Built of Masonry Units.

(b) *Concrete Units*

The dimensions and physical properties of the hollow concrete units are given in table 2; their general characteristics are listed below.

Block m, a two-cell, end-bearing, stone-concrete unit.

Block n, a cinder-concrete unit similar in size and shape to block *m*. Blocks *m* and *n* were purchased under Federal Specification SS-C-621, type 1, load bearing.

Block p, a two-cell, cinder-concrete bonding unit.

A second shipment of blocks *m* and *n* were received from the same manufacturer and used in the construction of additional walls. The units in the second shipment differed from those in the first in that they had thinner shells and were stronger; the stone-concrete blocks were less absorptive; the cinder-concrete blocks had a smoother surface texture.

(c) *Mortars*

The proportions and water retentivities of the mortars are given in table 3. The materials were proportioned by weight and mixed in a small batch mixer. The amounts of water were adjusted to the satisfaction of the mason.

Table 1.—*Physical properties of the bricks*

Designation	Average dimensions			Average dry weight	Absorption by weight during total immersion			Saturation coefficient, *C/B*	Absorption by partial immersion, flat, 1 min. [a]	Time required for total penetration by capillary action			Modulus of rupture	Compressive strength
	Thickness	Width	Length		5-hr cold	24-hr cold, *C*	5-hr boil, *B*			Flat	Edge	End		
	in.	*in.*	*in.*	*lb*	%	%	%		*g*	*hr*	*hr*	*hr*	*lb/in.*^{2}	*lb/in.*^{2}
b	3.6	7.8	2.2	4.4	7.7	8.3	11.4	0.73	37	0.4	1.9	12.5	1,1[illegible]0	7,580
c	3.9	8.1	2.3	5.0	14.2	14.6	16.9	.86	112	.1	.3	1.7	250	3,080
r	8.0	2.2	[b] 7.9	9.5	1.5	1.6	1.9	.84	3	1.4	------	------	1,720	4,460
s	3.8	8.4	2.3	5.3	11.5	12.3	14.5	.85	66	.3	.5	2.2	480	3,220
t	3.8	8.3	2.2	4.9	5.7	6.0	9.1	.66	37	.2	4.5	8.7	1,010	13,570

[a] Corrected on an equivalent area of 30 in.^{2} [b] Length parallel to the cores.

Table 2.—*Physical properties of the concrete units*

Designation	Exterior dimensions			Thickness of face shell	Weight			Absorption by 24-hr cold immersion		Compressive strength, gross area	Face shell immersed in ⅛ in. of water			
	Thickness	Width	Length		Dry	Per cubic foot of concrete	Per square foot of wall area				Absorption in 3 minutes	Capillary rise in first hr	Capillary rise	
													Height	Time
	in.	*in.*	*in.*	*in.*	*lb*	*lb*	*lb*	%	*lb/ft*^{3}	*lb/in.*^{2}	*g/cm*^{2}	*in.*	*in.*	*hr*
m [a]	7.8	11.9	7.9	1.54	35.2	119	54	11.1	13.1	860	1.36	6.0	6.7	35
	7.9	11.9	7.9	1.4	32.0	128	49	6.5	8.3	1,040	------	3.6	4.4	168
n [a]	7.8	11.9	7.9	1.51	25.4	91	39	14.0	12.6	690	0.33	2.0	5.0	168
	8.1	11.8	7.8	1.2	24.1	91	38	13.2	12.1	1,150	------	2.1	5.0	168
p	8.0	11.9	7.5	1.36	17.3	83	34	17.2	14.4	800	------	1.7	4.9	158

[a] The data in the second line are for a second shipment of the same kind of unit.

Table 3.—*Proportions and water retentivities of the mortars*

Mortar	Proportions of cement, lime hydrate, and sand [a]		Cementing materials		Average water content by weight of dry materials	Average water retentivity [c]
	By volume	By weight	Cement	Lime [b]		
					%	%
1	1:0.25:3	1:0.11:2.6	Portland	Putty	20.0	72
2	1:1:6	1:0.42:5.1	do	do	23.0	81
3	1:2:9	1:0.85:7.7	do	do	23.7	88
5	1:1:6	1:0.42:5.1	do	Berkeley	21.3	43
9	1:1:6	1:0.42:5.1	do	Standard	20.8	55
10	1:0:3	1:0:3.4	Masonry [d]		14.9	65

[a] Proportioning was by weight, assuming that portland cement weighed 94 lb/ft^3, masonry cement (Hy-Test) 70 lb/ft^3, hydrated lime 40 lb/ft^3 and that 1 ft^3 of loose, damp, Potomac River Building sand contained 80 lb of dry sand.

[b] Putty was made from Standard Lime & Stone Co.'s Washington brand, powdered quicklime (see table 5, BMS82). Other limes were dry hydrates.

[c] Determined according to Federal Specification SS–C–181b.

[d] Hy-Test masonry cement.

2. Description and Construction of the Walls

The walls were about 40 in. long, 50 in. high, and 8 or 12 in. thick. They were supported on steel channels to facilitate handling and were sealed at the ends and tops with a mortar parging ⅜ to ½ in. thick. Copper flashings were built into the walls at the bottom so as to collect and divert to the back face any leakage water passing through the wall or dropping inside to the bottom. A typical concrete-block wall is shown in figure 1, and a typical brick masonry wall is shown in figure 1 of BMS82. Of the 131 specimens tested, 44 were built of block *m*, 39 of block *n*, and 32 of brick *c*. Experienced masons were employed for the construction of the walls, and all but one specimen was built at the Bureau.

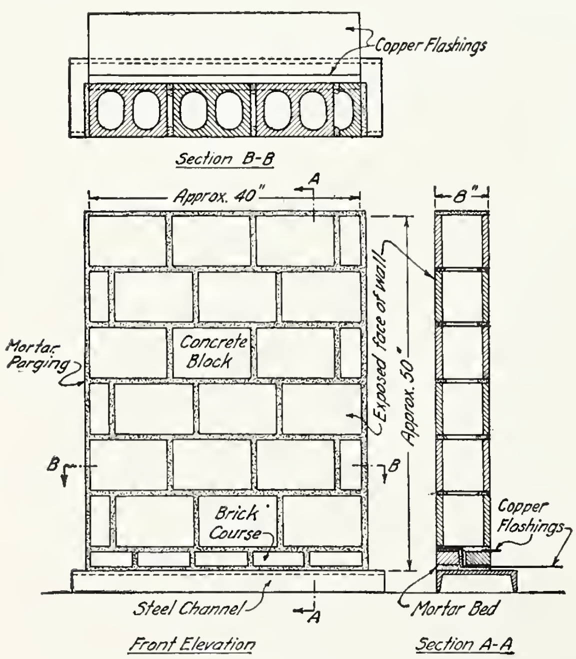


Figure 1.—*Typical concrete-block wall.*

With the exception of walls built of Munlock brick (brick *r*, table 1), all the untreated walls were purposely built to be highly permeable. Most of them were of workmanship *B*, described in BMS82, and the units were dry when laid.

3. Designation of the Walls and Waterproofings

The walls were numbered as built and were further identified by additional numbers to designate the kind of waterproofing and by letters to indicate the kind of masonry units. When a wall was waterproofed on the face, the designation number of the waterproofing was given after the wall number and before the letter designation of the kind of unit. For example, wall B189, built of block *m*, was waterproofed on the face with cement-water paint 5. The combined number and designation of this wall is B189–5*m*.

V. METHOD OF TESTING

1. Water-Permeability Test

The water-permeability test was severe and of greater duration than the natural wind and rain storms to which most building walls are subjected, and information of practical value on the permeability of the specimen was therefore obtained during an exposure period of 1 day. However, in order to determine the relative effectiveness of the better waterproofing treatments, the tests were sometimes continued for a maximum period of 5 days.

(*a*) *Apparatus and Test Method*

The testing apparatus is described and illustrated in BMS82. The walls were dry when placed to form one side of a pressure chamber. The face of the wall inside the chamber, referred to as the exposed face, was exposed to water flowing from a perforated tube at the rate of 40 gal/hr and to an air pressure equivalent to a 2-in. head of water (10 lb/ft^2) above atmospherie pressure. The temperature of the water applied to the walls was maintained above the dew point, and the relative humidity of the air in the testing room was usually between 80 and 90 pereent. The baeks of the walls were whitewashed so that the penetration of water eould be easily deteeted by the discoloration produeed.

(b) *Observations*

The speeimens were under continual observation for about 3 hr after starting each test, after which the observer inspeeted them at increasingly longer intervals.

The following observations were made:

1. Time required for the appearanee of moisture (dampness) on the baeks of the walls, above the flashings.
2. Time required for drops of water to appear on the baek of the walls, above the flashing.
3. Time required for leakage to flow from either of the flashings.
4. Maximum rate of leakage, if any.
5. Extent of damp area on the walls, ineluding that produeed by the capillary rise of moisture from water on the flashings.

When not exactly determined, the time of failure was assumed to be the middle of the interval between two inspeetions, and the uneertainty of the observation was assumed to be plus or minus one-third of the interval between the two inspeetions.

(c) *Rating of Performance*

The arbitrary ratings of wall performance are the same as those given in BMS82. They are based on the assumption that visible water or extensive damp areas on the back or leakage through the base of a wall would damage plaster, applied directly to the wall, or would injure the interior trim or furnishings of a building. Since the exposure given the test walls was eontrolled to prevent eondensation of moisture on the baeks, no eonclusions can be drawn from the tests regarding the effeets of eondensation in building walls similar to the test specimens.

The following is the system used for rating wall-performance:

Excellent (*E*).—No water visible on back of the wall (above the flashings) at the end of 1 day. Not more than 25 percent of the wall area damp at the end of 5 days. No leaks [3] through the wall in 5 days.

Good (*G*).—No water visible on the back of the wall at the end of 1 day. Less than 50 pereent of the wall area damp at the end of 1 day. No leaks through the wall at the end of 1 day.

Fair (*F*).—No water visible on baek of the wall during first 3 hours, but visible at end of 1 day. The rate of leakage through the wall less than 1 liter/hr at the end of 1 day.

Poor (*P*).—Water visible on back of the wall in 3 hr. or less and at the end of 1 day. Rate of leakage less than 5 liters/hr at the end of 1 day.

Very Poor (*VP*).—Rate of leakage through the wall equal to or greater than 5 liters/hr at the end of 1 day.

There was little praetieal differenee between the performance of walls rated as "Good" or "Excellent", and it is possible that walls rated as "Fair" would be eonsidered to have a satisfaetory resistanee to rain penetration exeept when subjected to rain and to winds of high velocity for long periods.

2. Outdoor Exposure

After having been tested, some of the least permeable waterproofed walls were stored outdoors at Washington, D. C., for periods ranging from 3 to 25 months during the interval July 1939 to May 1942. These walls were then brought indoors and again tested for permeability.

The monthly maximum and minimum air temperature and the monthly mean of daily maximum and daily minimum air temperatures are shown in figure 2, which also shows the number of thawing eycles per month. The air temperature fell below and then rose above freezing about 60 times each winter, and the data (obtained from the Weather Bureau) indicate that the air temperature did not rise above freezing more than onee in any one day. The monthly precipitation for the period January 1939 to May 1942 is given in table 4.

[3] Leaks are defined as follows: A leak is a flow of water from one or both flashings, the total rate of flow being equal to or greater than 0.05 liter/hr.

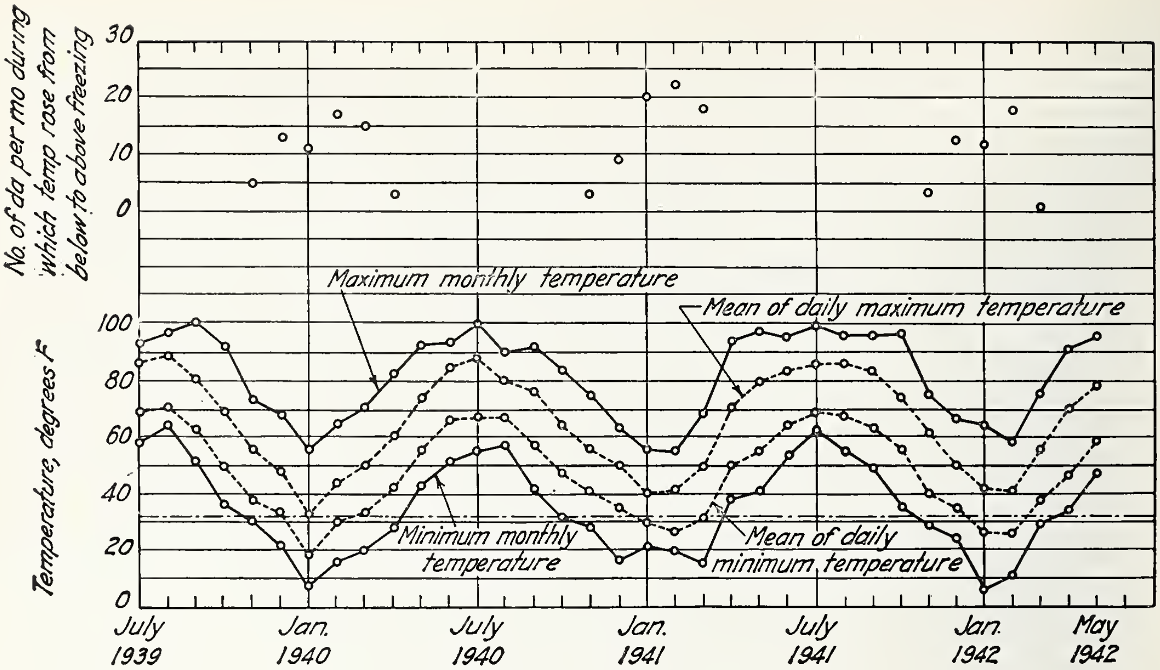


FIGURE 2.—*Temperature record.*

TABLE 4.—*Monthly precipitation at Washington, D. C.*

Month	Year 1939	1940	1941	1942	Normal
	in.	*in.*	*in.*	*in.*	*in.*
January	3.4	2.1	3.0	2.5	3.6
February	5.7	2.8	0.9	2.0	3.3
March	2.9	3.4	2.6	6.0	3.8
April	3.8	6.2	2.7	0.5	3.3
May	0.4	3.1	1.6	3.9	3.7
June	4.6	0.9	4.4	-------	4.1
July	2.0	5.7	5.7	-------	4.7
August	3.2	5.0	1.9	-------	4.0
September	6.9	1.3	0.5	-------	3.2
October	4.1	2.1	1.1	-------	2.8
November	1.4	5.3	0.8	-------	2.4
December	2.2	2.3	3.9	-------	3.3
Total	40.6	40.2	29.1	-------	42.2

VI. CEMENT-WATER PAINTS

1. MATERIALS AND CONSISTENCY

The proportions of the materials used in the cement-water paint treatments are listed in table 5. The dry powders contained white portland cement and hydrated lime, with or without admixtures of hygroscopic salts, water repellents, diatomaceous silica [4] an opaque pigment,[5] or finely screened Potomac River sand.

The cement contained no integral waterproofing and met the physical requirements of Federal Specification SS–C–191a. The hydrated lime used in paint 5 (table 5) was Certainteed brand dolomitic lime having a plasticity[6] figure of 530.

The hydrated lime used in the other cement-water paints was Berkeley brand high-calcium lime having a plasticity figure of 120.

The amount of water used in mixing the paints was calculated from that required to attain normal consistency of a paste, as determined according to Federal Specification SS–C–158–F4i. Paint 1 was mixed in three different consistencies, designated as thick, normal, and thin; the paint of each consistency containing, respectively, two, three, and four times the amount of water needed for normal consistency of the paste, according to the specification. Paints 2 to 14, inclusive, were mixed in the normal consistency only (table 5). The grouts used as the first coats in treatments 16 and 17 were of a relatively thicker consistency than the paints, in order to more easily maintain the aggregate in suspension.

[4] Dicalite, a diatomaceous silica, pigment grade, purchased from the Dicalite Co., New York, N. Y.

[5] Titanox, a titanium-barium pigment (TiO_2-$BaSO_4$), manufactured by the Titanium Pigment Co., South Amboy, N. J.

[6] Determined according to Federal Specification SS–L–351, Type F.

Table 5.—*Cement-water paint treatments* [a]

Designation	Proportions of cementing materials, by weight [b]	Kind and proportions of admixture, by weight	Normal water content by weight of dry materials
			Percent
1	70% cement *A*, plus 30% lime *C*.	None	[c] 100.8
2	100% cement *A*	do	67.8
3	90% cement *A* plus 10% lime *C*.	do	78.0
4	60% cement *A* plus 40% lime *C*.	do	114.0
5	70% cement *A* plus 30% lime *D*.	do	97.8
6	98% paint 1	2% NaCl	99.0
7	98% paint 1	2% $CaCl_2$	94.8
8	94% paint 1	6% NaCl	89.4
9	94% paint 1	6% $CaCl_2$	103.8
10	99.8% paint 1	0.2% calcium stearate	102.9
11	99.8% paint 1	0.2% ammonium stearate	103.2
12	95% paint 1	5% Dicalite	116.4
13	97% paint 1	3% TiO_2–$BaSO_4$	96.0
14	94% paint 1	6% TiO_2–$BaSO_4$	93.6
16	(d)	(d)	(d)
17	(e)	(e)	(e)

[a] Treatments 1 to 14, inclusive, consisted of 2 coats of the same kind and consistency of paint.
[b] Cement *A* was Atlas brand white portland cement, lime C was Berkeley brand high-calcium hydrated lime, and lime *D* was Certainteed brand dolomitic hydrated lime.
[c] Normal water content was 100.8 percent. The thick and thin consistencies of paint 1 contained, respectively, 67.2 and 134.4 percent of water.
[d] First, or seal, coat was a grout. The dry materials in the grout contained 60 per cent of sand passing a No. 16 sieve and 40 percent of Penn-Dixie brand gray portland cement by weight. Water content by weight of dry materials was 25 percent. Finish coat was paint 1, normal consistency.
[e] The dry materials in the seal coat contained 56 percent of sand passing a No. 50 sieve, and 44 percent of Medusa white portland cement, by weight. Water content was 36 percent by weight of dry materials. Finish coat was 99.8 percent Medusa white cement and 0.2 percent ammonium stearate, by weight. The water content was 58 percent by weight of dry materials.

The paints were prepared by slowly adding water to the dry powder, with constant stirring until a thick, smooth paste was formed. Additional water was then mixed with the paste until the proper paint consistency, as noted above, was reached.

