Paints For Exterior Masonry Walls

BUILDING MATERIALS AND STRUCTURES REPORT BMS110

UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

BUILDING MATERIALS AND STRUCTURES REPORTS

On request, the Superintendent of Documents, U. S. Government Printing Office, Washington 25, 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 25, 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	15¢
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*	*
BMS8	Methods of Investigation of Surface Treatment for Corrosion Protection of Steel	10¢
BMS9	Structural Properties of the Insulated Steel Construction Co.'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	15c
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	20¢
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	15¢
BMS25	Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs	15¢
SMS26	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 Northwestern States	15¢
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¢

*Out of print.

[List continued on cover page III]

Paints for Exterior Masonry Walls

by

CLARA SENTEL

ISSUED NOVEMBER 15, 1947

Building Materials and Structures Report BMS110

UNITED STATES DEPARTMENT OF COMMERCE • W. Averell Harriman, *Secretary*

NATIONAL BUREAU OF STANDARDS • E. U. Condon, *Director*

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1947

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, U. S. GOVERNMENT PRINTING OFFICE, WASHINGTON 25, D. C.
PRICE 15 CENTS

Foreword

Data on the relative durability and performance of four general classes of masonry paints are given in this report. Out-of-door weathering tests were conducted to determine the serviceability of paints applied to wall specimens constructed of new and used common brick; cast concrete; stone-, cinder-, and lightweight-aggregate-concrete block; and wood frame with cement-asbestos shingles.

Formulas for the paints and erection of the wall sections are described, as well as methods for applying paint to the specimens. Ratings based on the weathering characteristics and performance of each type of paint and evaluation of painting methods for coating different surfaces are given.

Painted specimens which are discussed in detail in the body of this report were exposed to atmospheric conditions in Washington, D. C., for a period of approximately three years. Results of the same tests for a 6-year period are shown graphically in the appendix. Conclusions are for the conditions of test described.

E. U. CONDON, *Director.*

Paints for Exterior Masonry Walls

by **Clara Sentel**

ABSTRACT

Four classes of masonry paints, cement-water, resin-emulsion, oil-base, and synthetic-rubber, and one whitewash were applied to test wall specimens of new and used common brick; cast concrete; stone-, cinder, and lightweight-aggregate-concrete block; and wood frame with cement-asbestos shingles to determine the durability of such paints on masonry surfaces. Specimens, exposed to atmospheric conditions for approximately 3 years, were rated on weathering characteristics. Durability of the paints was determined on the bases of type of paint used, type of surface coated, methods of application and curing, and conditions of casting and painting.

CONTENTS

I. INTRODUCTION

Tests to determine the comparative durability of four general types of paints and one whitewash applied under practical painting conditions to wall specimens of porous masonry were conducted at the National Bureau of Standards in an out-of-door test field. The specimens were exposed to weathering conditions for periods of from 24 to 33 months during the years from 1940 to 1943. As the use of porous masonry products has increased, so has the need for more knowledge of water-repellent and decorative finishes for such surfaces.

Permeability of masonry walls to water has been discussed in other reports of the Building Materials and Structures series.[1] This paper discusses the condition of specimens of porous masonry after exposure to the weathering period and reports the behavior of coatings of various types which were applied to these specimens.

Masonry specimens, to which the paints herein discussed were applied, were constructed of new and used common brick; cast concrete;

[1]Building Materials and Structures Reports BMS55, Effects of Wetting and Drying on the Permeability of Masonry Walls; BMS76, Effect of Outdoor Exposure on the Water Permeability of Masonry Walls; BMS82, Water Permeability of Walls Built of Masonry Units; BMS94, Water Permeability and Weathering Resistance of Stucco-Faced, Gunite-Faced, and "Knap Concrete-Unit" Walls; and BMS95, Tests of Cement-Water Paints and Other Waterproofings for Unit-Masonry Walls.

stone-, cinder-, and lightweight-aggregate-concrete block; and wood frame with cement-asbestos shingle facing.

Paints used in the tests were of the types commonly applied to masonry surfaces. They were white in color and included 20 cement-water paints, 4 resin-emulsion paints, 4 oil-base paints, 5 synthetic-rubber paints, and 1 whitewash. Some were proprietary brands while others were experimental mixes. These paints are suitable for use on foundations, exterior walls, porches, and fences, but should not be used for floors such as concrete, brick, or for other surfaces which might be subject to abrasion. Instead, for such floors, a very hard-drying paint with good water resistance and good gloss retention is recommended.

The test field used for the masonry paint experiments discussed in this paper was located in a section of the grounds of the National Bureau of Standards which was exposed to sunlight during the greater portion of the day (see fig. 1). Trees adjacent to the east and south side of the test field shaded a few of the wall specimens and tended to increase the humidity of the area. It was found that toward evening appreciable condensation was observed on the test panels. This condition was attributed to the sudden drop in temperature caused by the disappearance of the sun and was found favorable for the curing of cement-water paints but detrimental to oil-base and resin-emulsion type paints.

In the same area as that in which the specimens were tested at the Bureau, a small field office was built to facilitate the recording of test data and to serve as an "in-service" specimen. Further details concerning the field office are given in chapter IV of this paper.

II. MATERIALS

1. Paints

(a) Cement-water Paints

Cement-water paints are water-dilutable paints in which portland cement is the binder. They are especially suitable for use on porous masonry walls that are damp at the time of painting or are subject to dampness.

A typical cement-water paint film is hard, strong, and relatively brittle. This property, together with drying shrinkage, may result in the development of fine checking, usually referred to as "map cracking," (see chapter V). Such paints should weather by erosion, that is, by gradual wearing away of the coating. This behavior is considered normal, and unless erosion is rapid and map cracking progressive, such a breakdown is not serious. Cement-water paint possesses good decorative qualities as to hiding power and color. However, when wetted, as by rain, it becomes somewhat translucent or darker in the case of a color. On drying, the film returns to its original opaqueness and color.

Cement-water paints vary widely in composition. The ratio of portland cement to other ingredients is seldom less than 1 to 1, and may be as high as 9 to 1; the usual average is about 3 to 1.

In this study, 20 cement-water paints were tested—6 proprietary brands and 14 experimental mixes. Proprietary brands were purchased in original containers. Experimental mixes were made by tumbling the dry ingredients in a pebble mill (without pebbles in the jar) for 24 hours. To prevent chemical changes in composition, powder paints were stored in moisture-proof containers.

Cement-water paints *CW-1* to *CW-5*, inclusive, were proprietary brands. All had good

FIGURE 1.—*A portion of the test field showing the position of the walls.*

mixing properties and produced a smooth finish. Composition of these paints, as determined by laboratory analysis, is shown in table 1.

TABLE 1.—*Composition of proprietary brand cement-water paints CW-1 to CW-5*

[Determined by laboratory analysis]

Paint designation	Ingredients for cement-water paints	Composition by weight
		Percent
CW-1	Portland cement	89
	Titanium dioxide	4
	Insoluble	3
	Salt (calculated as NaCl)	2
	Stearates present	([1])
CW-2	Portland cement	48
	Calcium hydrated lime	49
	Hygroscopic salts and stearates present	([1])
CW-3	Portland cement	85
	Insoluble (apparently mica)	10
	Hygroscopic salts and stearates present	([1])
CW-4	Portland cement	75
	Titanium dioxide	5
	Lime	7
	Insoluble	10
	Salts and stearates present	([1])
CW-5	Portland cement	40
	Lime	43
	Zinc sulfide	4
	Insoluble	10
	Salt and stearates present	([1])

[1]Amount not determined.

Cement-water paint, *CW-6*, was a proprietary material consisting of two parts—a powder and an oil-like sealer, which dried to a smooth finish. The powder was mixed with water and applied to the damp surface; after aging for 24 hours, the first coating was followed by the sealer. No analysis is available since the material was supplied and handled by the manufacturer's representative.

Cement-water paints *CW-7* to *CW-20*, inclusive, were experimental formulas. The grout and 100-percent portland-cement coats were mixed at the field, while the other paints were prepared in the laboratory. Sufficient water was added to the dry ingredients to give a good brushing consistency. All the paints had good mixing properties except the waterproofed, white cements, which are difficult to mix by hand but can be mixed readily in a mechanical agitator. Cement-water paints containing sand showed slight texture but those without sand produced a smooth finish. Compositions of the cement-water paint group *CW-7* to *CW-20* is given in table 2.

TABLE 2.—*Composition of experimental mix cement-water paints CW-7 to CW-20*

[Determined by laboratory analysis]

Paint designation	Ingredients for cement-water paints	Composition by weight
		Percent
CW-7	Portland cement	70
	Calcium hydrated lime	30
CW-8	Portland cement	70
	Hydrated (92%) magnesium lime	30
CW-9	Portland cement	100
CW-10 (grout)	Portland cement	50
	Potomac River mortar sand (passing No. 20 sieve)	50
CW-11	Portland cement	50
	Silica sand (passing No. 20 sieve)	49
	Calcium stearate	1
CW-12	Portland cement	99
	Calcium stearate	1
CW-13	Portland cement	95
	Calcium stearate	1
	Calcium chloride	4
CW-14	Portland cement	46
	Silica sand (passing No. 20 sieve)	46
	Calcium chloride	4
	Lithopone (50% ZnS)	4
CW-15	Portland cement	92
	Calcium chloride	4
	Lithopone (50% ZnS)	4
CW-16	Commercial waterproofed white cement	100
CW-17	Commercial waterproofed white cement	96
	Calcium chloride	4
CW-18	Portland cement	50
	Calcium hydrated lime	49
	Calcium stearate	1
CW-19	Portland cement	98
	Flake mica	1
	Calcium stearate	1
CW-20	Portland cement	93
	Titanium dioxide	3
	Calcium chloride	4

(b) Resin-emulsion Paints

Resin-emulsion paints are water-reducible pastes of pigments ground in a vehicle of oil-extended resin (usually glycerol phthalate) which has been treated with an emulsifying agent to render it miscible with water. A typical resin-emulsion paint is easily applied by brush or spray and dries within a few hours to a smooth, opaque, flat finish. This type of paint normally weathers by chalking. However, excessive moisture or alkaline salt solutions forming back of the film may induce blistering, followed by flaking, or the alkalies may cause saponification of the nonvolatile vehicle resulting in erosion of the film.

Of the four resin-emulsion paints tested *RE–1*, *RE–2*, and *RE–4* were proprietary brands while *RE–3* was an experimental mix made by a manufacturer of emulsified resins. The compositions of these paints, shown in table 3, were supplied by the manufacturers.

All of the resin-emulsion paints, except *RE–2*, mixed readily with water in the proportions of 2 parts paste to 1 part water (by volume) for the first coat and 5 parts paste to 3 parts water for the finish coats. Brushing properties were good and the emulsion did not appear to break under the brush. Within 2 hours this paint dried dust free to a flat, smooth finish suitable for recoating within 18 hours.

The paste for resin-emulsion paint, *RE–2*, was mixed in the proportions of 2 parts paste to 1 part water (by volume) for both the first

TABLE 3.—*Composition of resin-emulsion paints RE-1, RE-2, RE-3, and RE-4*[1]

Paint designation	Ingredients for resin-emulsion paints	Composition by weight	
		Percent	
RE-1	Pigment:		47
	Titanium dioxide	10	
	Titanium-barium pigment	78	
	Mica	6	
	Silica	6	
	Vehicle:		53
	Emulsified alkyd resin	50	
	Water	50	
RE-2	Pigment:		52
	Titanium dioxide	6	
	Zinc oxide	8	
	Basic carbonate white lead	16	
	Magnesium silicate	15	
	Aluminum silicate	27	
	Calcium carbonate	28	
	Vehicle:		48
	Water and volatile matter	61	
	Oil-extended synthetic resin	32	
	Fungicide	1	
	Emulsifying agents	6	
RE-3	Pigment:		40
	Titanium dioxide	40	
	Titanium-barium pigment	40	
	Mica	10	
	Silica	10	
	Vehicle:		60
	Emulsified resin (containing 50% solids)	100	
RE-4	Pigment:		45
	Lithopone	100	
	Vehicle:		55
	Resin emulsion (containing 50% solids)	60	
	Casein solution	39	
	Lead manganese drier		

[1]Composition furnished by manufacturer.

and finish coats. Brushing properties were poor and the paint rolled under the brush. Within 2 hours the film dried dust free to a grainy, flat finish suitable for recoating within 18 hours.

(c) Oil-base Paints

The term "oil-base paints" is commonly used to describe ready-mixed paints which contain opaque pigments suspended in a vehicle of drying oils and thinner. Paints designed for use on masonry are usually formulated so that the first coat seals the surface sufficiently to prevent "spotting" or "flashes" of the second coat. Two coats, as a rule, are necessary for good hiding and durability.

Application of oil-base paints to damp surfaces or surfaces which may be subjected to dampness by the infiltration of moisture through structural defects is not recommended. The presence of such moisture frequently results in failure of the paint film by blistering, flaking, or rapid erosion.

Four commercial oil-base paints *O–1*, *O–2*, *O–3*, and *O–4* were tested. The composition of the proprietary brands in their reduced form were supplied by the manufacturers and are shown in table 4.