2. Method of Application and Curing

(*a*) *Preparation of the Walls for Painting*

The walls were tested for permeability and then dried before being prepared for painting. Dust and loose mortar particles were removed from the faces, and the moisture content of the walls at the time of painting was as shown in column 5 of table 6. For "normal" moisture content, the walls were wetted with one-fourth of the total quantity of water absorbed during the permeability test. The water was slowly and uniformly applied to the face to be painted, and only a small quantity of water dripped from the wall. The amounts of water applied for normal moisture content of 8-in. walls of brick *c* and blocks *m* and *n* were, respectively, 2.4, 1.8, and 1.3 lb/ft² of wall area. No water was

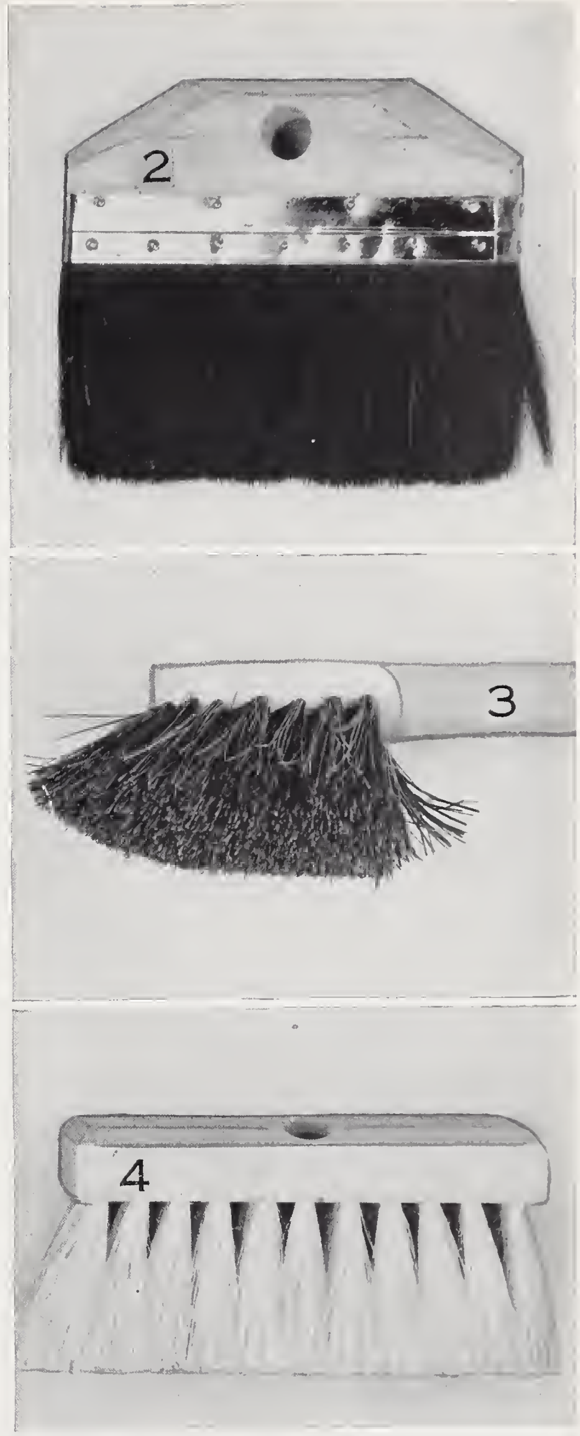


Figure 3.—*Brushes used to apply the cement-water paints and some other waterproofings.*

Brush 2 was a whitewash brush, brush 3 a fender-cleaning brush, and brush 4 a roofing brush.

applied to the walls listed as "dry" in column 5 (table 6), and those listed as "wet" were saturated by exposure for 16 or more hours to streams of water from a perforated tube. About 1 hr elapsed after the walls were wetted and before they were painted, and no water was visible on the wall faces when the paint was applied.

(*b*) *Kinds of Brushes*

The three kinds of brushes, numbered 2, 3, and 4, shown in figure 3 were used to apply the cement-water paints. Brush 2 was a whitewash brush with soft, flexible bristles 3¼ in. long. Brush 3 was a fender-cleaning brush about 6 in. wide and comparable in stiffness to the common scrub brush. The 2-in. fibers were made of stiff Palmyra (*borassus flabellifer*) fiber. Brush 4 was made by the Oxfiber Co., Frederick, Md., under the trade name of Perry roofing brush. This brush was 2½ in. wide and 7 in. long. It was intermediate in stiffness to brushes 2 and 3 and was made of Tampico fibers (*agave heteracantha*) 2½ in. long.

TABLE 6.—*Application and curing of cement-water paint treatments*

Wall	Designation [a]	Group number [b]	Type of brush [c]	Moisture content of backing [d]	Consistency of paint [e]	Amount of dry powder applied per 100 ft.²			Curing conditions [f]	
						First coat	Second coat	Two coats	Temperature	Moisture
1	2	3	4	5	6	7	8	9	10	11
						lb	*lb*	*lb*		
B162	1*m*	I, II, III, V, VI	3	Normal	Normal	10.1	4.1	14.2	Normal	Normal.
B310	1*m*	I, II, III, V, VI	3	do	do	10.7	8.1	18.8	do	Do.
B172	1*n*	I, II, III, V, VI	3	do	do	14.1	5.1	19.2	do	Do.
B54	1*cc*	I	3	do	do	14.3	5.7	20.0	do	Do.
B163	1*m*	I	4	do	do	7.0	2.9	9.9	do	Do.
B173	1*n*	I	4	do	do	13.6	5.0	18.6	do	Do.
B56	1*cc*	I, II, III	4	do	do	17.1	3.1	20.2	do	Do.
B164	1*m*	I	2	do	do	7.2	2.7	9.9	do	Do.
B313	1*m*	I	2	½ normal	do	7.5	7.1	14.6	do	Do.
B181	1*n*	I	2	Normal	do	15.4	7.7	23.1	do	Do.
B315	1*n*	I	2	½ normal	do	11.0	8.4	19.4	do	Do.
B57	1*cc*	I	2	Normal	do	17.4	3.8	21.2	do	Do.
B180	1*m*	II	3	Dry	do	9.6	4.2	13.8	do	Do.
B191	1*n*	II	3	do	do	14.8	6.2	21.0	do	Do.
B62	1*cc*	II	4	do	do	15.2	5.1	20.3	do	Do.
B196	1*m*	II	3	Wet	do	6.7	2.9	9.6	do	Do.
B312	1*m*	II	3	do	do	12.6	7.3	19.9	do	Do.
B202	1*n*	II	3	do	do	13.7	4.8	18.5	do	Do.
B65	1*cc*	II	4	do	do	5.2	2.9	8.1	do	Do.
B171	1*m*	III	3	Normal	Thin	7.1	3.3	10.4	do	Do.
B323	1*m*	III	3	do	do	12.5	6.8	19.3	do	Do.
B182	1*n*	III	3	do	do	12.6	6.1	18.7	do	Do.
B60	1*cc*	III	4	do	do	11.4	5.2	16.6	do	Do.
B177	1*m*	III	3	do	Thick	9.6	4.5	14.1	do	Do.
B324	1*m*	III	3	½ normal	do	12.2	9.7	21.9	do	Do.
B183	1*n*	III	3	Normal	do	19.1	6.6	25.7	do	Do.
B61	1*cc*	III	4	do	do	18.0	4.3	22.3	do	Do.
B329	1*cc*	III	4	½ normal	do	18.7	6.9	25.6	do	Do.
B178	1*m*	IV, V	3	Normal	Normal	8.4	3.2	11.6	do	Wet.
B309	1*m*	IV, V	3	do	do	15.9	6.9	22.8	do	Do.
B184	1*n*	IV, V	3	do	do	16.5	4.8	21.3	do	Do.
B314	1*n*	IV, V	3	do	do	14.7	8.6	23.3	do	Do.
B187	1*m*	IV	3	do	do	8.8	4.1	12.9	35° F	Do.
B193	1*n*	IV	3	do	do	15.3	6.5	21.8	35° F	Do.
B179	1*m*	IV	3	do	do	8.0	4.6	12.6	120° F	Do.
B185	1*n*	IV	3	do	do	13.4	6.5	19.9	120° F	Do.
B190	1*m*	V	3	do	do	9.1	3.3	12.4	Normal	Dry.
B201	1*n*	V	3	do	do	15.0	5.7	20.7	do	Do.
B186	2*m*	VI	3	do	do	10.3	3.3	13.6	do	Normal.
B192	2*n*	VI	3	do	do	18.3	7.3	25.9	do	Do.
B197	3*m*	VI	3	do	do	11.1	3.7	14.8	do	Do.
B311	3*m*	VI	3	do	do	14.9	7.6	22.5	do	Do.
B203	3*n*	VI	3	do	do	17.3	7.4	24.7	do	Do.
B319	3*n*	VI	3	do	do	9.6	8.4	18.0	do	Do.
B188	4*m*	VI	3	do	do	9.3	3.0	12.3	do	Do.
B308	4*m*	VI	3	do	do	10.0	7.5	17.5	do	Do.

[a] The number designates the kind of paint (table 5), the letter designates the kinds of units in the backing.
[b] The walls are divided into groups according to the variable given in section VI-3 of the text.
[c] Brush 2 was a whitewash brush; brush 3, a fender-cleaning brush; and brush 4, a roofing brush.
[d] Walls of normal moisture content contained one-fourth the amount of water absorbed during a permeability test made before treatment. Wet walls were nearly saturated, with no water showing on the surface. Dry walls were not wetted.
[e] See table 5 for water content of the paints.
[f] Walls given normal curing were stored indoors and wetted twice daily for 3 days. Walls cured at temperatures of 35° and 120° F. were placed for 1 week in rooms with controlled temperature, after which they were stored indoors. Wet-cured walls were wetted twice daily and draped with damp burlap for 1 week. Dry-cured walls were not wetted.

Table 6.—*Application and curing of cement-water paint treatments*—Continued

Wall	Designation [a]	Group number [b]	Type of brush [c]	Moisture content of backing [d]	Consistency of paint [e]	Amount of dry powder applied per 100 ft.²			Curing conditions	
						First coat	Second coat	Two coats	Temperature	Moisture
1	2	3	4	5	6	7	8	9	10	11
						lb	*lb*	*lb*		
B204	4*n*	VI	3	Normal	Normal	14. 2	4. 7	18. 9	Normal	Normal.
B189	5*m*	VI	3	do	do	9. 3	3. 1	12. 4	do	Do.
B320	5*m*	VI	3	do	do	12. 4	9. 5	21. 9	do	Do.
B195	5*n*	VI	3	do	do	15. 5	5. 8	21. 3	do	Do.
B199	6*m*	VII	3	do	do	8. 8	3. 4	12. 2	do	Do.
B205	6*n*	VII	3	do	do	14. 3	7. 2	21. 5	do	Do.
B200	7*m*	VII	3	do	do	8. 8	3. 0	11. 8	do	Do.
B211	7*n*	VII	3	do	do	13. 0	5. 5	18. 5	do	Do.
B206	8*m*	VII	3	do	do	8. 8	3. 3	12. 1	do	Do.
B212	8*n*	VII	3	do	do	12. 4	6. 2	18. 6	do	Do.
B316	8*n*	VII	3	½ normal	do	10. 9	8. 1	19. 0	do	Do.
B207	9*m*	VII	3	Normal	do	8. 5	3. 8	12. 3	do	Do.
B213	9*n*	VII	3	do	do	11. 7	6. 5	18. 2	do	Do.
B208	8*m*	VIII	3	do	do	9. 2	3. 4	12. 6	do	Dry.
B214	8*n*	VIII	3	do	do	12. 7	6. 3	19. 0	do	Do.
B209	9*m*	VIII	3	do	do	8. 8	3. 6	12. 4	do	Do.
B215	9*n*	VIII	3	do	do	11. 8	5. 9	17. 7	do	Do.
B318	9*n*	VIII	3	do	do	11. 2	8. 6	19. 8	do	Do.
B218	10*m*	IX	3	do	do	9. 8	3. 3	13. 1	do	Normal.
B217	10*n*	IX	3	do	do	13. 2	5. 6	18. 8	do	Do.
B219	11*m*	IX	3	do	do	8. 9	4. 2	13. 1	do	Do.
B251	11*n*	IX	3	do	do	9. 1	6. 2	15. 3	do	Do.
B220	12*m*	X	3	do	do	8. 9	2. 6	11. 5	do	Do.
B321	12*m*	X	3	do	do	13. 9	6. 2	20. 1	do	Do.
B252	12*n*	X	3	do	do	8. 2	5. 6	13. 8	do	Do.
B222	13*m*	XI	3	do	do	9. 0	3. 7	12. 7	do	Do.
B254	13*n*	XI	3	do	do	10. 5	6. 2	16. 7	do	Do.
B221	14*m*	XI	3	do	do	9. 5	3. 2	12. 7	do	Do.
B325	14*m*	XI	3	do	do	14. 7	9. 4	24. 1	do	Do.
B253	14*n*	XI	3	do	do	10. 3	6. 4	16. 7	do	Do.
B210	16*m*	XII	(g)	do	do	44. 0[h]	4. 3		do	Do.
B216	16*n*	XII	(g)	do	do	36. 0[h]	5. 2		do	Do.
B123	17*x*	XII	3	do		26. 8[h]	9. 9		do	Do.

[g] Brush 4 was used to apply the grouting coat; brush 3 to apply the finish coat.

[h] Weight of portland cement and sand (see table 5).

(c) *Application of the Paints*

The walls treated with cement-water paints 1 to 14, inclusive, were painted with two coats of the same kind and consistency of paint. The paint was applied, a brushful at a time, in sweeping horizontal strokes. Care was taken to thoroughly cover the surface, but pinholes (formed by the breaking of air bubbles under the wet film) were not brushed over and filled if they appeared several minutes after painting an area. The paint was kept at a uniform consistency by frequent stirring. Three walls were given one coat of cement-water paint over a grout coat (treatments 16 and 17, table 5).

The first coat of paint was applied during the morning hours. The wall was sprayed or lightly brushed with water about 5 hr afterward, and was again wetted the next morning before the application of the second coat. The amounts of dry powder applied per 100 ft² of wall area are given in columns 7, 8, and 9 of table 6.

The quantity of paint applied to a wall depended upon the surface texture of the masonry units, the kind of brush, the water content of the backing, and the technique employed by the individual who did the painting. The walls were built in two series. Those in the first series were painted by investigator *X*, and those in the second by investigator *Y*. The specimens in the second series may be identified in table 6 by their numbers, which are greater than B300. Most of the walls were in the first series (painted by investigator *X*), and the following observations were made by this investigator or may be noted from an examination of the data (table 6):

1. Nearly 30 percent more paint was applied to the walls of stone-concrete block (block *m*)

when using the fender brush (brush 3) than when using the other brushes.

2. There were fewer pinholes left in the paint films on the walls of cinder-concrete block (block *n*) when using the fender brush than when using the whitewash brush (brush 2), but the type of brush had little effect on the relative amount of paint applied to such walls.

3. When the moisture content of the backings was normal, nearly 60 percent more paint was applied with the fender brush to the rough-textured cinder-concrete block walls and to the highly absorptive brick walls than to walls of the stone-concrete block.

4. The relative amount of paint applied to walls of stone-concrete block or of brick *c* was considerably less when the backings were wet and nearly saturated with water than was the case when they were of normal moisture content. The paint ran down the faces of the saturated walls B196–1*m* and B65–1*cc* and was not readily absorbed, whereas it tended to "cake" when applied to the surface of the dry wall B62–1*cc*.

After painting the walls in group I, table 6, it was decided to use brush 3 for painting the stone- and the cinder-concrete block walls in groups II to XII, inclusive, and to use brush 4, roofing brush, for painting the brick walls in these groups. The only exceptions to this decision were made in applying the grout (treatment 16, table 5) for the first coat on walls B210 and B216. It was found that the sanded paints could be applied more easily with the roofer's brush (brush 4) than with brush 3, and brush marks on the grout coat were less prominent when brush 4 was used.

Although investigators *X* and *Y* painted similar walls with the same kind and consistency of paint, using the same brushes, it was noted that investigator *Y* used considerably more paint than did *X*. For walls of the stone-concrete block, the increase in the amount of paint applied by *Y* over that applied by *X* averaged 40 and 140 percent for the first and second coats. Investigator *Y* applied less paint for the first coat on the cinder-concrete block walls, but he averaged 40 percent more paint for the second coat than did *X*. Since, as previously noted, the surface texture of the second shipment of cinder-concrete block *n* was smoother than that on the units in the original group of walls, and since the amount of paint applied to cinder-block walls by both investigators was uniformly greater than that applied to the stone-concrete block, it is evident that surface texture was an important factor affecting the amount of paint applied, especially for the first coat.

Walls of brick *c*, normal moisture content, were wet enough to satisfy the painters, but they still had a considerable absorptive capacity and required more paint than did the walls of stone-concrete block. The lower absorptive capacity of the stone-concrete block of the second shipment (table 2), and used in the second series of walls, probably affected the amount of paint applied in the first coats.

(*d*) *Curing of the Coatings*

The temperature and moisture conditions to which the cement–water-paint treatments were subjected are given in columns 10 and 11, table 6. Wall coatings cured under "normal" temperature and moisture conditions were stored at room temperature and humidity and were wetted twice daily for 3 days after application of the second coat. The average, maximum, and minimum temperatures during "normal" curing of the walls were 75°, 85°, and 60° F, respectively. Similarly, the average, maximum, and minimum relative humidities, during normal curing, were 55, 70, and 40 percent. The dry-cured walls were stored at room temperature and humidity without wetting. The wet-cured walls were wetted twice daily for 1 week and draped with wet burlap supported a few inches from the painted faces. Some of the wet-cured walls were exposed to temperatures of 35° or 120° F for 1 week, after which they were stored at room temperature and humidity without further wetting. It was noted that the first coats applied to walls B187 and B193 (group IV, table 6) had not quite hardened after curing for 1 day at 35° F, when the second coats were applied. The paint coatings on all the walls were at least 1 month old before they were tested for permeability.

(e) Condition of the Cured Paint Coatings

The cement-water paint coatings were inspected after the walls had been cured and stored indoors for an average of about 11 months and just before they were tested for permeability. Most of the coatings were in excellent condition, some were slightly crazed, and those on about 20 walls, listed in table 7, were flaked or contained pinholes or larger openings. The reasons for the blistering and subsequent flaking of the outer paint films, which occurred only in walls of the first series, were not determined. The incidence of flaking in paint coatings on stone-concrete block, cinder-concrete block, and brick walls was, respectively, 50, 25, and 0 percent. None of the walls given dry curing was flaked, whereas half of those (of the first series) given wet curing were flaked. The walls of the first series were painted during the late spring and summer, and those of the second series during the winter, when the relative humidity of the air indoors (heated air) is usually lower than in the summer. The flaking was most pronounced in the lower portions of the walls, and the suction of the backings, which had been wetted before the second coat was applied, was probably low, so that the bond between the coats in walls given wet curing may not have developed properly. The rough texture of the units in cinder-concrete block walls may have produced a mechanical bond for the second paint coating, which reduced the incidence of flaking in these walls.

Pinholes and larger openings in the coatings resulted from the technique used in painting, which was intended to duplicate job practice, so that exceptionable care was not taken to "touch up" the walls after they had been painted. Some of the walls listed in table 7 were given additional treatment, and duplicate specimens of others were built and tested. (The numbers of the duplicate specimens are greater than B300.)

Coatings of the thin-consistency paint were very low in hiding power when wet. Since the hiding power of the paint coatings was lower when damp than when dry, the coatings containing hygroscopic salts often appeared to have a lower hiding power than similar ones prepared without the salts.