Oil-base paint, *O–1*, thinned according to the manufacturer's directions, showed good brushing qualities and penetration and no tendency to sag. Within 6 hours the film dried dust free

TABLE 4.—*Composition of oil-base paints O-1, O2, O-3, O-4*[1]

Paint designation	Ingredients for oil-base paints	Composition by weight	
		Percent	
O–1	Pigment:		71
	Lead-zinc pigment	78	
	Titanium dioxide	2	
	Silica and silicates	20	
	Vehicle:		29
	Processed linseed and tung oil	59	
	Mineral spirits	26	
	Japan drier	15	
O–2	Pigment:		65
	Portland cement	92 to 50	
	Tinting pigment	8 to 50	
	Vehicle:		35
	Linseed oil	94	
	Drier	6	
O–3[2]	Priming paint:		
	Pigment:		63
	Titanium pigment	38	
	Carbonate lead	37	
	Magnesium silicate	25	
	Vehicle:		37
	Treated linseed and tung oil	60	
	Drier and thinner	40	
O–3[2]	Finish coating:		
	Pigment:		61
	Titanium pigment	37	
	Lead sulfate	16	
	Zinc oxide	29	
	Magnesium silicate	18	
	Vehicle:		39
	Linseed oil	90	
	Drier and mineral spirits	10	
O–4	Pigment:		65
	White lead	60	
	Zinc oxide	26	
	Titanium oxide	8	
	Magnesium silicate	6	
	Vehicle:		35
	Linseed oil	86	
	Drier and thinner	14	

[1]Composition furnished by the manufacturer.
[2]Oil-base paint, *O-3*, consisted of two separately formulated paints, a primer and a finish coating.

to a smooth, eggshell finish suitable for recoating within 24 hours.

Thinned according to the manufacturer's directions, oil-base paint, *O–2*, had a slight pull under the brush but showed good penetration. Within 8 hours the film dried dust free to a smooth, glossy finish suitable for recoating within 48 hours.

Oil-base paint (priming and finish), *O–3*, consisted of two separately formulated paints, a primer and a finish coating, therefore required no thinner. Both showed good brushing qualities and penetration and no tendency to sag. The primer showed good sealing properties and within 8 hours dried dust free to a smooth, semiglossy finish suitable for recoating in 48 hours. The finish paint dried dust free within 8 hours to a smooth, semiglossy finish and to a firm finish in 24 hours.

Applied only to the specimens covered with cement-asbestos shingles, oil-base paint, *O–4*, was an outside house paint thinned with spar varnish (Fed. Spec. TT-V-121b) in the proportions of 2 qt of varnish per gal of paint for the priming coat and 1 qt of varnish per gal of paint for the finish coat. The priming coat dried dust free within 8 hours to a smooth, eggshell finish suitable for recoating within 24 hours. The finish coat dried to a smooth, high eggshell finish in 24 hours. The paint had good brushing and sealing properties.

(d) Synthetic-rubber Paints

There are two types of synthetic-rubber paints: the rubber-solution type, in which the synthetic rubber is added to a vehicle of treated drying oils, aromatic hydrocarbons, and coal tar thinners; and the rubber-emulsion type, in which the synthetic-rubber resin is treated with an emulsifying agent so that the paste paints are reducible with water. As these paints usually contain less pigment than those of other exterior finishes, the pigments selected must produce films of high opacity in order to give adequate hiding in two coats.

Coatings of synthetic-rubber paint should weather by chalking, although complete weathering characteristics for coatings of this type have not yet been fully established.

Five commercial brands of synthetic-rubber paints, *SR–1*, *SR–2*, *SR–3*, *SR–4*, and *SR–5*, were tested. When the tests were made, rubber-emulsion paints had poor storage stability and could only be supplied directly by the manufacturer. The composition of specimen *SR–5* was not available. The compositions of the other four rubber-emulsion brands were furnished by the manufacturer and are shown in table 5.

TABLE 5.—*Composition of synthetic-rubber paints, SR-1, SR-2, SR-3, and SR-4*[1]

Paint designation	Ingredients for synthetic-rubber paints	Materials by weight	
		Percent	
SR–1	Pigment:		38
	Titanium dioxide	44	
	Zinc oxide	20	
	Magnesium silicate	31	
	Diatomaceous silica	5	
	Vehicle:		62
	Rubber-base solution (containing 28% solids)	100	
SR–2	Pigment:		25
	Lithopone	100	
	Vehicle:		75
	Chlorinated rubber	18	
	Solvent mix	37	
	Plasticizers	12	
	Water	33	
SR–3	Pigment:		23
	Titanium dioxide	100	
	Vehicle:		77
	Chlorinated rubber	18	
	Solvent mix	37	
	Plasticizers	12	
	Water	33	
SR–4	Pigment:		23
	Titanium dioxide	100	
	Vehicle:		77
	Chlorinated rubber	17	
	Solvent mix	38	
	Plasticizers	14	
	Water	31	

[1]Composition furnished by manufacturer.

SR–1, synthetic-rubber paint, was of the rubber-solution type. Brushing properties and finish were good and were comparable to those of oil paints formulated for use on masonry. The material was used with satisfactory results as a primer under resin-emulsion and oil-base paints and as a finishing material. For the priming coat, rubber-solution type paint, *SR–1*, mixed readily with turpentine in the proportions of 1 pt turpentine to 1 gal paint; the finish coat was applied as received. Within 2 hours the film dried dust free to a smooth, low-gloss finish suitable for recoating within 18 hours.

Synthetic-rubber paints *SR–2*, *SR–3*, *SR–4*, and *SR–5* were the rubber-emulsion type and had physical properties similar to those of the resin-emulsion type.

Mixing readily with water in the proportions of 4 parts paint to 1 part water (by volume), synthetic-rubber paint, *SR–2*, is used for priming and finish coats. This paint had good brushing properties. Within 1 hour the film dried dust free to a smooth, flat finish suitable for recoating within 18 hours.

SR–3, synthetic-rubber paint, mixed readily with water in the same proportions as rubber-emulsion paint, *SR–2*, and showed good brushing properties. Within 1 hour the film dried dust free to a smooth, flat finish suitable for recoating within 18 hours.

In the same proportions as *SR–2*, synthetic-rubber paint *SR–4* mixed readily with water. Brushing properties were fair and there was slight pull under the brush. Within 1 hour the film dried dust free to a smooth, flat finish suitable for recoating within 18 hours.

Synthetic-rubber paint, *SR–5*, also mixed readily with water in the same proportions as *SR–2*. Brushing properties were poor and the paint rolled under the brush. Within 1 hour the film dried dust free to a grainy, flat finish suitable for recoating within 18 hours. The composition of this paint was not available.

(e) Whitewash

While the study of lime coatings was not anticipated in this project, one whitewash formulation was included. Whitewash is basically lime (either hydrated or quicklime paste) and water, but frequently other ingredients are added. The National Lime Association[2] lists ten formulas in its Bulletin No. 304-D. Formula No. 4, which was used in this test, contained the following ingredients:

Casein 5	lb dissolved in 2 gal of hot water.
Trisodium phosphate..3	lb dissolved in 1 gal of water.
Formaldehyde 3	pt mixed in 3 gal of water.
Lime paste 8	gal (50 lb of hydrated lime mixed with 6 gal of water.)