An examination was made of the paint coats on some walls that were damaged by overturning. It was found that the cement-water paint had penetrated a distance of ⅜ in. into some of the cinder-concrete block and to a greater distance into the joints between these block. The paint did not penetrate deeply into the brick or the stone-concrete block, but did penetrate a maximum of about ⅜ in. into the joints of walls containing these units.

TABLE 7.—*Tabulation of defects in cement-water paint coatings* [a]

Wall	Designation	Group [b]	Kind and extent of defects [c]
B162	1*m*	I, II III, V, VI	Severe flaking in lower half of wall.
B164	1*m*	I	Moderate flaking in lower half of wall.
B181	1*n*	I	Severe flaking; many pinholes.
B315	1*n*	I	Openings, pinholes near the joints.
B196	1*m*	II	Severe flaking.
B202	1*n*	II	Slight flaking in two blocks.
B171	1*m*	III	Slight flaking in one block.
B182	1*n*	III	Slight flaking at openings near the joints.
B60	1*cc*	III	Openings near the joints.
B177	1*m*	III	Severe flaking, lower two-thirds of wall.
B183	1*n*	III	Slight flaking.
B178	1*m*	IV, V	Severe flaking.
B184	1*n*	IV, V	Severe flaking in lower half of wall. Opening in face.
B179	1*m*	IV	Slight flaking over joints.
B186	2*m*	VI	Slight flaking.
B197	3*m*	VI	Do.
B188	4*m*	VI	Do.
B189	5*m*	VI	Moderate flaking.
B200	7*m*	VII	Slight flaking.
B220	12*m*	X	Severe flaking.
B221	14*m*	XI	Do.

[a] The paint coatings were examined after curing them and before the walls were tested for permeability. Slight defects in the coatings on some walls are not reported in the table.

[b] The walls are divided into groups according to the variable given in section VI-3 of the text.

[c] Flaking; Loss of outer paint film after preliminary blistering of the second paint coating, usually over small isolated areas. Openings were formed by air bubbles (pinholes) or by the failure of the paint film to cover and fill rough-textured areas.

3. Some Factors Affecting the Permeability of the Cement-Water Paint Coatings

Data obtained from permeability tests made on walls painted with cement-water paints are given in table 8. The walls are listed by groups in tables 6 and 8, according to the following variables:

Group	*Variant*
I	Brushes.
II	Moisture content of backing.
III	Water content of paint.
IV	Temperature of curing.
V	Moisture condition of curing.
VI	Cement-lime paint mixtures.

Group	*Variant*
VII	Admixture of hygroscopic salts.
VIII	Admixture of hygroscopic salts (dry curing).
IX	Admixture of water repellents.
X	Admixture of diatomaceous silica.
XI	Admixture of an opaque pigment.
XII	Grouting of the first coat.

The data in the first and second lines for each wall are for tests made, respectively, before and after treatment (see column 4). Data for tests made after additional treatment or after a period of outdoor exposure are given in the bottom lines.

TABLE 8.—*Permeability of walls treated with cement-water paints*

Wall	Designation [a]	Group [b]	Condition of wall, and period of outdoor exposure	Time [c] to failure as indicated by— Dampness on back	Water on back	Leakage from flashings	Maximum rate of leakage per hour	Area damp in 1 day	Rating
1	2	3	4	5	6	7	8	9	10
				hr	*hr*	*hr*	*Liters*	*Percent*	
B162	1*m*	I, II, III, V, VI	Before treatment	0.07	0.08	0.2	95	95	*VP*
			After painting [d]	.9	2.2	6.0	0.97	45	*P*
			Additional paint treatment	18 ±4				5	*G*
			May 1940 to Aug. 1941	10 ±2				10	*G*
B310	1*m*	I, II, III, V, VI	Before treatment	0.06	0.07	0.08	126	55	*VP*
			After painting	113			0	1	*E*
			Mar. 1941 to Mar. 1942	10 ±2		39 ±5	.09	10	*G*
B172	1*n*	I, II, III, V, VI	Before treatment	0.07	.07	0.07	137	80	*VP*
			After painting	11 ±3		52	0.13	1	*G*
			Sept. 1939 to Aug. 1941	28		76	.1	0	*G*
B54	1*cc*	I	Before treatment	0.1	.1	0.2	14.1	95	*VP*
			After painting				0	0	*E*
			July 1939 to Aug. 1941	18 ±3			0	1	*E*
B163	1*m*	I	Before treatment	0.15	.2	.1	10	80	*VP*
			After painting	5.2			0	65	*F*
			Sept. 1939 to Aug. 1941	11 ±3			0	15	*G*
B173	1*n*	I	Before treatment	0.05	.07	.05	142	80	*VP*
			After painting	25			0	0	*G*
			Sept. 1939 to Aug. 1941	49		43	.09	1	*G*
B56	1*cc*	I, II, III	Before treatment	0.2	.2	0.3	92	95	*VP*
			After painting	42			0	0	*G*
			July 1939 to Aug. 1941	1			0	40	*G*
B164	1*m*	I	Before treatment	0.1	.15	.4	9	92	*VP*
			After painting [d]	3.8	14 ±5	14 ±5	0.14	75	*F*
			Mar. 1940 to Aug. 1941	5.6			0	70	*F*
B313	1*m*	I	Before treatment	0.03	0.06	0.1	106	95	*VP*
			After painting				0	0	*E*
			Mar. 1941 to Mar. 1942	11 ±2			0	55	*F*
B181	1*n*	I	Before treatment	0.03	.03	.07	84	90	*VP*
			After painting [d]	.08	.1	.07	9.8	65	*VP*
			Mar. 1940 to Aug. 1941	.07	.3	.03	8.2	45	*VP*
B315	1*n*	I	Before treatment	.03	.03	.03	92	50	*VP*
			After painting [d]	.2	.04	1.0	1.4	10	*P*
			Mar. 1941 to Mar. 1942	.6	15 ±5	0.8	1.5	15	*P*
B57	1*cc*	I	Before treatment	.03	0.25	.3	76		*VP*
			After painting	1.4			0	65	*F*
			April 1940 to Aug. 1941	1.8			0	15	*G*
B180	1*m*	II	Before treatment	0.05	.07	.2	98	95	*VP*
			After painting	4	13 ±6	13 ±6	0.2	90	*F*
			Mar. 1940 to Aug. 1941	1.5	3.6	15 ±6	.14	50	*F*
B191	1*n*	II	Before treatment	0.03	0.03	0.06	62	85	*VP*
			After painting	3.3		15 ±6	0.04	8	*G*
			Mar. 1940 to Aug. 1941	0.5			0	5	*G*
B62	1*cc*	II	Before treatment	.05	.07	0.3	52	100	*VP*
			After painting	1.3			0	75	*F*
			April 1940 to Aug. 1941	3.7			0	15	*G*
B196	1*m*	II	Before treatment	0.05	.07	.2	71	90	*VP*
			After painting [d]	4.6			0	35	*G*
			April 1940 to Aug. 1941	4.4			0	45	*G*
B312	1*m*	II	Before treatment	0.03	.05	.08	118	95	*VP*
			After painting				0	0	*E*
			Mar. 1941 to Mar. 1942	15 ±5			0	20	*G*
B202	1*n*	II	Before treatment	0.03	.03	.05	104	90	*VP*
			After painting [d]	62 ±8			0	0	*E*
			April 1940 to Aug. 1941	1.4			0	20	*G*
B65	1*cc*	II	Before treatment	0.08	.1	.2	69	95	*VP*
			After painting	10 ±3			0	25	*G*
			April 1940 to Aug. 1941	3.4			0	40	*G*
B171	1*m*	III	Before treatment	0.07	0.09	0.3	133	100	*VP*
			After painting [d]	.4		.2	5.5	50	*VP*
			Additional painting	10 ±3			0	30	*G*
			May 1940 to Aug. 1941	10 ±2			0	30	*G*
B323	1*m*	III	Before treatment	0.05	.07	.09	147	90	*VP*
			After painting	10 ±2			0	2	*E*
			April 1941 to April 1942	10 ±2	18 ±3		0	70	*F*

See footnotes at end of table.

TABLE 8.—*Permeability of walls treated with cement-water paints*—Continued

Wall	Designation [a]	Group [b]	Condition of wall, and period of outdoor exposure	Time [c] to failure as indicated by—			Maximum rate of leakage per hour	Area damp in 1 day	Rating
				Dampness on back	Water on back	Leakage from flashings			
1	2	3	4	5	6	7	8	9	10
				hr	*hr*	*hr*	*Liters*	*Percent*	
B182	1*n*	III	Before treatment	0.03	0.03	.07	53	90	*VP*
			After painting [d]	.1	.1	.2	23	70	*VP*
			Additional treatment	.1	.2	1.3	2.8	52	*P*
			April 1940 to Aug. 1941	.3	1.8	3.8	3	45	*P*
B60	1*cc*	III	Before treatment	.02	0.03	0.2	79	100	*VP*
			After painting [d]	.85	3.6	3.6	0.65	75	*F*
			Additional treatment	4	------	------	0	20	*G*
			May 1940 to Aug. 1941	3.2	28	------	0	20	*G*
B177	1*m*	III	Before treatment	0.05	0.07	.2	119	100	*VP*
			After painting [d]	10 ±2	18 ±4	18 ±4	0.2	60	*F*
			May 1940 to Sept. 1941	9 ±2	------	------	0	20	*G*
B324	1*m*	III	Before treatment	0.06	0.08	0.09	138	95	*VP*
			After painting	61	------	------	0	0	*E*
			Mar. 1941 to Mar. 1942	19 ±3	------	39 ±6	.08	5	*G*
B183	1*n*	III	Before treatment	0.03	.05	0.07	46	85	*VP*
			After painting [d]	9 ±3	25	------	0	4	*G*
			May 1940 to Sept. 1941	18 ±3	------	------	0	1	*G*
B61	1*cc*	III	Before treatment	0.03	0.05	.2	107	94	*VP*
			After painting	.4	.9	4 ±1	1.4	90	*P*
			June 1940 to Sept. 1941	.7	3.5	------	0	30	*F*
B329	1*cc*	III	Before treatment	.15	0.22	0.35	66	90	*VP*
			After painting	6.1	10 ±2	------	0	25	*F*
B178	1*m*	IV, V	Before treatment	0.03	0.04	.15	72	100	*VP*
			After painting [d]	15 ±6	------	------	0	20	*G*
			Mar. 1940 to Aug. 1941	2.8	------	------	0	25	*G*
B309	1*m*	IV, V	Before treatment	0.04	.04	.04	129	90	*VP*
			After painting	------	------	------	0		*E*
			April 1941 to April 1942	9	------	------	0	25	*G*
B184	1*n*	IV, V	Before treatment	0.04	.05	.08	92	90	*VP*
			After painting [d]	.08	.08	.8	1.8	20	*P*
			Additional treatment	.8	.9	------	0	45	*P*
			June 1940 to Sept. 1941	18 ±4	------	------	0	2	*G*
B314	1*n*	IV, V	Before treatment	0.07	.08	.02	101	60	*VP*
			After painting	------	------	------	0	0	*E*
			April 1941 to April 1942	6.9	------	2.5	.17	4	*F*
B187	1*m*	IV	Before treatment	0.05	.07	0.2	94	100	*VP*
			After painting	5.7	------	15 ±6	0.08	30	*F*
			April 1940 to April 1941	5.7	------	39 ±6	.05	15	*G*
B193	1*n*	IV	Before treatment	0.03	.05	0.07	92	85	*VP*
			After painting	10 ±3	------	------	0	1	*G*
			April 1940 to Sept. 1941	4.5	------	39 ±6	.1	5	*G*
B179	1*m*	IV	Before treatment	0.05	.06	0.2	72	100	*VP*
			After painting [d]	14 ±6	------	------	0	20	*G*
			April 1940 to Aug. 1941	11 ±3	------	------	0	2	*G*
B185	1*n*	IV	Before treatment	0.02	.03	.04	72	85	*VP*
			After painting	18 ±4	------	------	0	1	*G*
			June 1940 to Sept. 1941	10 ±2	43	------	0	5	*G*
B190	1*m*	V	Before treatment	0.07	0.08	.2	130	100	*VP*
			After painting	15 ±6	------	------	0	30	*G*
B201	1*n*	V	Before treatment	0.04	.05	.08	86	90	*VP*
			After painting	17 ±4	------	------	0	1	*G*
			June 1940 to Sept. 1941	53	73	------	0	2	*G*
B186	2*m*	VI	Before treatment	0.05	0.08	.15	93	95	*VP*
			After painting [d]	4.5	------	------	0	45	*G*
			June 1940 to Sept. 1941	------	------	------	0	0	*E*
B192	2*n*	VI	Before treatment	0.03	.03	.06	45	85	*VP*
			After painting	1.5	9 ±3	------	0	13	*F*
B197	3*m*	VI	Before treatment	0.06	0.07	.2	89	100	*VP*
			After painting [d]	9 ±2	------	------	0	3	*G*
			June 1940 to Sept. 1941	58	------	------	0	0	*E*
B311	3*m*	VI	Before treatment	0.04	.08	.08	130	95	*VP*
			After painting	------	------	------	0	0	*E*
			Mar. 1941 to Mar. 1942	28	------	------	0	2	*G*
B203	3*n*	VI	Before treatment	0.02	.02	.08	90	85	*VP*
			After painting	.3	.3	1.2	1.7	22	*P*
			June 1940 to Sept. 1941	.2	.55	1.7	0.9	18	*P*
B319	3*n*	VI	Before treatment	0.05	0.05	0.02	106	60	*VP*
			After painting	------	------	------	0	0	*E*
			March 1941 to March 1942	3.5	------	2.5	0.2	5	*F*
B188	4*m*	VI	Before treatment	0.05	.08	0.2	104	100	*VP*
			After painting [d]	4	------	------	0	72	*F*
			June 1940 to Sept. 1941	11 ±3	------	------	0	35	*G*
B308	4*m*	VI	Before treatment	0.05	.06	.1	120	95	*VP*
			After painting	2.8	------	15 ±6	0.07	55	*F*
			April 1941 to April 1942	6.2	15 ±6	15 ±6	.21	90	*F*
B204	4*n*	VI	Before treatment	0.02	0.02	0.1	88	90	*VP*
			After painting	15 ±6	26 ±2	------	0	9	*G*
			June 1940 to Sept. 1941	18 ±3	------	------	0	1	*G*

See footnotes at end of table.

Table 8.—*Permeability of walls treated with cement-water paints*—Continued

Wall	Designation [a]	Group [b]	Condition of wall, and period of outdoor exposure	Time [c] to failure as indicated by—			Maximum rate of leakage per hour	Area damp in 1 day	Rating
				Dampness on back	Water on back	Leakage from flashings			
1	2	3	4	5	6	7	8	9	10
				hr	*hr*	*hr*	*Liters*	*Percent*	
B189	5*m*	VI	Before treatment	0.06	0.08	.2	81	100	*VP*
			After painting [d]	18 ±4			0	8	*G*
			June 1940 to Sept. 1941	11 ±3	25 ±1		0	20	*G*
B320	5*m*	VI	Before treatment	0.05	0.07	.1	149	95	*VP*
			After painting	19 ±4			0	0	*E*
			Mar. 1941 to Mar. 1942	17 ±4	39 ±6	39 ±6	.07	3	*G*
B195	5*n*	VI	Before treatment	0.04	0.05	0.07	116	90	*VP*
			After painting	15 ±6			0	6	*E*
			June 1940 to Sept. 1941	28			0	1	*E*
B199	6*m*	VII	Before treatment	0.05	.1	.2	108	100	*VP*
			After painting	4.7			0	30	*G*
			June 1940 to Sept. 1941	8			0	2	*G*
B205	6*n*	VII	Before treatment	0.02	.03	.06	79	90	*VP*
			After painting	.3		5.8	0.3	20	*F*
B200	7*m*	VII	Before treatment	.02	.08	0.2	137	100	*VP*
			After painting [d]	2.3			0.2	54	*F*
B211	7*n*	VII	Before treatment	0.04	.05	.07	113	90	*VP*
			After painting	19 ±3		39 ±6	0.2	8	*G*
B206	8*m*	VII	Before treatment	0.04	.07	0.2	125	100	*VP*
			After painting	9 ±2			0	3	*G*
			June 1940 to Sept. 1941	26			0	0	*G*
B212	8*n*	VII	Before treatment	0.03	.03	.09	134	95	*VP*
			After painting	.25	.3		0	25	*P*
			June 1940 to Sept. 1941	11 ±3			0	2	*G*
B316	8*n*	VII	Before treatment	0.1	.1	.01	89	60	*VP*
			After painting				0	1	*E*
			Mar. 1941 to Mar. 1942	29		3.2	.16	0	*F* [e]
B207	9*m*	VII	Before treatment	0.04	.08	0.19	83	100	*VP*
			After painting	8 ±2			0	25	*G*
			June 1940 to Sept. 1941	53			0	0	*G*
B213	9*n*	VII	Before treatment	0.05	.05	.07	68	95	*VP*
			After painting	2.8	5.5	15 ±6	0.75	45	*F*
			June 1940 to Sept. 1941	6.3			0	20	*G*
B208	8*m*	VIII	Before treatment	0.06	0.08	0.2	125	100	*VP*
			After painting	10 ±3			0	8	*G*
			July 1940 to Sept. 1941	34			0	0	*G*
B214	8*n*	VIII	Before treatment	0.04	.05	.09	126	90	*VP*
			After painting	.3		5.5	0.13	30	*F*
			July 1940 to Sept. 1941	.4	1	15 ±6	.06	25	*P*
B209	9*m*	VIII	Before treatment	0.06	0.08	0.2	88	100	*VP*
			After painting	11 ±3		39 ±6	0.04	20	*G*
			July 1940 to Sept. 1941	10 ±2	53		0	8	*G*
B215	9*n*	VIII	Before treatment	0.03	0.03	0.06	112	90	*VP*
			After painting	5.3		11 ±3	0.07	15	*F*
			July 1940 to Sept. 1941	11 ±3	28		0	1	*G*
B318	9*n*	VIII	Before treatment	0.07	0.08	0.01	104	40	*VP*
			After painting	6.2		15 ±6	0.03	5	*E*
			April 1941 to April 1942	1		2.6	.2	10	*F*
B218	10*m*	IX	Before treatment	0.04	.07	0.2	107	100	*VP*
			After painting	5			0	45	*G*
			July 1940 to Oct. 1941	11 ±2			0	10	*G*
B217	10*n*	IX	Before treatment	0.02	.03	.07	138	100	*VP*
			After painting	18 ±3			0	5	*G*
			July 1940 to Oct. 1941	63 ±8			0	0	*E*
B219	11*m*	IX	Before treatment	0.03	.06	.2	118	100	*VP*
			After painting	5			0	35	*G*
			July 1940 to Oct. 1941	11 ±2			0	7	*G*
B251	11*n*	IX	Before treatment	0.04	.05	.02	37	70	*VP*
			After painting				0	0	*E*
			Aug. 1940 to Oct. 1941	3.5		3.1	.5	10	*F*
B220	12*m*	X	Before treatment	0.03	.05	0.02	128	100	*VP*
			After painting [d]	2.9		11 ±3	0.4	75	*F*
			July 1940 to Oct. 1941	5			0	20	*G*
B321	12*m*	X	Before treatment	0.04	.05	0.2	137	90	*VP*
			After painting	5.3		15 ±6	0.07	30	*F*
B252	12*n*	X	Before treatment	0.04	.04	0.05	44	75	*VP*
			After painting	26		19 ±3	0.1	4	*F*
			Aug. 1940 to Oct. 1941	8 ±2		17 ±4	.04	1	*E*
B222	13*m*	XI	Before treatment	0.04	.07	0.2	111	100	*VP*
			After painting	6 ±1			0	25	*G*
			Aug. 1940 to Oct. 1941	26			0	1	*G*
B254	13*n*	XI	Before treatment	0.02	.03	.05	89	85	*VP*
			After painting	11 ±2		18 ±3	0.1	5	*F*
B221	14*m*	XI	Before treatment	0.05	.07	0.2	85	100	*VP*
			After painting [d]	3.5			0	75	*F*
B325	14*m*	XI	Before treatment	0.06	.07	.1	114	90	*VP*
			After painting	4.8			0	30	*G*

See footnotes at end of table.