When applied to damp walls, this whitewash dried to an opaque, hard, dust-free finish. Dur-

[2]National Lime Association, 927 Fifteenth Street N.W., Washington 5, D.C.

ing rainy weather the film became somewhat transparent but dried to its original opaqueness.

2. Wall Specimens

(a) General Description

The wall test specimens were constructed to face north and south and to have a vertical exposure. With the exception of the cement-asbestos shingle-faced walls, all specimens had faces measuring 2 ft by 2 ft with an over-all area of 11 sq ft, including both faces and sides. The shingle-faced walls had an area of approximately 32 sq ft.

A sheet of grade A asphalt roofing was placed between the wall specimen and the base on which it rested, to serve as a "water break." The wall specimen and the base were fastened together by 4-in. bolts embedded in mortar. Walls built of unit masonry had sloping roofs of painted galvanized metal equipped with gutters for carrying water off to the side away from the walls; the cement-asbestos walls had sloping roofs with a slight overhang, covered with painted asphalt roofing; and the cast-concrete walls had flat tops painted with two coats of exterior masonry paint containing chlorinated rubber.

The mortar used in walls of masonry units consisted of 1 part gray portland cement, 1 part calcium hydrated lime, and 6 parts Potomac River mortar sand, by volume.

Commercial workmanship was specified. Joints were not completely filled with mortar. Bed joints were furrowed, collar joints were left open, and only the outside of head joints was filled by lightly buttering outer edges of the bricks. Joints were cut flush with faces of specimens.

Wall specimens were allowed to stand from one to six weeks before painting. The first specimens to be coated were painted with cement-water or synthetic-rubber paints as they are usually less susceptible to moisture and alkaline solutions within new walls than are oil-base or resin-emulsion paints.

(b) New Common Brick

Wall specimens for test purposes were constructed with two grades of new red shale brick, one more porous than the other and, in each case, the walls were eight courses high. In one series, five header brick were used for the fifth course with header brick at alternate courses at the ends of the wall; whereas, in the other series, header brick were used only at alternate courses at the ends of the wall. Commercial workmanship was used.

(c) Used Common Brick

The material for a few walls was used common brick, which was purchased from a wrecking concern. These brick were laid in the condition received, and no attempt was made to determine the kind, amount, or depth of stains.

(d) Cast Concrete

The cast-concrete walls consisted of 1 part cement, 2.2 parts sand, and 3.5 parts coarse aggregate (by volume). The ingredients were mixed commercially and were cast in forms made of smooth pine coated with form oil. Rather dense slabs were produced, but the surface was marred with voids apparently made from entrapped air.

(e) Stone-concrete Block

The stone-concrete block were sand and gravel block, gray-tan in color, with porous but fairly smooth faces. Test walls constructed with the block were similar in dimensions and workmanship to those of the lightweight-aggregate-concrete or cinder-concrete block.

(f) Cinder-concrete Block

Cinder-concrete block were dark gray in color and measured approximately 8 by 8 by 12 in. Walls were laid two blocks wide and three courses high. Joints were lightly smoothed with the point of a trowel.

(g) Lightweight-aggregate-concrete Block

Expanded blast-furnace slag, medium gray in color, was used for the lightweight-aggregate-concrete block. Each block measured approximately 8 by 8 by 12 in. and had two oval cells. Walls were laid two blocks wide and three courses high. Joints were lightly smoothed with the point of a trowel.

(h) Cement-asbestos Shingles

The specimens for these tests were panels consisting of 16 new, oyster-white, cement-asbestos shingles laid with an 11-in. exposure over a wood frame. The shingles were purchased from two manufacturers in regular and heavy thicknesses.

III. PAINTING THE WALL SPECIMENS

1. General Procedure

The methods of preparing the surface for painting, and of thinning, mixing, and applying the paints were essentially the same for all materials tested.

The exact procedures followed in the application of each type of paint are described in succeeding sections of this chapter.

(a) Preparation of the Surface

Prior to painting, dust and loose mortar were removed by brushing with a stiff bristle brush. During hot, dry weather very porous surfaces, such as concrete block, were sprinkled with water to decrease the suction and to prevent the paint from setting under the brush, except where oil-base paints were to be applied. To remove the surface glaze, cast-concrete walls were washed with a 10-percent hydrochloric acid solution and then thoroughly rinsed with clean water.

(b) Mixing of Paints

Proprietary paints were mixed according to the manufacturers' direction, which conformed closely to the procedure used in mixing the experimental paints. Thinner was added gradually to the mixture which was stirred constantly. Water was used for paints of the cement-water, resin-emulsion, and rubber-emulsion types. If the manufacturer indicated that the mixture should be thinned, either paint thinner, mixing sealer, or spar varnish was added to the oil-base paints. Turpentine was used for thinning the first coat of rubber-solution paints.

In the preparation of experimental mixes for tests of cement-water paints, approximately equal parts (by volume) of powdered cement-water paint and water were used. A small portion of the water was first stirred into the dry powder. As soon as a smooth paste had been formed, the remainder of the water was added and the paint solution again mixed well. This was allowed to stand for thirty minutes before being given another vigorous stirring, after which the paint was ready for application to the wall specimen panels.

(c) Application of Paints

All paints were applied by brush. Cement-water paints were worked well into the damp walls with an ordinary scrub brush to fill voids and openings and to provide a continuous, water-resistant film. The use of soft-bristled or whitewash brushes is not recommended for the application of cement-water coatings, as this method will not produce as good mechanical bond between the paint and the surface as stiff-bristled brushes. A 3-in. paint brush was employed to spread organic coatings on the surfaces of the specimens and a whitewash brush was used for whitewash.

2. Cement-water Paints

Two coats of cement-water paints were applied to the specimen panels allowing 24 hours of drying time between coats. During hot, dry weather the first coat was sprayed lightly with water before application of the second coat, which was kept damp for 72 hours. During hot, windy weather the walls were sprayed late in the afternoon until the films were well dampened; during damp, humid weather no spraying was necessary. The films hardened satisfactorily in approximately 3 days.

3. Resin-emulsion Paints

For tests on resin-emulsion paints, surfaces of the wall specimens were given two coats. The resin-emulsion paints were either self-primed or applied over cement-water or synthetic-rubber primers. If it rained during the 24-hour aging period of the resin-emulsion or synthetic-rubber primers, application of the second coat was postponed until the first clear day. Cement-water primers were allowed to age 72 hours.