TABLE 8.—*Permeability of walls treated with cement-water paints*—Continued

Wall	Designation [a]	Group [b]	Condition of wall, and period of outdoor exposure	Time [c] to failure as indicated by— Dampness on back	Water on back	Leakage from flashings	Maximum rate of leakage per hour	Area damp in 1 day	Rating
1	2	3	4	5	6	7	8	9	10
				hr	*hr*	*hr*	*Liters*	*Percent*	
B253	14*n*	XI	Before treatment	0.03	..03	.03	135	70	*VP*
			After painting	2.5	----	14 ±6	0.2	10	*F*
			Aug. 1940 to Oct. 1941	63	----	----	0	1	*E*
B210	16*m*	XII	Before treatment	0.03	.06	0.2	96	100	*VP*
			After painting	11 ±3	----	----	0	10	*G*
			July 1940 to Sept. 1941	----	----	----	0	0	*E*
B216	16*n*	XII	Before treatment	0.04	.04	.07	123	90	*VP*
			After painting	35	----	----	0	0	*E*
			July 1940 to Oct. 1941	111	----	----	0	0	*E*
B123	17*x*	XII	Before treatment	0.2	.2	.08	103	65	*VP*
			After painting	----	----	----	0	0	*E*

[a] The number designates the kind of paint (table 5); the letter designates the kinds of units in the backing.
[b] The walls are divided into groups according to the variable given in section VI-3 of the text.
[c] The uncertainty of the observation is given if it exceeds 10 percent of the total elapsed time. Dashes indicate no failure of the wall.
[d] Some flaking or other defect noted in second paint coat before permeability test was made (see table 7).
[e] Possibly *G*.

(a) *Kind of Brush*

The effect on permeability of the kind of brush used to apply paint 1 to walls of stone- or cinder-concrete block or of brick is shown by the data given for the walls of group I, table 8. The moisture content of the backings, the consistency of the paint, and the curing conditions were normal, as given in table 6. The ratings of these walls, listed in table 9, indicate that brush 3 (fender brush) was the most effective and brush 2 (whitewash brush) the least effective for general use on all three kinds of backings. Brush 4 (roofing brush) was nearly as effective as brush 3, and brush 2 was the least effective when used on the rough-textured cinder-block backings.

TABLE 9.—*Effect of kind of brush on permeability* [a]

Kind of brush	Ratings of walls [b] of different units: Block *m*	Block *n*	Brick *c*
Whitewash brush (No. 2)	[c] *F, E*	[d] *VP, P*	*F*
Fender-cleaning brush (No. 3)	[e] *G, E*	*G*	*E*
Roofers brush (No. 4)	*F*	*G*	*G*

[a] Walls painted with cement-water paint 1 (group I, tables 6 and 8).
[b] If 2 ratings are given, they are for separate walls.
[c] Moderate flaking noted in outer paint film before the test.
[d] Severe flaking and many pinholes noted in outer paint film before the test.
[e] Outer coating badly flaked; test made after repainting.

(b) *Kind of Backing and Its Moisture Content*

The performance ratings of the walls of group II (tables 6 and 8) are given in table 10. The walls were painted with paint 1 and were cured under normal conditions. Walls of normal or wet moisture content were rated *G* or *E*. Two of the three walls that were not wetted but were dry when painted were rated *F*. The other, of cinder-concrete block, was rated *G*. The wetted walls were nearly saturated, but no water was visible on the backings when they were painted. Paint coatings applied to the wet backings were most resistant to water penetration, but a wide range in moisture content of the backings (normal to wet) had little important effect on permeability. The kind of masonry unit in the backings had no important effect on the permeability of the paint coatings applied to walls of normal or wet moisture content.

TABLE 10.—*Effect of kind of backing and of moisture content on permeability* [a]

Kind of masonry unit in backing	Ratings of walls [b] of different moisture contents when painted: Dry	Normal	Wet
Stone-concrete block *m*	*F*	[c] *G, E*	[d] *G, E*
Cinder-concrete block *n*	*G*	*G*	*E*
Brick *c*	*F*	*G*	*G*

[a] Walls painted with cement-water paint 1 (group II, tables 6 and 8).
[b] If 2 ratings are given, they are for separate walls.
[c] Outer coating badly flaked; test made after repainting.
[d] Severe flaking noted in outer paint coating before test.

(c) *Paint Consistency*

The effects of paint consistency on the permeability of the walls in group III are given in table 11. The thin, normal, and thick consistencies of paint 1 contained, respectively, 134, 101, and 67 percent of water by weight of dry powder (table 5). The data (tables 8 and 11) show that walls of cinder-concrete block and of brick (walls B182 and B60), treated with thin paint, were rated *VP* and *F*, respectively. These walls were again tested after having been repainted with one coat of the same consistency, and their ratings, not shown in table 11, were raised to *P* and *G*, respectively. Of the two walls of stone-concrete block, treated with thin paint, one was rated *VP* and one *E*. However, nearly twice as much paint was applied to wall B323, rated *E*, as was used on wall B171 (table 6). The walls of concrete block treated with paint of normal or thick consistency, and not damaged by flaking, were rated *G* or *E*. The brick wall treated with paint of normal consistency was rated *G*; those treated with thick paint were rated *P* or *F*.

The data are meager, but they indicate that the thin paints applied to concrete-block walls were ineffective unless heavy or repeated applications of the paint were made.

TABLE 11.—*Effect of paint consistency on permeability*[a]

Consistency of paint [b]	Ratings of walls [c] of different units		
	Block *m*	Block *n*	Brick *c*
Thin	*VP, E*	*VP*	*F*
Normal	[d]*P, E*	*G*	*G*
Thick	[d]*F, E*	*G*	*P, F*

[a] Walls painted with cement-water paint 1 (group III, tables 6 and 8).
[b] Paint 1, of thin, normal, and thick consistency, contained, respectively, 134.4, 100.8, and 67.2 percent water, by weight of dry powder.
[c] If two ratings are given, they are for separate walls.
[d] Severe flaking noted in outer coating before test.

(*d*) *Curing Conditions*

The effects of temperature and moisture conditions during the curing of the cement-water paint coatings applied to walls built of concrete blocks (groups IV and V, tables 6 and 8) are given in table 12. Wall B187–1*m* given a wet curing at 35° F was rated *F*, but the comparison specimen, built of cinder- instead of stone-concrete block, was rated *G*. The walls given wet curing for 1 week at a temperature of 120° F showed a satisfactory resistance to water penetration, and in general the range in temperature had no important effect on permeability. Similarly, the walls cured at normal temperatures and under the range of moisture conditions of dry, normal, and wet had an average performance rating of *G*, and the effects on permeability of the differences between the given moisture conditions during curing were unimportant. It should be noted, however, that the test walls were of normal moisture content when painted, and that cement-water paint coatings applied to dry building walls exposed without wetting to the wind and sun may be more permeable than those on the test specimens.

TABLE 12.—*Effects of temperature and moisture conditions during curing on permeability* [a]

Type of curing [b]		Ratings of walls [c] of different units	
Temperature	Moisture condition	Block *m*	Block *n*
35° F	Wet	*F*	*G*
Normal	Dry	*G*	*G*
	Normal	[d]*G, E*	*G*
	Wet	[e]*G, E*	[d]*P, E*
120° F	Wet	*G*	*G*

[a] Walls painted with cement-water paint 1 (groups IV and V, tables 6 and 8 respectively).
[b] Walls given normal curing were stored indoors and wetted twice daily for 3 days. Walls cured at temperatures of 35° and 120° F were placed for 1 week in rooms with controlled temperature, after which they were stored indoors. Wet-cured walls were wetted twice daily and draped with damp burlap for 1 week. Dry-cured walls were not wetted.
[c] If 2 ratings are given, they are for separate walls.
[d] Outer coating badly flaked; test made after repainting.
[e] Severe flaking noted in outer coating before test.

(*e*) *Kind of Paint and of Admixtures*

The effects of the relative proportions of portland cement and hydrated lime and of the kind of hydrated lime on the permeability of the walls treated with cement-water paints may be noted from the data in table 8 for the walls listed in group VI.

There was no important difference between the average permeability of the walls treated with paints 1 to 5, and all but a few of the walls showed a satisfactory resistance to water penetration. Five of the walls whose coatings were not flaked when tested gave *E* performances; and of the remainder, two were rated *G*, two *F*, and one *P*. In general, the painted walls built of stone-concrete block were less permeable than those built of cinder block. The cinder-concrete units were more difficult to paint than the stone-concrete block, and it is probable that flaking or pinholes in the paint coatings affected the permeability of the specimens more than did the relative proportions of cement and lime.

The admixture of hygroscopic salts in cement-water paints had no important effect on the permeability of the test walls (see table 13). The walls treated with paint 1 and given either dry or normal curing were in most cases slightly less permeable than those treated with paints 6, 7, 8, or 9, which contained sodium or calcium chloride. The backings of the specimens were of normal moisture content, and it is possible that the admixture of hygroscopic salts in paints applied to dry backings or cured outdoors without wetting may be of benefit.

TABLE 13.—*Effect on permeability of hygroscopic salts in cement-water paint* [a]

Paint [b]	Kind and proportion, by weight, of hygroscopic salts		Rating of the walls [c]			
			Normal curing of walls of—		Dry-curing of walls of—	
	Sodium chloride	Calcium chloride	Block *m*	Block *n*	Block *m*	Block *n*
	%	%				
1	0	0	[d] *G, E*	*G*	*G*	*G*
6	2	0	*G*	*F*	---	---
7	0	2	*F*	*G*	---	---
8	6	0	*G*	*P, E*	*G*	*F*
9	0	6	*G*	*F*	*G*	*F, E*

[a] Data on the application and curing of the paint and on the permeability of the walls are contained in tables 6 and 8; walls painted with paint 1 are listed in groups I and V, the others in groups VII and VIII.
[b] The composition and proportions of the paints are given in table 5.
[c] If two ratings are given, they are for separate walls.
[d] Outer coating badly flaked; test made after repainting.

The permeability of the paint coatings containing calcium or ammonium stearates (paints 10 and 11, table 5) may be obtained from the data in table 8 for the walls in group IX. These walls were rated *G* or *E* and their performances were comparable to those of similar walls (group I) treated with paint 1, prepared without ammonium stearate. No significant differences were noted in the permeabilities of coatings of paints 1, 10, or 11.

The effects on permeability of the admixture of 5 percent of Dicalite (diatomaceous silica) in cement-water paint may be determined by an examination of the data in table 8 for walls B310–1*m* and B172–1*n* of group I and for walls B321–12*m* and B252–12*n* of group X. The data clearly indicate that coatings containing Dicalite, paint 12, were significantly more permeable than similar ones prepared without it. The walls treated with paint 12 were rated *F* when tested immediately after painting, those treated with paint 1 were rated *G* or *E*.

Data on the permeability of concrete-block walls painted with cement-water paints 13 or 14, containing Titanox, an opaque pigment, are given in table 8 for walls of group XI. These paints were effective on backings of stone-concrete block *m* and the walls were rated *G*. Cinder-concrete block walls, similarly treated, were rated *F*. Paints 13 and 14 were comparable in effectiveness to paint 1 when applied to stone-concrete block walls, but they were significantly more permeable than paint 1 when tested immediately after application to cinder-concrete block walls.

(*f*) *Use of a Grout Coat*

Cement-water paints containing fine sand (treatments 16 and 17, table 5) were used for the first coat on walls of stone- or cinder-concrete blocks. The application of a grout to wall B210–16*m*, listed in group XII of table 6, resulted in a considerable loss of the coarser particles of sand, and much less grout adhered to this wall than is indicated in table 6. The sanded paints bonded well to the coarse-textured units in walls B216–16*n* and B123–17–*x*, and the loss of aggregate from these specimens was small. The walls of cinder-concrete block were rated *E*, after painting, that of stone-concrete block was rated *G*, and the data show that the grouts were most effective when applied to the coarse-textured units.

4. Effect of Weathering Exposure on Permeability

The periods of outdoor weathering to which the cement-water paint walls were subjected, given in table 8, show that the average durations of exposure for walls of the first and second series were, respectively, 16 and 12 months.

Some of the paint coatings were so crazed, flaked, or weather-stained after exposure that their repainting, for the sake of appearance, was desirable. The coatings containing stearate waterproofings (paints 10 and 11) were less weather-stained than were others prepared without stearates. Crazing was more severe over the joints of concrete-block backings than over the units, and the reverse was true for most of the coatings applied to brick backings. The paint films on many of the cinder-concrete block backings were spalled over small isolated areas because of popping of the concrete in the faces of the units.

The weathering exposure did not, in general, have an important effect on the permeability of walls treated with cement-water paints. A summary of the ratings, before and after weathering, of walls in the first and second series is given in table 14. Walls of the first series were significantly less permeable after exposure than before. The ratings of walls in the second series were higher immediately after painting than those of the walls in the first; after exposure, they were lower. The average weights of the dry powder applied to backings of concrete blocks *m* and *n* of the first series (walls with numbers lower than B300) were, respectively, 12 and 20 lb/ft^2, and the amount applied to backings of block *m* or *n* of the second series was 20 lb. The cinder-concrete block used in walls of the second series had a smoother surface texture than those used in the walls of the first series, but the paint coatings on walls of the second series were thicker than those of the first. The data indicate that thick coatings of cement-water paints may be more effective when first applied than thinner coatings, but are less effective after weathering exposure.

TABLE 14.—*Effect of weathering exposure on permeability*

Wall-performance rating	Number of walls in each rating classification—			
	First series [a]		Second series [a]	
	Before exposure	After exposure	Before exposure	After exposure
E	5	9	12	0
G	29	37	0	6
F	14	4	1	7
P	5	3	1	1
VP	1	1		-----

[a] Numbers of walls in first series were less than B300; those in the second series were greater (Tables 6 and 8).

An examination of the walls after the weathering exposure indicated that the coatings on the most permeable specimens contained cracks over the joints equal to or greater in width than 0.01 in. Nearly all the walls listed as having flaked coatings were rated *G* or *E* after the weathering exposure, whereas most of the walls containing pinholes or larger openings in the coatings were given lower ratings.

The walls in group X (table 8) treated with coatings containing Dicalite were less permeable after the weathering exposure than before, and their performances were comparable to those of walls treated with paint 1.

Except for the differences noted between the permeabilities of walls of the first and of the second series and for those noted in group X (table 8), the weathering exposure had no important effect on the permeability of any kind or group of specimens.

5. Discussion

The masonry walls treated with cement-water paints were, with few exceptions, highly resistant to water penetration both before and after weathering them outdoors. Walls of coarse-textured cinder-concrete block were painted to best advantage when using a stiff brush, such as the fender brush. Even then, pinholes or larger openings were often left after the painting, and the most effective treatment for coarse-textured walls was the application of a grout coating (a paint containing fine sand) for the first coat. Walls so treated were rated *E*, both before and after weathering.

Although a range in moisture content of the backing, from that of near saturation to a damp condition, had little effect on permeability, dry walls that were painted without prewetting were significantly more permeable than those that were wetted. The paint coatings of normal consistency were less permeable than those of thin consistency. A coating of thick consistency applied to a brick wall was rated lower than one of normal consistency.

The amount of paint applied per unit of wall area increased with the ruggedness of the surface and was greatest for walls of cinder-concrete block. For units of like surface texture, thick paint films resulting from excessive amounts of paint were more resistant to water penetration, when first applied, than thinner coatings. After exposure to the weather, the thick coatings were less resistant. The average performance of the thinner coatings of normal-consistency paint, applied to walls of the first series, was higher after weathering than before.

The range in the relative proportions of portland cement and of hydrated lime in the paints, as well as the number of treated specimens, was limited. Most of the walls were highly resistant to water penetration both before and after weathering, but the data do not clearly indicate that any one of the paints, 1 to 5, inclusive, was superior to the others. Paints containing admixtures of hygroscopic salts, water repellents, diatomaceous silica, or an opaque pigment were no more effective than similar paints prepared without these admixtures. The range of curing conditions to which the walls were subjected did not have an important effect on their permeability.

The assistance of James N. Calhoun (investigator *X*) and Harold L. Manley (investigator *Y*) in constructing the wall specimens, preparing and applying the paints, and making the tests is gratefully acknowledged. Mr. Calhoun also determined the physical properties of the various paint mixtures and gave valuable suggestions during the preparation of this report.

VII. PROPRIETARY WATERPROOFINGS APPLIED TO THE EXPOSED FACES OF THE WALLS

1. Pigmented Surface Coatings

The permeabilities, before and after treatment, and after weathering outdoors, of walls treated with pigmented proprietary waterproofings are given in table 15. The table gives the designation of the walls, their condition when tested, data obtained from the tests, and the performance ratings.