4. Oil-base Paints

To obtain information on the behavior of oil-base paints, two coats were applied. The oil-base paints were either self-primed or applied over cement-water or synthetic-rubber primers. Twenty-four hours of drying time elapsed after the application of synthetic-rubber primers and between two coats of oil paint. After a cement-water primer was used or before the oil-base paint was applied directly to porous masonry, at least 1 week of clear, dry weather was allowed to precede application of the oil-base coating.

5. Synthetic-rubber Paints

The surfaces for testing were given two coats of synthetic-rubber paints. They were self-primed or applied over cement-water primers. Twenty-four hours of drying time was allowed between coats for synthetic-rubber primers and 72 hours for cement-water primers. Rubber paints were applied on either clear or damp days but not to surfaces on which there was free water.

6. Whitewash

Two coats of whitewash were applied to the test surfaces. The walls were dampened with water before brushing on the first coat. Twenty-four hours of drying time was allowed between each coat. The second coat of whitewash dried to a flat, opaque finish.

A schedule which may be used as a guide in estimating the drying time for various masonry paints is given in table 6.

IV. PAINTING THE FIELD OFFICE

The small structure which served as a field office was built of 3-cell, 8- by 8- by 16-inch, open-textured, cinder-concrete block laid up with cement-lime mortar.

Both the exterior and interior walls were finished with grout containing equal parts (by volume) of white portland cement and Potomac River mortar sand mixed with enough water to give a creamy consistency. The grout was scrubbed into the exterior walls and allowed to harden for 24 hours, after which a second coat consisting of 2 parts of white portland cement and 1 part of Potomac River mortar sand mixed with enough water to give a creamy consistency was applied. The exterior grout finish dried to form a light cream-colored, hard, dust-free surface, possessed of good decorative qualities and also provided an efficient barrier against rain penetration. After exposure of slightly more than one year, the grout was clean, nonchalking, and relatively free of map cracking as is shown in the illustration of the field office, figure 2.

For the interior walls, a first coat of grout was scrubbed into the faces and allowed to age for 96 hours. A coat of resin-emulsion paint was then applied which dried to a smooth, flat finish in 24 hours.

In order to obtain additional information on synthetic-rubber solution paint in service, however, two coats were applied over the grout finish on the exterior walls and chimney. The rubber-base paint was easily applied, had good covering and hiding properties, and was given a descriptive rating of "Very Good" or a numerical rating of 9 after 2 years of exposure.

TABLE 6.—*Time to be allowed between applications of typical masonry paints on concrete and clay surfaces*

Wall specimens	Grout		Cement water		Resin emulsion		Oil base		Rubber solution		Whitewash	
	1st coat Drying time	2d coat Drying time	1st coat Drying time	2d coat Drying time	1st coat Drying time	2d coat Drying time	1st coat Drying time	2d coat Drying time	1st coat Drying time	2d coat Drying time	1st coat Drying time	2d coat Drying time
	Days	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
Stone-concrete block	1	1										
Do	1			1								
Do	30				1	1						
Do	90						2	2				
Do	3								1	1		
Do			1	1								
Do			30[1]		1	1						
Do			90[1]				2	2				
Do			3[1]						1	1		
Do											1	1
Cinder-concrete block	1	1										
Do	1			1								
Do	30				1	1						
Do	90						2	2				
Do	3								1	1		
Do			1	1								
Do			30		1	1						
Do			90				2	2				
Do			3						1	1		
Do											1	1
Lightweight aggregate concrete block	1	1										
Do	1			1								
Do	30				1	1						
Do	90						2	2				
Do	3								1	1		
Do			1	1								
Do			30		1	1						
Do			90				2	2				
Do			3						1	1		
Do											1	1
New common brick[2]			1	1								
Do			30		1	1						
Do			90				2	2				
Do			3						1	1		
Do					1	1						
Do							2	2				
Do									1	1		
Do											1	1
Cast concrete			1	1								
Do					1	1						
Do							2	2				
Do									1	1		
Do											1	1
Cement-asbestos shingle					1	1						
Do							2	2				
Do									1	1		
Used common brick:[3]												
Sound, with tight joints									1	1		
Chipped or with open joints	3								1	1		
Do											1	1

[1]If 2 coats of cement-water paint are necessary, the second coat may be applied 24 hr. after the first coat. The second coat should then be allowed to dry for 30 days before application of the resin-emulsion paint, 90 days before application of oil-base paint, and 3 days before rubber solution paint.

[2]Grout would not ordinarily be used on new common brick walls, but may be if necessary, following the same procedure as is given for concrete block walls.

[3]Unstained used common brick can be treated same as new common brick.

FIGURE 2.—*Field office with cinder-concrete block walls and chimney of new common brick.*

V. TEST RESULTS

1. Basis of Evaluation

To evaluate the performance of the coatings included in this report, the paints were applied to the surfaces and allowed to age, after which they were rated for appearance, durability, and general performance. The spreading rate and the reflectance of each separate coat of paint were also noted. Wall sections constructed of new common brick; cast concrete; stone-, cinder-, and lightweight-aggregate-concrete block were rated according to the paint used. However, because badly stained used common brick and new cement-asbestos shingles would not ordinarily be painted, the only basis by which their paint performance could be evaluated was according to the coating surface.

(a) Appearance and Durability

The appearance and durability of the paints were classified descriptively as: "Very Good," "Good," "Fair," "Poor," and "Very Poor" and numerically as "9-8," "7-6," "5-4," "3-2," and "1-0." The number of wall specimens in each classification was tabulated for each paint tested.

(b) General Rating

The general rating was an arbitrarily devised means of evaluating the performance of each paint. The rating scale was based on weathering characteristics of the paint film, which included the most common types of paint failures described as "slight," "definite," and "bad" and further defined as follows:

Bleeding: The working up of a stain or other material into succeeding coats, imparting to them a certain amount of color.

Blistering: Formation of bubbles on the surface of paint film, usually caused by moisture behind the film.

Chalking: Powdering of the paint film at or just beneath the surface.

Checking: A defect in organic coatings, manifested by slight breaks in the film surface.

Erosion: Wearing away of the paint film by the action of the weather.

Flaking: Detachment of small pieces of coatings, generally irregular in shape, and having an average diameter of less than 1/4 in. (See Scaling.)

Map cracking: Slight breaks in the film surface of cement-water paints.

Scaling: An advanced form of flaking; arbitrarily called "scaling" when the detached pieces of coating have an average diameter greater than 1/4 in. (See Flaking)

Weathering characteristics of cement-water paints and organic coatings (resin-emulsion, oil-base, and synthetic-rubber paints) were classified according to the following scale of descriptive terms and numerical values:

Very good (9-8): Cement-water paints—no evidence of deterioration. Organic coatings—slight chalking. Though they were equally as durable as the organic coatings, cement-water paints were less decorative because of stains and collection of dirt.

Good (7-6): Cement-water paints—slight map cracking and erosion. Organic coatings—slight chalking. (Repainting not necessary for protection, but would improve appearance. Surface should be prepared by light brushing.)

Fair (5-4): Cement-water paints—bad map cracking, slight scaling, erosion partially exposing surface. Organic coatings—definite chalking, slight checking and flaking. (Repainting advisable. Loose, scaling paint should be removed by brushing.)

Poor (3-2): Cement-water paints—definite erosion, bad scaling. Organic coatings—film breakdown (checking, cracking, scaling.) (Repainting indicated for protection and appearance. Surface should be well cleaned with a wire brush.)

Very Poor (1-0): Cement-water paints—bad scaling, bad erosion. Organic coatings—flaking and bad erosion. (Repainting indicated. Surfaces should be well cleaned with a wire brush.)

(c) Reflectance

Reflectance readings, by indicating color changes in painted surfaces, were one means of evaluating hiding power of paints, appearance during weathering tests, amount of dirt collected by the film, and degree of erosion. In these tests, readings were made before the surfaces were painted, as soon as the paint was dry, and at intervals during the tests. Reflectance of surfaces ranged from 2 percent for cinder block to 35 percent for concrete surfaces. Initial reflectance readings were listed for each type of paint to show the degree of hiding obtained when two coats were applied to the various masonry surfaces. Subsequent readings were not reported numerically but aided partially in determining composite properties of the paints.

(d) Spreading Rate

Spreading rate is the area covered by coating a surface with a given quantity of paint; it is expressed in square feet per pound of dry powder for the cement-water paints and square feet per gallon of mixed paint for the organic coatings. For instance, 1 pound of cement-water paint should cover approximately 25 square feet on cast concrete and 1 gallon of organic coating should cover approximately 400 square feet on brick or similar surfaces.

2. Paints

(a) Cement-water Paints

Cement-water paints as a group were satisfactory both in appearance and durability, receiving a general rating of 70 percent "Good", 20 percent "Fair", 5 percent "Poor", and 5 percent "Very Poor." The high rating shown is a good indication that this type of paint is suitable for use on new porous masonry. Figure 3 illustrates a typical cement-water paint after 3 years exposure.

Figure 3.—*Specimen of new common brick painted with two coats of commercial cement-water paint.*

Figure 4.—*Cast-concrete specimen painted with two coats of cement-water paint.*

Dark streaks on the upper portion of the panel were caused by dirt washing from the flat top.

As indicated by their average ratings, most of the cement-water paint films weathered by erosion and map cracking. Erosion was more pronounced on the cast-concrete walls and was probably caused by the dense and uneven surface and the flat tops, which permitted water to run down over the face of the specimen. Voids and unevenness of the concrete are illustrated by the form marks and depressions shown on the panel in figure 4. Poor adhesion, indicated by flaking and scaling of the film, was noticed on new common brick coated with cement-water paints designated, *CW–2* and *CW–6*. This is shown in figure 5 where definite flaking has occurred on the bottom course and slight flaking over a scattered area. Cement-water test paint, *CW–2*, however, appeared to adhere satisfactorily when applied to open-textured surfaces such as cinder- and stone-concrete block. As a class, cement-water paints had a tendency to give best results on open-textured walls. Test results are shown in table 7.

(b) Resin-emulsion Paints

Resin-emulsion paints as a group received a general rating of 29 percent "Good," 42 percent "Fair," 24 percent "Poor," and 5 percent "Very Poor." The wide range of general ratings, which resulted in comparatively low average ratings, could be attributed to differences in the priming coats. When applied over a base coat of grout or a cement-water paint containing little or no lime, resin-emulsion paints weathered by chalking and gradual erosion. Figure 6 shows typical resin-emulsion paint applied on new common brick over grout. Figure 7 shows the same paint applied on stone-concrete block over a portland cement base. When applied directly to new masonry, these coatings failed by blistering and flaking except where the paint film was sufficiently porous to allow the moisture to pass through. This type of failure is well illustrated in figure 8 by the dark areas which show where the paint has flaked from the brick.

Test results indicated that for satisfactory use of resin-emulsion paints on new open-textured masonry, particular attention should be given to selecting a primer which will fill the voids and protect the finish coat from excess alkali which normally "leaches" from new walls. Results are shown in table 8.

(c) Oil-base Paints

Oil-base paints did not follow a prescribed pattern, but as a group received a general rating of 40 percent "Good" and 60 percent "Fair." The variation in performance of the same paints used on the same type of surface can be attributed to the application or omission of a protective first coat. Open-textured wall specimens primed with a grout coating which was allowed to dry and followed by two coats of oil-base paint showed less flaking, scaling, and bad erosion than those covered only by the oil-base coatings. Figure 9 shows the even texture and good appearance of two coats of oil-

TABLE 7.—*Test results of cement-water paints*

Paint designation	Number of test walls	Wall specimens	Spreading rate (average)		Initial reflectance	Appearance					Durability					General rating (average)
		Material	Primer	Finish coat		VG	G	F	P	VP	VG	G	F	P	VP	
			sq ft/lb	*sq ft/lb*	*Percent*											
CW-1	8	New common brick; stone-concrete block; cinder-concrete block; cast concrete.	22	39	79	----	5	2	1	----	1	5	2	----	----	7
CW-2	8	Do	25	42	81	----	2	3	3	----	----	1	1	6	----	3
CW-3	4	New common brick; stone-concrete block; cinder-concrete block.	18	32	75	----	3	1	----	----	----	4	----	----	----	7
CW-4	5	New common brick; stone-concrete block; cinder-concrete block; cast concrete.	25	40	78	----	3	2	----	----	----	4	1	----	----	6
CW-5	5	Do	25	40	81	----	2	2	1	----	----	2	2	1	----	5
CW-6	3	New common brick; cast concrete; lightweight - aggregate-concrete block.	[1]	[1]	73	----	----	----	----	3	----	----	----	----	3	1
CW-7	4	New common brick; stone-concrete block; cinder-concrete block.	23	37	81	----	3	1	----	----	----	4	----	----	----	7
CW-8	3	Do	19	32	80	----	2	1	----	----	----	3	----	----	----	7
CW-9	6	New common brick; stone-concrete block; cinder-concrete block; cast concrete.	19	34	80	----	5	1	----	----	----	5	1	----	----	7
CW-10 (Grout)	1	Cinder-concrete block.	10	18	70	----	1	----	----	----	----	1	----	----	----	7
CW-11	3	New common brick; cast concrete; lightweight - aggregate - concrete block.	22	32	78	----	1	1	1	----	----	2	1	----	----	5
CW-12	3	Do	23	32	78	----	1	1	1	----	----	1	2	----	----	5
CW-13	3	Do	28	33	78	----	1	1	1	----	----	3	----	----	----	6
CW-14	3	Do	24	33	79	----	1	1	1	----	----	3	----	----	----	6
CW-15	3	Do	24	31	79	----	1	----	2	----	----	2	1	----	----	5
CW-16	3	Do	24	31	79	----	2	----	1	----	----	2	1	----	----	6
CW-17	3	Do	26	33	79	----	2	----	1	----	----	3	----	----	----	7
CW-18	3	Do	27	37	81	----	2	----	1	----	----	2	1	----	----	6
CW-19	3	Do	26	36	79	----	2	1	----	----	----	3	----	----	----	7
CW-20	3	Do	26	35	80	----	2	----	1	----	----	2	1	----	----	6

[1]Sprayed on by manufacturer's representative.