Table 15.—*Permeability of walls treated with pigmented proprietary surface coatings*

Trade name	Wall No.	Designation [a]	Condition of wall and period of outdoor exposure	Time [b] to failure as indicated by—			Maximum rate of leakage per hour	Area damp in 1 day	Rating
				Damp on back	Water on back	Leak from flashing			
				hr.	*hr.*	*hr.*	*Liters*	*Percent*	
Aquaplex	B256	21*n*	Before treatment	0.03	0.04	0.03	75	70	*VP*
			After treatment	.5	2.0	14 ±6	4.6	35	*P*
	B257	22*n*	Before treatment	.03	0.03	0.03	117	70	*VP*
			After treatment	.1	1.0	.6	10	30	*VP*
			Aug. 1940 to Oct. 1941	.2	0.2	.4	7	25	*VP*
	B258	23*n*	Before treatment	.04	0.05	.04	122	75	*VP*
			After treatment	.1	2.0	.3	19	40	*VP*
			Aug. 1940 to Oct. 1941	.2	0.3	.4	22	25	*VP*
Dricoat	B111	24*cc*	Before treatment	.02	0.13	.4	69	10	*VP*
			After treatment	.4	1.7	1.7	13	95	*VP*
Drye	B326	25*cc*	Before treatment	.08	0.1	0.3	108	100	*VP*
			After treatment	17 ±3	---	---	0	5	*G*
			Dec. 1941 to May 1942	1.3	---	---	0	60	*F*
Maure Brush-Tex	B198	26*m*	Before treatment	0.05	0.1	0.2	76	100	*VP*
			After treatment	.3	1.3	.2	7.6	100	*VP*
Maure Plaster Special	B103	27*cc*	Before treatment	.06	0.06	.35	30	95	*VP*
			After treatment	18 ±4	---	---	0	2	*E*
			July 1939 to Aug. 1941	1.5	2.5	15 ±6	1	90	*P*
Tymstone	B303	28[c]	Before treatment [d]	(d)	(d)	(d)	(d)	(d)	(d)
			As received	---	---	---	0	0	*E*
			Nov. 1940 to Jan. 1942	---	---	---	0	0	*E*
			Feb. 1942 to June 1942	---	---	---	0	10	*E*
Varcraft	B223	29*m*	Before treatment	0.04	0.08	0.2	95	100	*VP*
			After treatment	.4	2	1.3	3.5	80	*P*
			Aug. 1940 to Oct. 1941	.3	1.1	3.9	0.4	75	*P*
	B255	29*n*	Before treatment	.04	0.04	0.04	67	70	*VP*
			After treatment	.03	.5	.05	14	50	*VP*

[a] The number designates the kind of waterproofing treatment, the letter designates the kind of units used in the backings.
[b] The uncertainty of the observation is given if it exceeds 10 percent of the total elapsed time. Dashes indicate no failure of the wall.
[c] Backing built of Waylite concrete block laid in and coated with Tymstone mortar.
[d] No test made.

(a) *Aquaplex*

Aquaplex S–6 and Aquaplex Q–68 were emulsified resin paints (waterproofings 21, 22, and 23, table 15), manufactured by the Resinous Products Co., Philadelphia, Pa. Aquaplex S–6 was a thin paste having a specific gravity of 1.03, and, after thinning with water, it was applied as a priming coat in treatment 21. Aquaplex Q–68 was a white pigmented paste, having a specific gravity of 1.38 and was also thinned with water before using it. The waterproofings were applied with a paint brush, either singly, in combination with each other, or with spar varnish, to dry walls built of the cinder-concrete block *n*.

Wall B256–21*n* was given a priming coat made from 4 parts, by volume, of Aquaplex S–6 and 1½ parts of water. The amount of S–6 applied was equivalent to 140 ft²/gal of paste. The second and third coats applied to the wall on successive days after application of the priming coat contained 4 parts, by volume, of Aquaplex Q–68 to 3 parts of water. The amounts of paste applied were equivalent to 360 and 540 ft²/gal for the second and third coats, respectively.

Treatment 22, applied to wall B257–22*n*, consisted of two coats of Aquaplex Q–68 thinned with a volume of water equal to that of the paste. The applications were made on successive days, and the amounts of paste used were equivalent to 180 and 380 ft²/gal for the first and second coats, respectively (90 and 217 ft²/gal of paint).

Treatment 23, applied to wall B258–23*n*, consisted of one coat of spar varnish and two coats of Aquaplex Q–68, each applied on successive days. The spar varnish met the requirements of Federal Specification TT–U–121a and weighed 7.5 lb/gal. The amount of varnish applied was equivalent to 120 ft²/gal. The Aquaplex Q–68 was thinned with water as for treatment 22, and the amounts of paste applied were 235 and 330 ft²/gal, respectively, for the second and third coats (135 and 190 ft²/gal of thinned paint).

It required about 25 to 30 min to apply each coat of paint, and all the walls had been stored indoors for 6 months when they were tested for permeability.

The walls treated with Aquaplex were rated *P* or *VP* in the premeability tests made after treatment and also after exposure outdoors. The coatings were water repellent, but they contained many pinholes over the block and some larger openings over the joints. They were not crazed or flaked after weathering outdoors for 14 months, but, when returned indoors, they were dusting badly and contained many rust spots from particles of iron in the block. Examination of the coatings during the weathering exposure period disclosed the growth of black and pink fungi over small isolated areas on more than half of the block.

The walls were painted with the same technique used to apply cement-water paint coatings, and special care was not taken to "touch up" and fill pinholes or larger openings in an area that had been painted. It is possible that the coatings would have been more effective if a stiffer brush had been used, or if the paints had been applied to units having a smoother surface texture.

(*b*) *Dricoat*

Dricoat (waterproofing 24, table 15) was a white pigmented waterproofing, manufactured by the Billings-Chapin Co., New York, N. Y. The material was said to be a waterproof sealer, for exterior or interior use, that could be applied as received to wet or to dry surfaces. The instructions for use stated that the wall surface should be clean and that the waterproofing should be kept well stirred and flowed onto the wall surface with a brush as though it were a varnish and not brushed out as for a paint.

Two applications of Dricoat were made with a paint brush on successive days to the face of wall B111–24*cc*. The wall was dry, and it required about 25 min. to apply each coat. The average amounts of Dricoat applied were equivalent to 100 ft²/gal for the first coat and 130 ft²/gal for the second, about 57 ft²/gal for both coats. The wall was stored indoors and tested for permeability 6 weeks after treatment. When first tested, the treatment was water repellent, but after 1 day the applied water formed a continuous film over the face. The wall was rated VP, the rate of leakage was high, and water penetrated to the back in less than 2 hr.

(*c*) *Drye*

Drye (waterproofing 25, table 15) was manufactured by the Weather Seal Co., Cincinnati, Ohio. The ingredients in the material were said to include iron dust, chloride of lime, alum, and portland cement. The instructions for use were to mix to a thin consistency with water and apply with a brush, with frequent stirring. Two coats, to be applied on successive days, were recommended for waterproofing the outside face of masonry walls.

Wall B326–25*cc* was waterproofed with two treatments of Drye. The material was prepared for application by adding water to the dry powder until a thin paste of brushing consistency was prepared. The amounts of added water, by weight of dry materials, were 60 percent for the first coat and 80 percent for the second. The applications were made on successive days, and the amounts applied were equivalent to 35 lb of powder per 100 ft² of wall area for the first coat and 6 lb for the second. The brick were highly absorptive, and it is possible that more water should have been added to the waterproofing for the first treatment. The joint structure in the masonry could still be observed after treatment, and the color of the wall when dry was a dull, rusty brown interspersed with small isolated areas of lighter or darker shades.

The treatment with Drye was effective. The wall was rated G, and only 5 percent of the back of the wall was damp after an exposure of 1 day. When again tested, after weathering outdoors for 17 months, the damp area on the back, at 1 day, was 60 percent, and the wall was rated F. There was no water visible on the back, and no leakage was observed from the flashings during the tests.

(*d*) *Maure Brush Tex and Plaster Special*

The Maure Corporation, New York, N. Y., sponsored the construction and waterproofing of eight masonry walls. One of these was waterproofed with Maure Brush-Tex and one with Maure Plaster Special (waterproofings 26 and 27, table 15). The waterproofing and testing of the other six walls, treated with Maure Liquid Waterproofing, will be discussed elsewhere in this report, see section VII–2 (d). All of the materials were said to contain an emulsion of linseed oil and were recommended for use on either wet or dry masonry surfaces. The application of the waterproofings was made under the direction of L. C. Maure.

Maure Brush-Tex was a light-colored plastic paint suitable for application with a brush. The material was thinned with a small amount of water, and the specific gravity after thinning was 1.44. Two coats were applied, one immediately after the other, to wall B198–26*m*, using a 3½-in. paint brush. The amounts of thinned material applied for the first and second coats were equivalent to about 60 and 38 ft²/gal, respectively. The total time required for treatment was 15 min. The wall was stored indoors and tested for permeability about 1 month after treatment. The data show that the treatment with Maure Brush-Tex was ineffective. The wall leaked badly, was penetrated to the back by water in less than 1½ hr, and was rated *VP*.

The Maure Plaster Special was a pigmented waterproofing paste of troweling consistency that dried or set to a hard finish after application. Two coats of Plaster Special were applied with a plasterer's trowel to the exposed face of wall B103–27*cc* on successive days. The suction of the highly absorptive brick in the wall was reduced by a thorough wetting, and the first coat of Plaster Special was applied, as received, the amount used being equivalent to about 11 ft²/gal. The next day the first coat was slightly crazed before it was wetted down and a second coat applied. The amount applied for the second coat was equivalent to 67 ft²/gal. The wall was tested about 1 month after treatment.

The Maure Plaster Special on wall B103 was effective when first applied, and the wall was rated *E*. This wall was weathered outdoors for 2 years and again tested. The top portion of the waterproofing was severely cracked, and one small portion of it had spalled. The cracks in the coating appeared to be located over the mortar joints of the brick backing. It is probable that damage to the coating of Plaster Special was caused or aggravated by frost action in the brick backing. Before being tested for permeability, the loose, spalled, portion of Plaster Special was removed and replaced by a coating of portland-cement mortar. The wall was rated *P* in the permeability test, and water penetrated to the inside face of the brick backing in less than 3 hr.

(*e*) *Tymstone*

Tymstone (waterproofing 28, table 15) was a pigmented, cementitious material containing magnesium oxychloride cement. After tempering the Tymstone powder with water, it was used as a mortar and as a coating for masonry units. Tymstone Studio, Chicago, Ill., sponsored the construction and waterproofing with Tymstone of one wall built of Waylite concrete units. The wall, B303, was built in Chicago, and the method of construction was said to be as follows: The faces of the Waylite block were dipped into Tymstone mortar, and the block were placed into positions in the wall. The wall faces were then smoothed with a brush. The standard formulation for Tymstone mortar was used, and it was claimed that it was dense enough to greatly retard the penetration of water but sufficiently porous to permit the passage of vapor. A number of hard, thin brick-tiles were bonded to a portion of the inside, unexposed face of the wall about 30 min. after the Waylite units were dipped into Tymstone mortar.

When received, the specimen contained seven courses of Waylite block and was too great in height to be tested. W. A. Wilson, of the Ludowici Celadon Co., Washington, D. C., acting for the Tymstone Studio, removed the top course of block and substituted a course of brick header units at the top and bottom of the wall. A special Tymstone mortar, known as Tymstone Patching Cement, was tempered with water and used to coat the brick before placing them in the wall. The joints between the brick were about ⅛ in. thick. The wall was tested for permeability about 10 days after its reconstruction.

When tested for permeability, the Tymstone-coated wall was rated *E*, and there was no penetration of water through the wall during an exposure period lasting 5 days. The Tymstone Patching Cement was hygroscopic and became sticky because of water absorbed from the humid air during the test.

Wall B303 was weathered outdoors for 18 months and tested twice for permeability during the interval November 1940 to June 1942. At the end of the exposure period, the Tymstone coating was dusting badly, and the joints between the Waylite units were plainly discernible. The wall was rated *E* in both tests made after the exposure periods (table 15).

(*f*) *Varcraft*

Varcraft (waterproofing 29, table 15) was a white pigmented oil-base paint made by the Varcraft Works, Pottstown, Pa. Two coats of Varcraft were applied on successive days, with a paint brush, to the exposed faces of each of two concrete-block walls. The walls were dry when treated, and the paint was applied as received, ready-mixed.

The amounts of paint used for the first and second coats on wall B223–29*m* were equivalent to 145 and 270 ft²/gal, respectively. The amounts similarly applied to wall B255–29*n* were equivalent to 95 and 150 ft²/gal. The walls were stored indoors and were tested for permeability 11 months after being painted.

The Varcraft applied to the wall built of stone-concrete block (wall B223) reduced the rate of leakage through the wall, which was rated *P*. The coatings applied to a backing of cinder-concrete block (wall B255) were less effective, and this specimen was rated *VP*. The technique used in painting these walls was similar to that used for applying cement-water paints and Aquaplex (waterproofing 22, table 15). It is possible, that the treatments might have been more effective if a stiffer brush had been used.

After weathering outdoors for 1 year, the coating on wall B223 was dusting, and the permeability of the wall was again rated *P*.

(g) *Discussion*

The most effective and durable of the pigmented waterproofing materials were those containing portland or magnesium oxychloride cement. The treatments with Drye and Tymstone were rated *G* and *E*, respectively, and were comparable in performance to cement-water paint coatings. A thick trowel coating of Maure Plaster Special, containing an emulsion of linseed oil, was rated *E* when first applied. A thinner coating of a similar material (Brush-Tex), applied with a brush, was ineffective. Brush coatings of emulsified resin or oil-base paints were rated *VP* or *P*, and were much less effective as waterproofing than were cement-water paint coatings.

Since the water was applied to the exposed faces of the walls from a pipe with perforations spaced on 1-in. centers, the permeability test was more favorable to water-repellent surfaces than to those that were readily wetted. The applied water combined into rivulets on water-repellent coatings and a large area was not covered with water until the degree of repellency was reduced. Some coatings were still highly water repellent after an exposure lasting 1 day.

2. Colorless Surface Coatings

The results obtained from the permeability tests before and after treatment, and after outdoor exposure on walls treated on the exposed faces with colorless waterproofings, are described in table 16.

Table 16.—*Permeability of walls treated with colorless proprietary surface coatings*

Trade name	Wall	Designation [a]	Condition of wall and period of outdoor exposure	Time to failure as indicated by [b]—			Maximum rate of leakage per hour	Area damp in 1 day	Rating
				Dampness on back	Water on back	Leakage from flashing			
				hr	*hr*	*hr*	*Liters*	*Percent*	
Ampruf	B109	31*cc*	Before treatment	0.1	0.2	0.2	48	100	*VP*
			After treatment	.4	.5	1	29	95	*VP*
Ceremul-W	A18	32*cc*	Before treatment	.3	.5	.6	73	85	*VP*
			After treatment	-----	-----	-----	0	0	*E*
			Dec. 1940 to Aug. 1941	2.1	2.3	1.5	6.9	60	*VP*
	B116	32*cc*	Before treatment	.09	.09	.3	51	100	*VP*
			After treatment	11 ±3	19 ±3	-----	0	15	*F*
			Nov. 1940 to Aug. 1941	2	2.3	6	5.4	90	*VP*
	19	32*bb*	Before treatment	.1	.15	.2	17	100	*VP*
			After treatment	3.6	5.7	15 ±6	.03	70	*F*
			May 1941 to Aug. 1941	.35	.85	.4	6.1	95	*VP*
			Additional treatment	8	17 ±4	-----	0	60	*F*
Filporize	B113	33*cc*	Before treatment	.02	.04	.2	61	100	*VP*
			After treatment	.15	.17	1	47	100	*VP*
Maure Liquid Waterproofing	B244	34*cc*	Before treatment	.05	.1	.25	31	95	*VP*
			After treatment	.08	.5	.9	15	100	*VP*
	B243	34*cc*	Before treatment	.05	.06	.2	87	100	*VP*
			After treatment	.3	.3	.5	51	100	*VP*
	B245	33*m*	Before treatment	.03	.05	.08	132	90	*VP*
			After treatment	.1	.2	.3	8	90	*VP*
	B246	34*m*	Before treatment	.04	.05	.07	141	90	*VP*
			After treatment	.3	.55	.6	9	90	*VP*
	B247	34*n*	Before treatment	.05	.05	.03	64	70	*VP*
			After treatment	.1	.1	.15	16	75	*VP*
	B248	34*n*	Before treatment	.03	.04	.04	63	75	*VP*
			After treatment	.08	.1	.3	12	65	*VP*
Por-filite	B261	35*r*	Before treatment	.04	-----	.85	2.6	75	*P*
			After treatment	.03	-----	2.5	.9	60	*F*
	B267	35*r*	Before treatment	3.6	-----	1.8	1.4	25	*P*
			After treatment	6.2	-----	-----	0	15	*G*
	B268	35*r*	Before treatment	.5	3.5	4	.25	75	*F*
			After treatment	.9	4.6	6.2	.2	60	*F*
Surten-R	B107	36*cc*	Before treatment	.02	.02	.3	43	95	*VP*
			After treatment	.2	.2	.85	22	90	*VP*
	B112	36*cc*	Before treatment	.06	.1	.2	57	95	*VP*
			After treatment	.2	.2	.7	13	90	*VP*
	B130	36*m*	Before treatment	.03	.03	.1	10	75	*VP*
			After treatment	.1	.15	.4	5	85	*VP*

[a] The number designates the kind of waterproofing treatment, the letter designates the kind of units used in the backings.
[b] The uncertainty of the observation is given if it exceeds 10 percent of the total elapsed time. Dashes indicates no failure of the wall.

(a) *Ampruf*

This material (waterproofing 31, table 16) was a clear, colorless liquid said to contain chlorinated rubber in solution with benzol or high-flash-point naphtha. It was manufactured by the American Waterproofing Co., New York, N. Y.

One coat of Ampruf was applied by G. F. Bowdish, of the G. F. Muth Co., Washington, D. C. to the exposed face of wall B109–31*cc*. The wall was dry when the material was applied with a 3½-in. paint brush, first to the bed joints, then to the brick, and finally to the head joints. The amount of Ampruf applied was equivalent to 68 ft²/gal, but the suction of the highly absorptive brick *c* was not satisfied. The material was not diluted before treatment and weighed 7.2 lb/gal. The wall was tested for permeability 8 days after treatment.

Water penetrated to the back of wall B109–31*cc* in 30 min, the maximum rate of flow was nearly 30 liters/hr and the wall was rated "*VP*," after treatment. The face of the wall was water repellent when the test was started, but was only slightly repellent after an exposure lasting 1 day, at which time the rate of leakage was a maximum.

(b) *Ceremul-W*

Gargoyle Ceremul–W (waterproofing 32, table 16) was a milky-white emulsion of wax in water, colorless after drying, made by the Socony-Vacuum Oil Co., New York, N. Y. The wax content of the emulsion was said to be 45 percent, half of which was a paraffin wax with a melting point of 135° F, and the remainder was a microcrystalline (amorphous) wax with a melting point above 155° F. It was recommended that Ceremul–W be used without dilution when applied to walls built of very highly absorptive or porous units, and that a dilution of not more than 1 part of water to 1 of Ceremul–W be used on walls of medium- or of low-absorptive bricks. It was stated that only one coating of the material need be applied to masonry walls when they were either wet or dry, but it was not recommended that the walls be wetted before treatment. The specific gravity of Ceremul–W was about 0.9.

Three brick walls were treated on the exposed faces with Ceremul–W. Two of these walls, 19–32*bb* and A18–32*cc*, were 12 in. thick; the other, B116–32*cc*, was 8 in. thick. All the walls were of workmanship B. They were dry and clean when treated.

Wall B116, built of the highly-absorptive brick *c*, was treated with undiluted Ceremul–W in 17 min. The material was applied with a paint brush, and the amount used was equivalent to 154 ft²/gal.

Wall A18 was also treated with undiluted Ceremul-W in 17 min. The material was applied generously with a paint brush (as though painting with a varnish), and the amount applied was equivalent to 156 ft²/gal.