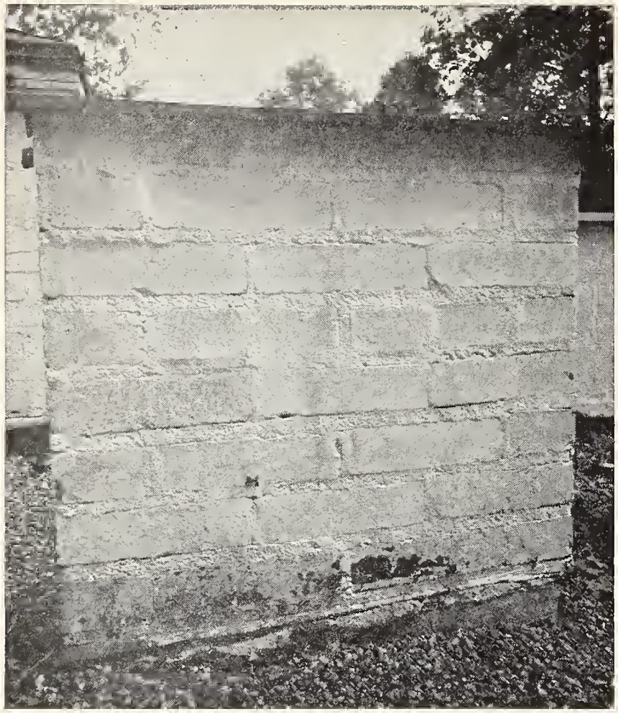

FIGURE 5.—*Commercial cement-water paint applied to specimen of new common brick.*

Poor adhesion is indicated by the flaking and scaling shown in the dark areas in the photograph.

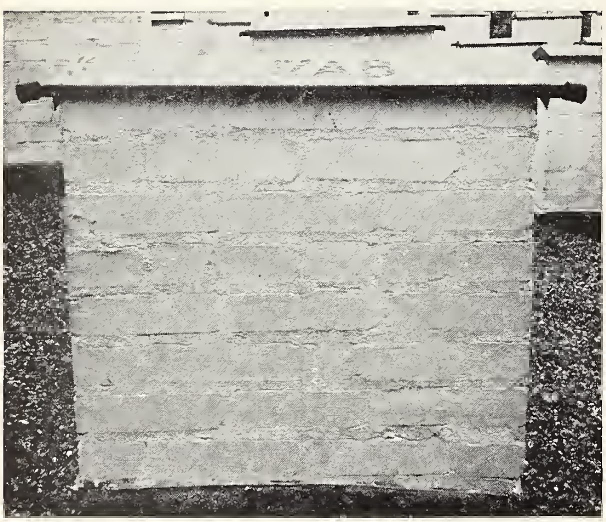

FIGURE 6.—*Resin-emulsion paint, RE-1, applied over grout on new common brick.*

FIGURE 7.—*Resin-emulsion paint, RE-1, applied over portland cement wash to stone-concrete block.*

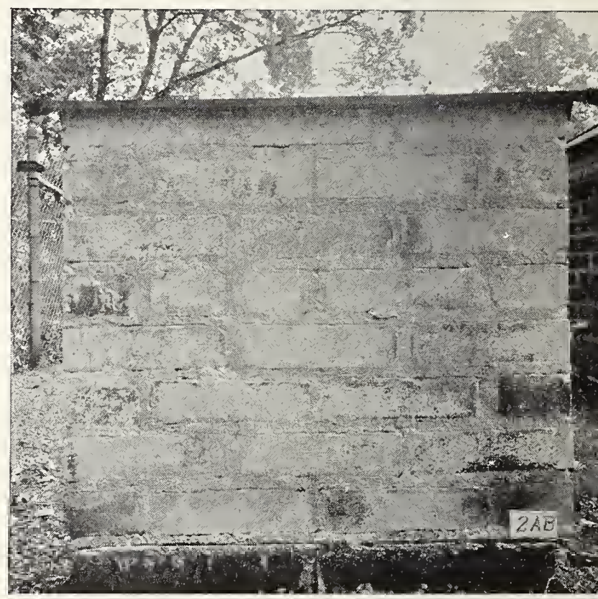

FIGURE 8.—*Specimen of new common brick to which two coats of resin-emulsion paint, RE-1, were applied directly.*

The dark areas show where the paint has flaked and scaled from the brick.

base paint applied over grout on cinder-concrete block. Figure 10 shows the first stage of flaking and scaling which may occur when oil-base paints are applied directly to open-textured masonry. On wall surfaces known to be damp, a primer of rubber-solution paint improved the durability of the finish coat.

The results obtained in tests of oil-base paints, indicate that they should not be used on open-textured masonry surfaces, either old or new, unless a grout or similar coating has first been applied to fill the openings. As oil-base paints produce films which are generally impermeable to moisture, their use is seldom recommended on masonry walls less than 6 months old. The results of tests on three oil-base paints are shown in table 9.

TABLE 8.—*Test results of resin-emulsion paints*

Paint designation	Number of test walls	Wall specimens	Spreading rate (Average)			Initial reflectance	Appearance					Durability					General rating	
		Material	Primer	2d coat	3d coat		VG	G	F	P	VP	VG	G	F	P	VP	Range	Average
			sq ft/gal	*sq ft/gal*	*sq ft/gal*	*Percent*												
RE-1	22	New common brick; stone-concrete block; cinder-concrete block; cast concrete.	279 [1]19	384	[2]538	80	----	10	8	4	----	----	5	12	3	2	0 to 7	4
RE-2	6	New common brick; stone-concrete block; cinder-concrete block; cast concrete.	375 [1]16	429	[3]500	65	----	3	3	----	----	----	1	3	2	----	3 to 6	4
RE-3	5	New common brick; lightweight-aggregate-concrete block.	222 [1]18	282	[3]325	80	----	3	----	2	----	----	2	2	1	----	2 to 7	5
RE-4	5	New common brick; cinder-concrete block; cast concrete.	338 [1]17	411	--------	75	----	----	4	1	----	----	2	1	2	----	3 to 6	4

[1]The spreading rate for wall panels primed with cement-water paints is expressed in sq ft/lb instead of sq ft/gal.
[2]Two specimens only.
[3]One specimen only.