Wall 19, built of the medium-absorption brick *b*, was given two treatments of one coat each. The wall was tested for permeability after the first treatment, then exposed outdoors, again tested, and then dried before the second application. The Ceremul-W was diluted with an equal volume of water for both treatments. The material was liberally applied to the crevices in the joints of two courses at a time, and then it was brushed horizontally across the brick. The first treatment required 13 min, and the amount of diluted material applied was equivalent to 185 ft²/gal (370 ft²/gal of undiluted Ceremul-W). Although the wall had weathered outdoors for 8 months, the second application was not absorbed as readily as the first, and the face of the wall appeared to be water repellent. The waterproofing had to be "worked" into the joints to prevent it from running down the face. The second treatment required about twice as much time and two-thirds as much material as the first. The brick in wall 19 had a glossy appearance after treatment, but there was very little or no discoloration noted on any of the walls waterproofed with Ceremul-W.

The treatments with Ceremul-W were effective when first applied, particularly on the 12-in. wall A18, built of brick *c*. The face of wall A18 was still water repellent, and there was no dampness on the back of the wall after an exposure lasting 5 days, and the wall was rated *E*. There was some white discoloration in the joints and on some of the brick at the end of the first day of test, but this disappeared when the surface of the wall had dried.

The walls treated with Ceremul-W were again tested after having weathered outdoors for 3 to 9 months. The wall faces were still water repellent throughout the tests, but the average rate of leakage was 6 liters/hr. The walls were rated *VP*. Wall 19 was treated for the second time, after it had been stored outdoors, and, when tested, was again rated *F*. There was no leakage from the flashings, but 60 percent of the back of the wall was damp. It is not known if the permeability tests (which were severe) or the weathering exposures were responsible for the loss in effectiveness of treatment with Ceremul-W.

(c) *Filporize*

The Filporize (waterproofing 33, table 16) was a colorless material manufactured by Stone & Murphy, Inc., Middletown, Conn. Information on the label stated that Filporize was "A colorless liquid waterproofing that stretches, for application to brick, cement, stucco, art stone, cut stone. Application should be made with a criss-cross motion with a full brush to a clean, dry surface. For brick or concrete, use 200 to 250 ft²/gal for the first coat and 300 to 400 ft²/gal for the second coat. Allow 48 hr between coats."

Two coats of Filporize were applied to the exposed face of wall B113–33*cc*, the second application was made 2 days after the first. The wall was dry and application was made with a 4-in. paint brush. The amounts of Filporize applied were equivalent to 123 ft²/gal for the first coat and 111 ft²/gal for the second. The brick were highly absorptive, and it required about 14 min to apply each coat. The wall was stored indoors and was tested for permeability 1 month after treatment.

There was no discoloration noted on the wall after treatment.

Although the wall face was water repellent when the test was started, water penetrated to the back of the wall in 10 min; the rate of leakage was excessive, and the treatment was rated *VP*.

(*d*) *Maure Liquid Waterproofing*

Maure Liquid Waterproofing (waterproofing 34, table 16) had a milky appearance but dried clear and colorless. The liquid had a specific gravity of 1, and was diluted with an equal amount of water before use. Six walls, two of brick *c*, two of stone-concrete block, and two of cinder-concrete block, were treated when dry. One wall of each kind of backing was given two coats, one applied immediately after the other, and its companion specimen was given three coats. A whitewash brush (brush 2, fig. 3) was used to apply the waterproofing, starting each coat at the top of the wall, and care was taken in brushing to prevent the liquid from foaming under the brush. The total amounts of thinned Liquid Waterproofing required for two and for three coats applied to walls built of the highly absorptive brick *c* (B244 and B243) were, respectively, equivalent to 48 and 45 ft^2/gal. Similarly, the amounts applied to walls built of stone-concrete block (B245 and B246) were 66 and 57 ft^2/gal, and those applied to walls of cinder-concrete block (B247 and B248) were 89 and 82 ft^2/gal. The walls were tested for permeability about 5 weeks after treatment.

All the treated walls were rated *VP*. The rate of leakage, after treatment, was greatest from walls of brick *c* and least from walls of stone-concrete block *m*. The walls were water repellent, and the application of two or of three coats of Liquid Waterproofing did not result in a significant difference in the permeability of the specimens.

(*e*) *Por-fil-ite*

Por-fil-ite, formula B, for brick masonry (waterproofing 35, table 16) was a colorless liquid having a specific gravity of 0.82. The material was made by International Chemicals, Inc., Washington, D. C., and two coats were applied with a paint brush to the exposed faces of three walls, B261, B267, and B268, built of Munlock brick (brick *r*, table 1). The walls were dry when treated, and the applications to each wall were made on successive days, under the direction of T. K. McPherson. The waterproofing was applied first to the head joints and then to the brick and bed joints. The applications were liberal, and the surfaces of the brick and mortar joints appeared to be nearly saturated. The average amounts of Por-fil-ite applied for the first and second coats were equivalent to 350 and 370 ft^2/gal, respectively. The walls were tested for permeability about 2 months after being waterproofed.

The walls of Munlock brick were rated *P* or *F* before treatment, and were not as permeable as walls built of concrete block or of brick *c*. The treatments with Por-fil-ite significantly reduced the permeabilities of the specimens, which were rated *F* or *G*. (The tests do not indicate how effective the waterproofing would be if applied to walls that leaked badly and that were rated *VP* before treatment.)

(*f*) *Sur-Ten-R*

Sur-Ten-R was a milky-white emulsion of wax in water (waterproofing 36, table 16) manufactured by Pal-Verd Inc., Chicago, Ill., under license from the Institute of Paper Chemistry, Appleton, Wis. It was stated that the material was clear and colorless, when dry, and that it contained 30 percent of waxes having a melting point of 122° F or more. Pal-Verd Inc. sponsored the construction and waterproofing of three specimens. The walls were dry when treated on the exposed face with Sur-Ten-R, under the direction of C. L. Burnham.

Sur-Ten-R was mixed with an equal volume of warm water (104° F) and then applied with a paint brush to wall B107–36*cc*, built of highly absorptive brick. After the wall was given one brush coat, a small amount, 5 oz, of undiluted Sur-Ten-R was immediately brushed on the joints. The material applied to the joints was not readily absorbed by the masonry, and a white discoloration was left on portions of the brick near the joints after the waterproofing had dried on the wall. The weight per gal of the diluted material was 8.2 lb, and the total amount of undiluted Sur-Ten-R applied was equivalent to 127 ft^2/gal.

Wall B112–36*cc* was given a brush coating of a solution containing 2 parts of Sur-Ten-R and 1 part of warm water (116° F). The time required to apply the solution with a paint brush was 4 min. The joints in the wall were then immediately painted with about 5 oz of undiluted Sur-Ten-R in about 9 min. The total amount of undiluted Sur-Ten-R applied was equivalent to 105 ft^2/gal. After drying the wall, portions of the brick near the joints showed a white discoloration, as was also noted for wall B107.

Wall B130–36*n* (built of cinder-concrete block) was treated with one coat of Sur-Ten-R diluted with an equal volume of water. A hand-operated, pressure-type spray gun, designed for spraying liquid insecticides, was used for 30 min to apply the waterproofing, and the surfaces of the concrete block appeared to be saturated. The amount of undiluted Sur-Ten-R applied was equivalent to 208 ft^2/gal. The wall showed no discoloration after the waterproofing had dried. The brick walls B107 and B112 were tested for permeability 9 days after treatment, wall B130 was tested about 3 weeks after treatment.

The treatments with Sur-Ten-R were ineffective, and the performances of the walls were rated *VP*. The faces of the walls were water repellent throughout the tests, and white discolorations became more prominent over the brick and the joints within an hour after the tests were started. When the walls were stored indoors for a few weeks, after the tests, a growth of green mold developed on the treated faces.

(g) *Discussion*

The colorless waterproofings, with the exception of Gargoyle Ceremul-W, were ineffective as waterproofings when applied to walls with high rates of leakage, and such walls were rated *VP*, both before and after treatment. Two walls coated with Ceremul-W were rated *F* and one was rated *E* after treatment. When again tested after weathering outdoors, these walls were rated *VP*. Walls of brick *r* treated with Por-fil-ite, were rated *P* or *F* before treatment, and the effectiveness of Por-fil-ite, when applied to walls rated *VP*, was not determined. The tests described in BMS 7 and BMS 76 show that treatments with solutions containing 10 percent of paraffin and 5 percent of tung oil in mineral spirits were also ineffective. The coatings of a paraffin and tung-oil wax, applied to the joints of brick walls, were unsightly, and were ineffective as waterproofings after an exposure outdoors of 1 year.

The data indicate that the only effective and durable methods of waterproofing brick walls without changing their appearance is by cutting out and repointing the joints with mortar or by brushing a portland-cement grout into the joints. The grout may contain 1 part of cement to about 1½ parts of fine sand, and it should be applied to the dampened joints with a stiff brush. If the brick texture is smooth, excess grout may be easily cleaned from the units with a damp sponge.

Test walls with repointed joints were found to be less permeable after outdoor weathering than before, whereas the permeability of walls with grouted joints was found to be slightly, but not seriously, increased after exposure. While repointing or grouting are effective treatments for the joints in brick walls, it may be necessary to also apply a water-repellent (colorless) waterproofing to underburned, highly absorptive brick; the water repellent, if used, should be applied after grouting or repointing.

VIII. LARSON PRE-FORMED WATERPROOFING UNITS

1. Construction of the Specimens

The Brisk Waterproofing Co., New York, N. Y., sponsored the construction of ten 13-in. brick masonry walls, of which 6 contained the Larson Pre-formed Waterproofing Units, waterproofing 37, table 17.

The waterproofing units were made of heavy asphalt-impregnated felt or paper dusted with mica. They were preformed to fit the brick and course dimensions, and were lapped and sealed at the ends to form a series of waterproof membranes, as shown in figures 4, 5, 6, and 7. The vertical joints between the units were lapped 4 in. and sealed with an asphalt plastic cement of troweling consistency, which contained cut-back asphalt and asbestos fiber. The walls were laid in common American bond, starting with three stretcher courses. They were constructed in two groups, differing from each other in the extent and method of filling the interior of the vertical joints with mortar. The membrane waterproofings, placed in some of the walls of each group, were similar.

The bed joints in the first group of walls were furrowed, and the collar joints were open. The head joints were buttered as in workmanship B (described in BMS82), except that the buttering was heavier, and mortar was also placed in the head joints of the center tier, or wythe. The bottom edge of the bottom membrane in the waterproofed walls was sealed to the copper flashing, and the upper edge extended one course above and one tier behind the bottom of the next membrane above. The construction of the walls was begun at the back by laying the second and third tiers to the height of the header courses. The backs of the membranes were daubed with spots of plastic cement to bond them to the vertical faces of the masonry. A mortar bed was placed on the horizontal surfaces of the membranes, and the plastic cement at the joints was lightly coated with mortar. Joints in the wall faces were cut. The sequence for laying courses and tiers was the same for the plain and waterproofed walls in both groups. The bricks were laid in mortar 2, and the average absorption during partial immersion of the brick *s* in the first group of walls was nearly 70 g (table 1).

The bed joints in the walls of the second group were furrowed. The head joints in the facing tier were filled solidly with mortar; those in the center and backing tiers were buttered. The face of the backing tier was parged. The collar joint between the facing and center tiers was filled with mortar by heavily buttering the sides of the brick and by slushing from above. No mortar was placed between the membrane, if used, and the vertical face of the center tier. The suction of the brick was nearly 40 g (table 1). The face joints were cut flush, and weep holes were made in the lower portions of the bed joints in the second stretcher course of the facing. The holes did not extend past the first collar joint and did not penetrate the membrane.

FIGURE 4.—*Wall B236 during construction.*

The lower membrane is bonded to the copper flashing.

2. EFFECTIVENESS AND DURABILITY

The plain (not waterproofed) walls of group 1 were more permeable than those containing the membrane waterproofing, but the performances of the waterproofed specimens were disappointing. The sponsors had specified a highly permeable type of workmanship, and water penetrated the backs of walls B235 and B239 at or below the inner header courses in 30 min or less. The data indicate that leakage entered the facings faster than it leaked out at lower elevations, so that water flowed over the tops of the membranes. The air pressure maintained against the face of the wall was equivalent to a head of 2 in. of water, and the membranes were lapped a single brick course. The Brisk Waterproofing Co. recommends, in practice, that weep holes be placed in the facings at the bottom of walls waterproofed with Larson units. Weep holes were therefore cut in the head joints of the second or third courses from the bottom of the waterproofed walls. The weep holes effectively drained the collar joint of wall B236, and the wall was rated *G* instead of *VP*. It is probable that mortar in the collar

FIGURE 5.—*Brick wall containing membrane waterproofing.*

Brick Waterproofing Co., series 1.

joints of the other walls prevented the weep holes in them from functioning.

The walls of the second series were of a less permeable construction than those of the first, and the plain specimens, built without the membranes, were rated *P*. All the walls contained weep holes at the bottom of the facing tiers. Waterproofed walls B263 and B265 were rated *E*. When again tested, after plugging the weep holes, wall B263 was rated *G*, and wall B265 was again rated *E*.

The walls were weathered outdoors for 30 months and, when again tested, the weathering was found to have had no significant effect on permeability.

The tests on the walls sponsored by the Brisk Waterproofing Co. showed the importance of adequate drainage through weep holes at the bottoms of highly permeable facings in walls containing membranes. The Brisk Waterproofing Co. states that none of its installations along the Atlantic Seaboard that were in the path of the hurricane of September 1938 showed any indication of leakage. They further point out that the air pressure on a building wall may fluctuate considerably during a storm. It is possible that, if the facings of the walls in series 1 had been less permeable, or if the air pressure on the test walls had fluctuated between 0 and 10 lb/ft^2, the water penetrating the facings would have drained to the outside and would not have overtopped the membranes.

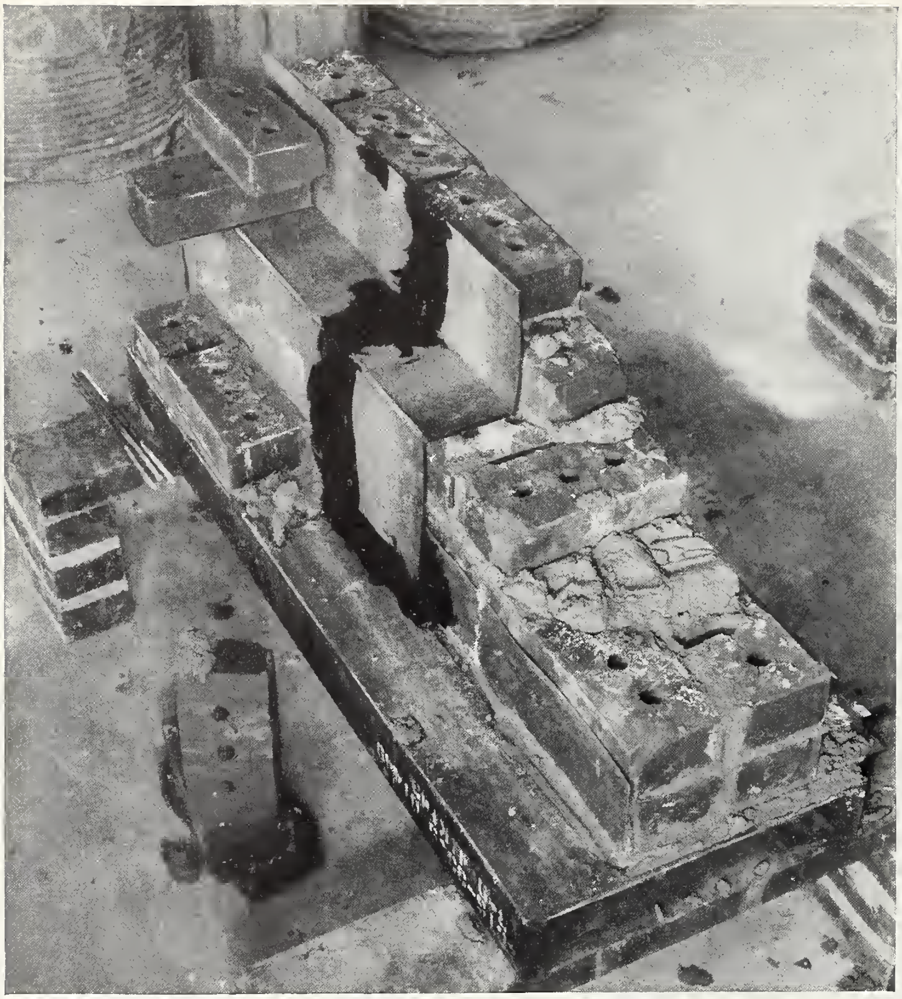


FIGURE 6.—*Brick wall during construction, series 2.*

TABLE 17.—*Effectiveness of Larson Pre-formed Waterproofing Units*

Wall	Designation [a]	Condition of wall and period of outdoor exposure	Time to failure as indicated by—[b] Dampness on back	Water on back	Leakage from flashing	Maximum rate of leakage per hour	Area damp in 1 day	Rating
WALLS OF GROUP 1								
			hr.	*hr.*	*hr.*	*Liters*	*Percent*	
B237	*ss*	Not waterproofed	0.3	0.3	0.3	33	80	*VP*
B238	*sp*	do	.2	.2	.3	99	25	*VP*
B235	*s37s*	Without weep holes	.2	.5	.25	19	60	*VP*
		With weep holes	.3	.5	.5	4.5	60	*P*
B239	*s37s*	Without weep holes	.3	.3	1.2	14	65	*VP*
		With weep holes	.3	.3	0.7	15	65	*VP*
B240	*s37s*	Without weep holes	10±3	----	----	0	4	*G*
		With weep holes	1.7	----	----	0	10	*G*
B236	*s37p*	Without weep holes	2.2	----	.5	11	15	*VP*
		With weep holes	63	----	53	0.2	0	*G*
WALLS OF GROUP 2								
B264	*tt*	Not waterproofed	0.08	0.08	0.35	0.07	100	*P*
		Sept. 1939 to May 1942	.05	.05	.35	2	95	*P*
B266	*tt*	Not waterproofed	.04	.09	.1	0.4	100	*P*
		Sept. 1939 to May 1942	.03	.04	.1	2.2	90	*P*
B263	*t37t*	Waterproofed	----	----	----	0	0	*E*
		Weep holes plugged	3.5	----	----	0	25	*G*
		Oct. 1939 to May 1942	----	----	----	0	0	*E*
B265	*t37t*	Waterproofed	----	----	----	0	0	*E*
		Weep holes plugged	----	----	----	0	0	*E*
		Oct. 1939 to May 1942	----	----	----	0	0	*E*

[a] The number designates the kind of waterproofing treatment, the letter designates the kind of units used in the walls.
[b] The uncertainty of the observation is given if it exceeds 10 percent of the total elapsed time. Dashes indicate no failure of the wall.

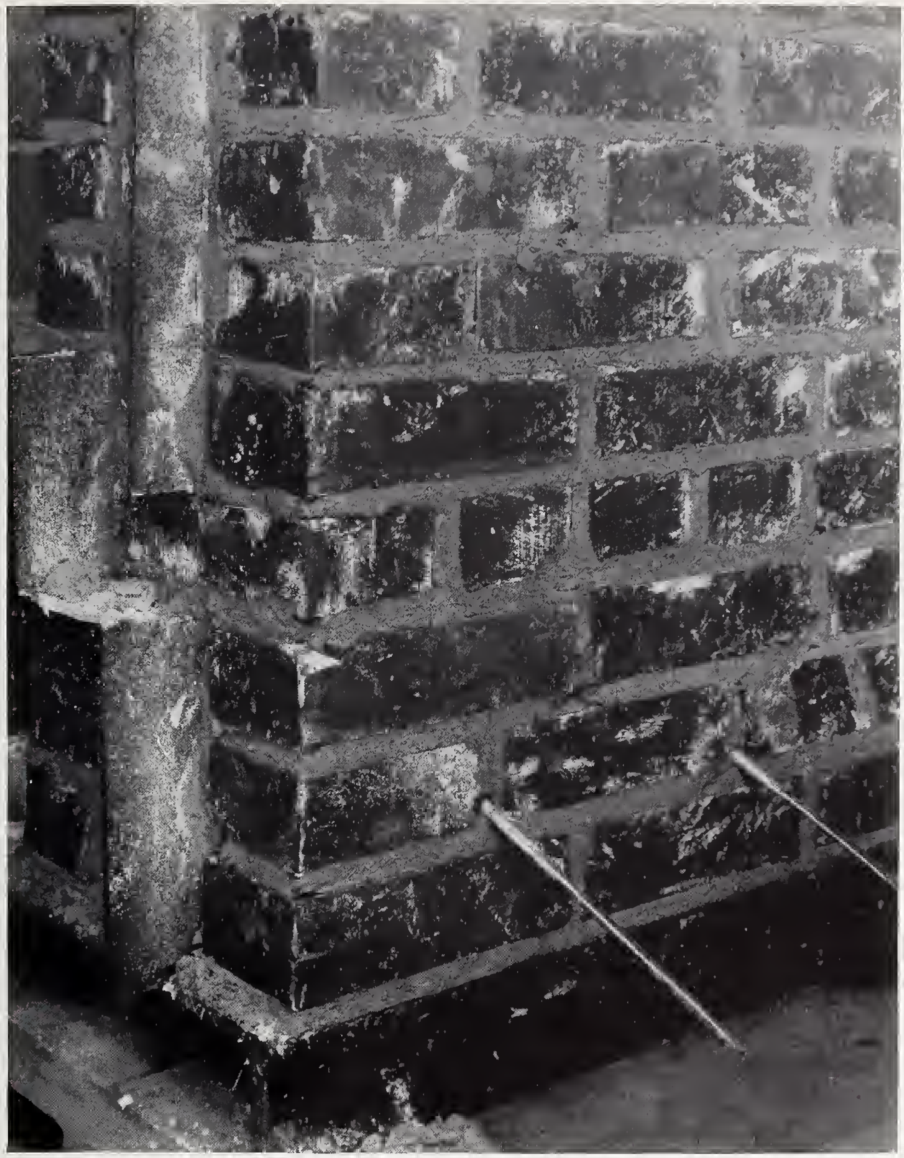


FIGURE 7.—*Brick wall, series 2.*

Note weep holes in facing.

IX. WATERPROOFING APPLIED TO THE UNEXPOSED FACES OF THE WALLS

Waterproofings applied to the backs (unexposed faces) of the walls covered the edges of the end and top pargings, but they were not applied to those portions of the walls between the upper and lower flashings (fig. 1).

Most of the walls were built of the highly-absorptive brick *c*, and all were selected on the basis of tests made before treatment as having a maximum of leakage from the upper rather than the lower flashings. The walls were dry when treated, unless otherwise noted.

1. BITUMINOUS COATINGS

Bituminous coatings are often used as damp-proofings or as waterproofings on the inside faces of masonry walls above grade. The materials used in the coatings applied to the test walls were purchased in the open market and under Federal specification, wherever applicable. The data obtained from tests made before and after treatment are given in table 18.

Table 18.—*Permeability of walls waterproofed on the backs, unexposed faces*

Kind of waterproofing	Wall	Designation [a]	Condition of wall and period of outdoor exposure	Time to failure as indicated by [b]— Dampness on back	Water on back	Leakage from flashings	Maximum rate of leakage per hour [c]	Area damp in 1 day	Rating
BITUMINOUS COATINGS									
				hr	*hr*	*hr*	*Liters*	*Percent*	
Asphalt	B96	*cc*41	Before treatment	0.01	0.02	0.3	54	95	*VP*
			After treatment	.5	.5	.9	1.1	40	*P*
Coal tar	B97	*cc*42	Before treatment	.07	.1	.3	60	90	*VP*
			After treatment	.2	.2	.3	29	80	*VP*
Asphalt roof coating	B92	*cc*43	Before treatment	.15	.35	.35	64	95	*VP*
			After treatment	.3	.3	.4	39	95	*VP*
Asphalt emulsion	B66	*cc*44	Before treatment	.06	.08	.25	51	95	*VP*
			After treatment	2.2	3.5	1.7	2.6	80	*P*
Bituminous plastic cement	B93	*cc*45	Before treatment	0.03	0.1	0.25	58	95	*VP*
			After treatment	1.6	1.6	6	34	30	*VP*
CEMENTITIOUS COATINGS									
Portland-cement and sand brush coating.	B98	*cc*51	Before treatment	0.1	0.2	0.2	46	95	*VP*
			After treatment	.35	----	15±6	0.07	35	*F*
	B108	*cc*51	Before treatment	.1	.1	0.3	55	95	*VP*
			After treatment	.1	.2	4.0	0.6	95	*P*
Iron-dust brush coating (iron dust and salammoniac).	B100	*cc*52	Before treatment	.07	.08	0.3	48	100	*VP*
			After treatment	.1	.1	.3	16	90	*VP*
Portland-cement and iron-dust brush coating.	B101	*cc*53	Before treatment	.04	.04	.3	49	95	*VP*
			After treatment	.1	.25	.55	0.4	95	*P*
Portland-cement, iron-dust, and sand trowel coatings.	B102	*cc*54	Before treatment	.1	.1	.3	44	95	*VP*
			After treatment	.75	----	----	0	8	*E*
			Apr. 1940 to Aug. 1941	.4	----	----	0	15	*E*
	B104	*cc*54	Before treatment	.08	.09	.4	36	100	*VP*
			After treatment	.4	----	----	0	8	*G*
			Mar. 1940 to Aug. 1941	1.0	----	10	0.2	10	*F*
Mortar parging	B68	*cc*55	Before treatment	0.07	.1	0.25	46	100	*VP*
			After treatment	----	----	----	0	30	*G*
			July 1939 to Aug. 1941	.3	5	----	0	45	*F*
PROPRIETARY MATERIALS									
Armor Coat	B304	*n*56	Before treatment	0.03	0.05	0.07	30	90	*VP*
			After treatment	.7	.7	----	0	20	*P*
	B305	*m*56	Before treatment	.02	.03	.1	30	90	*VP*
			After treatment	2.5	2.5	----	0	25	*P*
Driecoat	B106	*cc*24	Before treatment	0.07	0.08	.2	31	95	*VP*
			After treatment	.3	.3	.3	6	80	*VP*

[a] The number designates the kind of waterproofing treatment, the letter designates the kind of units used in the walls.
[b] The uncertainty of the observation is given if it exceeds 10 percent of the total elapsed time. Dashes indicate no failure of the wall.
[c] Rate of flow from upper flashing only.

(*a*) *Asphalt*

One coat of a primer and one coat of hot asphalt (waterproofing 41, table 18) were applied to the back of wall B96–*cc*41. The primer and the asphalt met the respective requirements of Federal Specifications SS–A–701 and SS–A–666, type 3. The amount of primer used was 5.7 lb/100 ft^2 of wall area, and the wall was primed 2 days before the asphalt was applied. The asphalt was smoking hot when applied to the wall with an enamel daubing brush. The asphalt did not adhere well to the brush, and there was considerable waste during application. After the first coat had been brushed on the wall, additional asphalt was applied to many areas that did not appear to be properly coated. The brick mason who applied the asphalt stated that he would have preferred a mop to the daubing brush for the purpose. The coating was about 1/16 in. thick, and the amount of asphalt applied was about 47 lb/100 ft^2. The wall was tested for permeability 2 weeks after it was waterproofed.

It required about 15 min. after starting the test for wall B96 to become sufficiently wet, so that some of the applied water ran off the exposed face of the wall at the bottom. Leaks appeared in the asphalt coating above the upper flashing in about 30 min, but the maximum rate of leakage through the coating (1.1 liters/hr) was observed after an exposure period of 1 day. At that time, about 15 large blisters 1 to 2 in. in diameter and about 30 small blisters ⅛ in. in diameter were observed in the coating. Most of the blisters were located over the brick and many had collapsed, permitting a flow of water from them to the upper flashing. It is probable that water penetrating the masonry at the joints had formed blisters in the coating at the points of weakest bond, on the smooth-textured surfaces of the brick. The performance of the wall was rated P.

(*b*) *Coal Tar*

One coat of a primer and one coat of hot tar (waterproofing 42, table 18) were applied to the back of the wall B97–*cc*42. The primer (creosote oil), met the requirements of Federal Specification TT–W–561a, and was applied with a paint brush. The amount of primer applied was 5.9 lb/100 ft². Two days after priming the wall, the hot coal tar was applied with the same type of brush used to apply the hot-asphalt coating to wall B96. The tar dripped from the brush, but it was applied to the wall with less difficulty than was the asphalt. The thickness of coating was 1/16 to 1/8 in., and the amount applied was 56 lb/100 ft² of wall area. The coal tar met the requirements of Federal Specification R–P–381, type II. The wall was tested for permeability 3 weeks after it was waterproofed.

The coal-tar coating, applied to wall B97, was more permeable than the asphalt coating applied to a similar specimen and was rated *VP*. The first leak in the coating occurred in 12 min over the center of a header brick in the second header course from the bottom. The second leak was noted over a head joint in the first header course. The rate of leakage (from the upper flashing) was a maximum of 29 liter/hr after an exposure period of 1 day. At that time the lower two-thirds of the coating was wet and covered with blisters.

(*c*) *Asphalt roof coating*

One coat of an asphalt roof coating of brushing consistency (waterproofing 43, table 18) was applied to wall B92–*cc*43. The trade name of the roof coating was Sure Seal, and it was made by the Lasting Products Co., Baltimore, Md. The material was said to be 100-percent pure asphalt and asbestos, and it met the requirements of Federal Specification SS–R–451, except that the slippage and flow at 140° F, on metal and prepared roofing, was a maximum of 2½ in., exceeding the permissible maximum.

The material was applied to the back of the wall with a whitewash brush (brush 2, fig. 3), and the amount applied was 16.5 lb/100 ft². The wall was tested for permeability 6 weeks after it was waterproofed.

The wall was rated *VP*. Leaks in the coating appeared first over the joints in the second header course in 0.3 hr and later over the brick. The rate of leakage was a maximum of 39 liters/hr at the end of 1 day. The back of the wall was wet and blisters 1/8 to 1/4 in. in diameter had formed over each brick. There were no blisters over the joints.

(*d*) *Asphalt Emulsion*

An asphalt emulsion of troweling consistency (waterproofing 44, table 18), known as Goroco-Aquaseal, made by the Armstrong Cork Products Co., Lancaster, Pa., was applied to to wall B66–*cc*44. The emulsion contained asphalt, clay, and water but did not contain fibers. It was recommended for use as a protective coating for concrete, metal, or saturated felt. There was no Federal specification applicable to this material.

A coating 1/16 to 1/8 in. thick was applied to the back of the wall with a plastering trowel; the amount applied was 66 lb/100 ft² of wall area. The wall was tested for permeability 2 months later.

About 50 blisters up to 1 in. in diameter were found on the back of the wall after an exposure of 1 day, and water leaked through many of them that had broken. The wall was rated *P*.

(*e*) *Bituminous plastic cement*

One coat of a bituminous plastic cement of troweling consistency (waterproofing 45, table 18) was applied to the back of wall B93–*cc*45. The material, known as Ruberoid Plastic Cement, was made by the Ruberoid Co., Baltimore, Md., and it met the requirements of Federal Specification SS–C–153, type I, asphaltic base.

When applied to the wall, Ruberoid Plastic Cement pulled away from the masonry at a

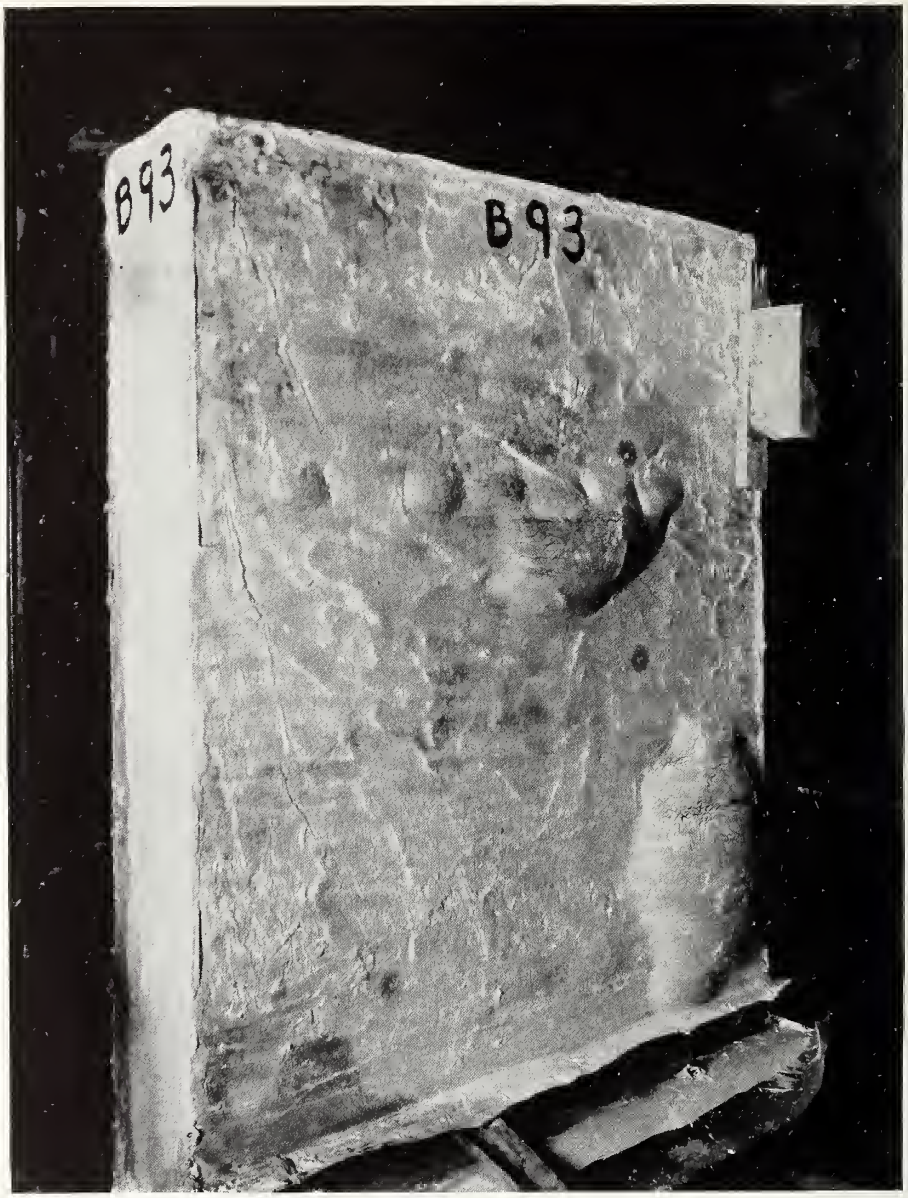


FIGURE 8.—*Back of wall B93, about 5 hours after start of test.*

The wall was treated on the back with bituminous plastic cement.

few joints, and it required careful troweling to coat the wall. The amount applied was about 110 lb/100 ft^2 of wall area. The thickness of the coating was about ⅛ in., and the wall was tested for permeability 2 months after treatment.

Large blisters formed at and below the second header course from the bottom of the wall and at the lower-right portion of the wall in about 4 or 5 hr, as shown in figure 8. The large blister in the lower-right portion of the photograph broke at the flashing in 5½ hr. The maximum rate of leakage from the upper flashing was 34 liters/hr at 1 day, and the wall was rated *VP*.

(*f*) *Discussion*

None of the bituminous coatings applied to the back of the walls was rated better than *P*. The coatings were more or less blistered after an exposure of 1 day, and it is probable that continued or repeated exposure would seriously damage them and still further increase their permeability. The backs of the walls were not plastered, and it was not determined if plaster would have prevented the formation and enlargement of blisters in the bituminous coatings. It is probable, however, that a plaster coating would not have prevented damage to the bond between the waterproofing and the inside faces of the test walls. The data indicate that bituminous coatings are of little benefit as waterproofings on the inside faces of walls that leak badly.

2. Coatings of Cementitious or of Proprietary Materials

The materials used in the cementitious coatings were portland cement, Potomac River building sand, iron dust (iron powder and sal ammoniac), and hydrated lime. They were used singly or in combination and were tempered with water to a brushing (grout) or to a troweling (mortar) consistency. The building sand, except for that used in a mortar parging, was screened through a No. 16 sieve. A sieve analysis of the screened sand is given in table 19.

Table 19.—*Sieve analysis of screened Potomac River building sand* [a]

U. S. Standard Sieve number	Percentage by weight of sand passing
	Percent
16	100
30	71
50	20
100	3

[a] Potomac River building sand screened through No. 16 sieve.

(a) *Portland-Cement and Sand Brush Coating*

Two coats of a cement-sand grout (waterproofing 51, table 18) were applied to each of two walls, wall B98 and B108–*cc*51. The proportions of the grout, by weight, were 1 part of portland cement to 2 parts of dry sand screened through a No. 16 sieve. The amount of water added was 27 percent, by weight, of the dry materials. The walls were wetted thoroughly, but there was no water visible on the masonry when the two coatings were applied to the walls on successive days, using a roofing brush (brush 4, fig. 3). A considerable portion of the larger sand particles dropped from the walls, especially during application of the first coats, and the proportion of cement in the grout remaining on the wall was probably larger than is indicated. The first coats were wetted lightly before the second ones were applied. The grout was frequently stirred during its application, and the amounts applied were approximately equal for each coat. The amounts of cement used for both coats were 23.5 and 24.4 lb/100 ft^2 of wall area for walls B98 and B108, respectively. The amount of cement used was slightly greater in weight than the average weight of the dry powder required for the coatings of cement-water paints applied to similar walls. The walls were wetted twice daily for 3 days and were tested for permeability about 3 months after treatment.

Walls B98 and B108 were rated *F* and *P*, respectively, after treatment, and the rate of leakage through the walls was reduced from an average of about 50 to less than 1 liter/hr.

(b) *Iron-Dust (Iron Powder and Sal Ammoniac) Brush Coating*

Two brush coats of iron dust and sal ammoniac (waterproofing 52, table 18) were applied to wall B100–*cc*52. The wall was thoroughly wetted before each treatment, but it was allowed to dry until no water was visible on the back when the coatings were applied. The waterproofing was Euco brand iron waterproofing made by the Euclid Chemical Co., Cleveland, Ohio. The material was mixed to a heavy-paint consistency by adding 1⅓ parts of water by weight to 1 part of Euco, and it was kept well stirred during application. The two applications were made 2 days apart with a paint brush. The waterproofing was applied first to the joints in the wall and then to the brick. The water in the mixture was readily absorbed by the brick, and the color of the wall, after treatment, was mottled with different shades of brown. The amounts of Euco used for the first and second coats were, respecitvely, 8.1 and 7.0 lb/100 ft^2 of wall area. The wall was wetted twice daily, 1 day after the first coat, and 3 days after the second coat was applied. It was tested for permeability about 4 months after treatment.

Water penetrated the coating at the header courses in less than 10 min, the maximum rate of flow was 16 liters/hr, and the wall was rated *VP*.

(*c*) *Portland-cement and iron-dust brush coatings*

Two brush coats of portland cement mixed with iron powder and salammoniac (waterproofing 53, table 18) were applied to wall B101–*cc*53. The waterproofing was mixed in the proportions, by weight, of 10 percent of Euco brand iron waterproofing and 90 percent of portland cement. The dry mixture was then tempered with 38 percent of water, by weight, to the consistency of a grout or a thick paint. The wall was wet, but there was no water visible on the surface when two applications of the grout were made, 2 days apart, with a brush. The amounts of cement applied for the first and second coats were, respectively, 32.8 and 14.1 lb/100 ft^2 of wall area. The wall was wetted twice daily for 3 days after the second treatment, and the treated surface was mottled in shades of brown. The permeability of the specimen was tested about 4 months after treatment.

Water became visible on the coating behind the second header course in 15 min and the rate of leakage reached a maximum of 0.4 liter/hr in about 6 hr. The wall was rated *P*.

(*d*) *Portland-cement, iron-dust, and sand trowel coatings*

Wall B102–*cc*54 was treated with two trowel coatings of a portland cement and sand mixture containing Euco brand iron dust and salammoniac. The proportions used were 1:0.11:2 parts, by weight, of cement, Euco, and dry sand, passing a No. 16 sieve; the amount of water added was 18 percent, by weight, of the dry materials. The first coat was applied with a steel plastering trowel, and, although the brick backing had been thoroughly wetted, the suction of the backing removed so much water from the mortar that it was troweled with a wooden float after a short period of time. Two days later the mortar covering was wetted and the second coat applied. The thicknesses of the first and second coats were 0.25 and 0.3 in., respectively, and the amounts of cement applied were respectively equivalent to 87 and 113 lb/100 ft^2 of wall area. The wall was stored in air having a relative humidity of 85 percent for 5 days, and it was tested for permeability 4 months after treatment.

A similar treatment, consisting of one brush and two trowel coats, was applied to wall B104–*cc*54. The proportions of the grout and plaster were, respectively, 1:0.11:1 and 1:0.11:2 parts, by weight, of cement, Euco, and dry sand passing a No. 16 sieve. The water contents were, respectively, 36 and 17 percent, by weight, of the dry materials. The brush coat was applied to the wetted surface with a whitewash brush, and it was followed almost immediately, while the grout was damp, with the first trowel coat. This trowel coat was scratched and 2 days later, after wetting, the second trowel coat was applied. The trowel coats were not rodded and were a total of about 0.9 in. in thickness. The amounts of cement applied for the brush coat, the first and second trowel coats were, respectively, 12, 175, and 155 lb/100 ft^2 of wall area. The walls (B102 and B104) were given a preliminary conditioning exposure lasting 2 days and were dried before being tested for record.

The treatments were highly effective, and the walls were rated *G* or *E*. When again tested, after having been weathered outdoors for 16 months, walls B102 and B104 were rated *E* and *F*, respectively. Both walls were damp in vertical strips at the ends, where the waterproofing covered the pargings on the masonry. A small leak (0.2 liter/per hr) from cracks in the coating over the right parging on wall B104 reduced the rating of this wall from *G* or *E* to *F*.

(*e*) *Mortar parging*

One trowel coat of a mortar parging (waterproofing 55, table 18) was applied to wall B68–*cc*55. The mortar (mortar 1, table 3) had a water content of 18 percent, by weight, of dry materials. The wall was wetted thoroughly and the mortar parging was placed to a depth of 0.43 in. with a steel plasterering trowel. The amount of cement applied was 105 lb/100 ft^2 of wall area. The wall was wetted twice daily for

3 days. It was tested 7 weeks after treatment, but was not given a preliminary conditioning test.

Moisture (dampness) penetrated the wall in two vertical belts at the ends, but there was no leakage from the upper flashing, and no water was visible on the back at the end of 1 day. Since only 30 percent of the wall area was damp in 1 day, the wall was rated *G*. When again tested after having been exposed outdoors for 2 yr, water became visible on the back over the first header course in 5 hr, and the wall was rated *F*.

(*f*) *Armor Coat*

Armor Coat (waterproofing 56, table 13) was a white pigmented cementitious powder, manufactured by Armor Laboratories, Glendale, Calif. The makers sponsored the construction and waterproofing of two 8-in walls, one of stone and the other of cinder-concrete block.

The dry walls were prepared for painting by scraping loose bits of mortar and some efflorescent salts from the back with a putty knife. The backs were then thoroughly wetted, and application of the paint was begun when water was no longer visible on the masonry. The paint was prepared by mixing 10 parts, by weight, of Armor Coat with 8.2 parts of water.[7] A small portion of the water was slowly added to the powder, with constant stirring until a paste was formed. Fifteen minutes later the remainder of the water was stirred into the paste, and the paint was ready for use about 20 min after final mixing. Two applications of paint were made to each wall with a paint brush on successive days by G. W. Ketch. About 50 g of a paste made from Armor Coat, white silica sand passing a No. 50 sieve, and water was rubbed into the joints of each wall, and the walls were lightly wetted before the second coat was applied. The amounts of dry powder used in the first and second paint coats on wall B304–*n*56 (cinder-concrete block) were respectively, equivalent to 8.6 and 3.5 lb/100 ft². Similarly, the amounts of powder applied to wall B305–*m*56 (stone-concrete block) were 9.8 and 3.2 lb/100 ft². The walls were wetted once a day for 2 days, and were stored indoors for 3 weeks before they were tested for permeability.

Small drops of water penetrated pinholes in the Armor Coat on the first course of cinder-concrete block of wall B304 (table 18) in 0.7 hr. A similar failure occurred in the coating on the first course of stone-concrete block of wall B304 in 2½ hr. The leakage from pinholes in the coatings was small and was not enough to promote a significant flow of water. After an exposure of 1 day, drops of water were still visible on the lower half of the walls and both were rated *P*.

(*g*) *Dricoat*

Dricoat, a white pigmented waterproofing with the consistency of a paint, is described in section VII–1 (b). Two applications of Dricoat were made on successive days to the back of wall B106–*cc*24. The amounts applied were approximately equivalent to 100 and 130 ft²/gal for the first and second coats, respectively.

Water penetrated the coating behind a head joint in the first header course in 18 min. The wall was rated *VP*, and the maximum rate of flow of 6 liters/hr was observed after 7 hr of exposure.

(*h*) *Discussion*

Cementitious materials are in general use for waterproofing the inside faces of basement walls, but they are not as widely used as bituminous coatings for waterproofing the backs of walls above grade. Walls below grade may be subjected to a head of several feet, rather than inches, of water, and the permeability test described in this paper is not readily applicable for measuring the effectiveness of waterproofings for such walls. The data and wall ratings obtained from the tests on cementitious coatings applied to the backs of the walls are of principal value in comparing the effectiveness of these coatings with the other waterproofings that were tested, and which were intended for use on walls above grade. Since basement rooms are not usually used as living quarters unless the plaster or other interior finish is furred from the wall, the occasional penetration of water which does not develop into leakage may not be objectionable. It is probable, therefore, that the waterproofing treatments rated as *G* or *E* in table 18 may be satisfactory for use on basement walls.

None of the brush coatings of cementitious or of proprietary materials was rated better than *F*. Trowel coatings of portland cement and sand, mixed with or without admixtures of powdered iron and salammoniac, were applied to three walls and were rated *G* or *E*. Although two of these walls were significantly more permeable after weathering outdoors than before, it should be noted that the walls were stored outdoors without protection, and the

[7] The instructions issued by the Armor Laboratories, Inc., for the application of two coats of Armor Coat include a recommendation that the first coat be of thinner consistency than the second. "Two Coat Jobs: First coat, 1 part Armor Coat to 1½ parts water; second coat, 1 part Armor Coat to 1¼ parts water or in equal proportions by volume."

exposure was more severe than if the coatings had been applied to the inside faces of building walls.

X. CONCLUSIONS

The following pertains to the effectiveness and durability of the cement-water paints and of the other waterproofings applied to the small, highly permeable walls built of bricks or of concrete blocks. The waterproofed specimens were tested under conditions simulating wind-driven rain. The durability of the most effective treatments was measured by comparing the permeability of the specimens before and after outdoor weathering exposure.

1. Cement-Water Paints

(a) Two coats of cement-water paints applied to the exposed faces of masonry walls were highly effective as waterproofings. Although weather-stained after an exposure outdoors of 1 or 2 years, many of the paint coatings were found to be less permeable after exposure than before.

(b) The paints were more easily applied to walls of rugged-textured units (cinder-concrete block) with stiff brushes (fender-cleaning brush) than with soft brushes (whitewash brush). The coatings were less permeable and contained fewer pinholes when applied with a stiff brush. A roofing brush, intermediate in stiffness between a fender-cleaning and a whitewash brush, was effective for use on walls of smooth-textured brick.

(c) Cement-water paint coatings for walls of rough-textured units reached a maximum of effectiveness and durability when fine sand was added to the paint used for the first coat. The sanded paint filled depressions in the surfaces of the units and sealed small openings in the joints, so that the second coat of paint (prepared without sand) was easily applied.

(d) Coatings applied to dry highly-absorptive walls were more permeable than those applied to similar backings that were damp when painted.

(e) Coatings of a paint of thin consistency (low in powder content) were more permeable than those of a normal consistency.

(f) The amount of normal-consistency paint applied was dependent upon the surface texture of the units used in the walls. Backings of rough textured cinder-concrete block required more paint than did those of the relatively smooth textured stone-concrete block.

(g) Two thick coatings of normal-consistency paint applied to similar walls with like brushes were less permeable when first applied than two thinner ones. When again tested after outdoor weathering, the reverse was true; the average permeability of thick coatings was found to have increased, and that of thinner coatings had decreased.

(h) Within the range tested, the differences in the relative proportions of portland cement and of hydrated lime used in the paints had no consistent effect on the permeability of the coatings.

(i) The admixture of hygroscopic salts, water repellents, diatomaceous silica, or of an opaque pigment did not increase the effectiveness of the paints.

2. Emulsified Resin and Oil-Base Paints

Coatings of an oil-base paint and of the emulsified resin paints, applied with a paint brush to walls of concrete blocks, were permeable and much less effective as waterproofings than the cement-water paints.

3. Colorless Surface Waterproofings

The colorless waterproofings, except a water emulsion of waxes known as Gargoyle Ceremul–W, were ineffective, and permeable walls treated with them leaked excessively. Coatings of Ceremul–W were slightly more permeable than coatings of cement-water paints. The Ceremul–W treatments were found to have lost much of their effectiveness when the treated walls were again tested after outdoor weathering.

4. Joint Treatments

(a) A highly effective and durable method of waterproofing brick walls without changing their appearance was the repointing of the face joints with mortar.

(b) A portland-cement grout applied to the joints of brick walls was an effective waterproofing. A thin coating of the grout containing fine sand was brushed over the joints with a stiff brush, filling minute openings between the units and the mortar. The permeability of the treatments was significantly but not seriously increased by outdoor weathering.

5. Membrane Waterproofing

A series of waterproof membranes built into the masonry was an effective waterproofing when drainage of leakage water was provided. Drainage was obtained through adequate weepholes at the bottom of the facing tier. When not drained, the leakage water trapped in the masonry filled the cavities in the wall and ran over the tops of the membranes.

6. Waterproofings on the Inside (Unexposed) Faces of the Walls

(a) Bituminous coatings applied to the inside faces of brick walls were ineffective as waterproofings. Blisters filled with water developed in the coatings, and the rates of leakage from blisters that had collapsed was high.

(b) Brush coatings of portland cement and sand leaked slightly but were more effective as waterproofings than bituminous coatings.

(c) Trowel coatings of portland-cement mortars, prepared with or without the admixture of iron powder and sal ammoniac, were highly resistant to water penetration.

Washington, December 5, 1942.

BUILDING MATERIALS AND STRUCTURES REPORTS

[Continued from cover page II]

BMS33	Plastic Calking Materials	10¢
BMS34	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 1	10¢
BMS35	Stability of Sheathing Papers as Determined by Accelerated Aging	10¢
BMS36	Structural Properties of Wood-Frame Wall, Partition, Floor, and Roof Constructions with "Red Stripe" Lath Sponsored by The Weston Paper and Manufacturing Co	10¢
BMS37	Structural Properties of "Palisade Homes" Constructions for Walls, Partitions, and Floors, Sponsored by Palisade Homes	10¢
BMS38	Structural Properties of Two "Dunstone" Wall Constructions Sponsored by the W. E. Dunn Manufacturing Co	10¢
BMS39	Structural Properties of a Wall Construction of "Pfeifer Units" Sponsored by the Wisconsin Units Co	10¢
BMS40	Structural Properties of a Wall Construction of "Knap Concrete Wall Units" Sponsored by Knap America, Inc	10¢
BMS41	Effect of Heating and Cooling on the Permeability of Masonry Walls	10¢
BMS42	Structural Properties of Wood-Frame Wall and Partition Constructions with "Celotex" Insulating Boards Sponsored by The Celotex Corporation	15¢
BMS43	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 2	10¢
BMS44	Surface Treatment of Steel Prior to Painting	10¢
BMS45	Air Infiltration Through Windows	10¢
BMS46	Structural Properties of "Scot-Bilt" Prefabricated Sheet-Steel Constructions for Walls, Floors, and Roofs Sponsored by The Globe-Wernicke Co	10¢
BMS47	Structural Properties of Prefabricated Wood-Frame Constructions for Walls, Partitions, and Floors Sponsored by American Houses, Inc	10¢
BMS48	Structural Properties of "Precision-Built" Frame Wall and Partition Constructions Sponsored by the Homasote Co	10¢
BMS49	Metallic Roofing for Low-Cost House Construction	10¢
BMS50	Stability of Fiber Building Boards as Determined by Accelerated Aging	10¢
BMS51	Structural Properties of "Tilecrete Type A" Floor Construction Sponsored by the Tilecrete Co	10¢
BMS52	Effect of Ceiling Insulation Upon Summer Comfort	10¢
BMS53	Structural Properties of a Masonry Wall Construction of "Munlock Dry Wall Brick" Sponsored by the Munlock Engineering Co	10¢
BMS54	Effect of Soot on the Rating of an Oil-Fired Heating Boiler	10¢
BMS55	Effects of Wetting and Drying on the Permeability of Masonry Walls	10¢
BMS56	A Survey of Humidities in Residences	10¢
BMS57	Roofing in the United States—Results of a Questionnaire	10¢
BMS58	Strength of Soft-Soldered Joints in Copper Tubing	10¢
BMS59	Properties of Adhesives for Floor Coverings	10¢
BMS60	Strength, Absorption, and Resistance to Laboratory Freezing and Thawing of Building Bricks Produced in the United States	15¢
BMS61	Structural Properties of Two Nonreinforced Monolithic Concrete Wall Constructions	10¢
BMS62	Structural Properties of a Precast Joist Concrete Floor Construction Sponsored by the Portland Cement Association	10¢
BMS63	Moisture Condensation in Building Walls	10¢
BMS64	Solar Heating of Various Surfaces	10¢
BMS65	Methods of Estimating Loads in Plumbing Systems	10¢
BMS66	Plumbing Manual	20¢
BMS67	Structural Properties of "Mu-Steel" Prefabricated Sheet-Steel Constructions for Walls, Partitions, Floors, and Roofs Sponsored by Herman A. Mugler	15¢
BMS68	Performance Test for Floor Coverings for Use in Low-Cost Housing: Part 3	15¢
BMS69	Stability of Fiber Sheathing Boards as Determined by Accelerated Aging	10¢
BMS70	Asphalt-Prepared Roll Roofings and Shingles	15¢
BMS71	Fire Tests of Wood- and Metal-Framed Partitions	20¢
BMS72	Structural Properties of "Precision-Built, Jr." Prefabricated Wood-Frame Wall Construction Sponsored by the Homasote Co	10¢
BMS73	Indentation Characteristics of Floor Coverings	10¢
BMS74	Structural and Heat-Transfer Properties of "U. S. S. Panelbilt" Prefabricated Sheet-Steel Constructions for Walls, Partitions, and Roofs Sponsored by the Tennessee Coal, Iron & Railroad Co	15¢
BMS75	Survey of Roofing Materials in the North Central States	15¢
BMS76	Effect of Outdoor Exposure on the Water Permeability of Masonry Walls	15¢
BMS77	Properties and Performance of Fiber Tile Boards	10¢
BMS78	Structural, Heat-Transfer, and Water-Permeability Properties of Five Earth-Wall Constructions	20¢
BMS79	Water-Distributing Systems for Buildings	15¢
BMS80	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 4	15¢
BMS81	Field Inspectors' Check List for Building Construction (cloth cover, 5 x 7½ inches)	20¢
BMS82	Water Permeability of Walls Built of Masonry Units	20¢

[List continued on cover page IV]

BUILDING MATERIALS AND STRUCTURES REPORTS

[Continued from cover page III]

BMS83	Strength of Sleeve Joints in Copper Tubing Made With Various Lead-Base Solders	10¢
BMS84	Survey of Roofing Materials in the South Central States	15¢
BMS85	Dimensional Changes of Floor Coverings with Changes in Relative Humidity and Temperature	10¢
BMS86	Structural, Heat-Transfer, and Water-Permeability Properties of "Speedbrik" Wall Construction Sponsored by the General Shale Products Corporation	15¢
BMS87	A Method for Developing Specifications for Building Construction—Report of Subcommittee on Specifications of the Central Housing Committee on Research, Design, and Construction	10¢
BMS88	Recommended Building Code Requirements for New Dwelling Construction with Special Reference to War Housing	20¢
BMS89	Structural Properties of "Precision-Built, Jr." (Second Construction) Prefabricated Wood-Frame Wall Construction Sponsored by the Homasote Co	15¢
BMS90	Structural Properties of "PHC" Prefabricated Wood-Frame Constructions for Walls, Floors, and Roofs Sponsored by the PHC Housing Corporation	15¢
BMS91	A Glossary of Housing Terms	15¢
BMS92	Fire-Resistance Classifications of Building Constructions	25¢
BMS93	Accumulation of Moisture in Walls of Frame Construction During Winter Exposure	10¢
BMS94	Water Permeability and Weathering Resistance of Stucco-Faced, Gunite-Faced, and "Knap Concrete Unit" Walls	10¢
BMS95	Tests of Cement-Water Paints and Other Waterproofings for Unit-Masonry Walls	15¢