TABLE 9.—*Test results of oil-base paints*

Paint designation	Number of test walls	Wall specimens	Spreading rate (Average)			Initial reflectance	Appearance					Durability					General rating	
		Material	Primer	2d coat	3d coat		VG	G	F	P	VP	VG	G	F	P	VP	Range	Average
			sq ft/gal	*sq ft/gal*	*sq ft/gal*	*Percent*												
O-1	12	New common brick; stone-concrete block; cast concrete; cinder-concrete block.	191 [1]15	330	281	78	6	3	1	2	----	6	2	1	3	----	2 to 9	6
O-2	6	New common brick; stone-concrete block; cinder-concrete block; lightweight-aggregate-concrete block.	263 [1]14	323	233	73	1	1	3	1	----	----	2	1	3	----	2 to 7	4
O-3	4	New common brick; cinder-concrete block; lightweight-aggregate-concrete block.	215 [1]15	301	408	75	----	2	----	2	----	----	3	----	1	----	2 to 7	5

[1]The spreading rate for wall panels primed with cement-water paints is expressd in sq ft/lb instead of sq ft/gal.

TABLE 10.—*Test results of synthetic-rubber paints, solution and emulsion types*

Paint designation	Number of test walls	Wall specimens	Spreading rate (Average)			Initial reflectance	Appearance					Durability					General rating (Average)
		Material	Primer	2d coat	3d coat		VG	G	F	P	VP	VG	G	F	P	VP	
			sq ft/gal	*sq ft/gal*	*sq ft/gal*	*Percent*											
SR-1	5	New common brick; cinder-concrete block; cast concrete.	296 [1]14	340	[2]375	80	1	2	2	----	----	1	2	2	----	----	6
SR-2	2	Cinder-concrete block; cast concrete.	220 [1]10	318	[2]310	78	----	----	1	1	----	----	----	2	----	----	5
SR-3	4	New common brick; cinder-concrete block; cast concrete; lightweight-aggregate-concrete block.	220 [1]16	326	[3]295	78	----	2	----	1	1	----	1	1	----	2	3
SR-4	3	New common brick; lightweight-aggregate-concrete block.	200 [1]17	240	[3]293	76	----	----	2	1	----	----	----	1	2	----	3
SR-5	2	Do	190 [1]16	233	[2]290	74	----	----	1	1	----	----	----	----	2	----	3

[1]The spreading rate for wall panels primed with cement-water paints is exppressed in sq ft/lb instead of sq ft/gal.
[2]One specimen only.
[3]Two specimens only.

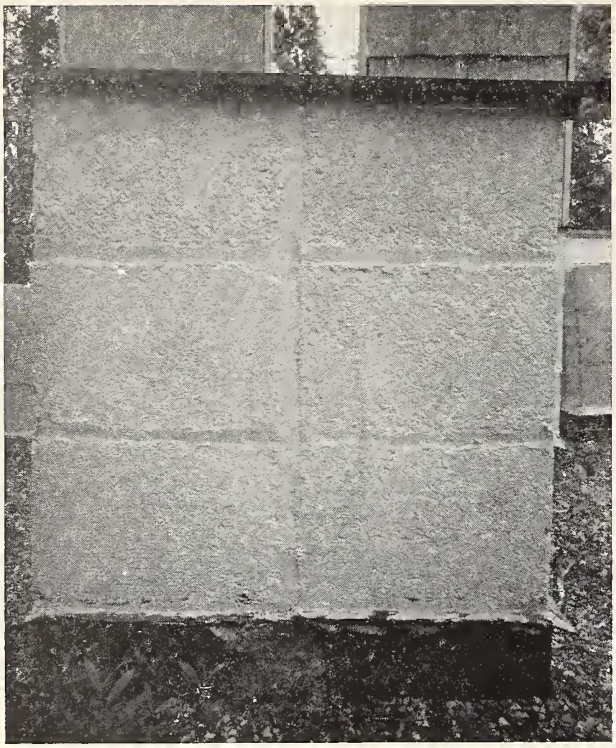

FIGURE 9.—*Specimen of cinder-concrete block painted with oil paint over base coat of grout.*

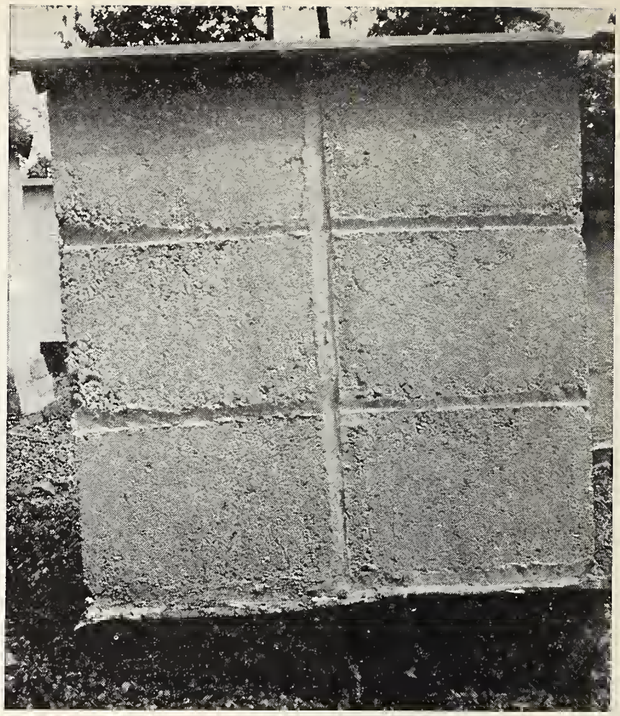

FIGURE 10.—*Open-textured stone-concrete block specimen to which two coats of oil-base paint were applied directly.*

(d) *Synthetic-rubber Paints*

The *SR–1* synthetic-rubber solution-type paint, of which there was only one sample, gave satisfactory performance both for appearance and durability, and a general rating of "Good". Synthetic-rubber emulsion-type paints, *SR–2, SR–3, SR–4,* and *SR–5,* were not as good, approximately 20 percent of their general ratings being "Fair" and 80 percent "Poor". It may be that a part of their failure can be attributed to the fact that they were in an early stage of development and formulation had not been perfected. Test results are shown in table 10.

Figure 11 shows two coats of rubber-solution type paint applied to a specimen constructed of new common brick. The mortar joints in the test specimen were purposely left open so that water, such as wind-driven rain, could enter the wall. In some types of organic coatings this condition would normally cause early breakdown by blistering and flaking. With this sample of rubber-solution type paint, however, the effect observed after 30 months of exposure, other than the expected chalking, was that slight flaking occurred on two bricks, as indicated by the small dark spots on the end bricks in the 4th and 7th courses at the right of the illustration.

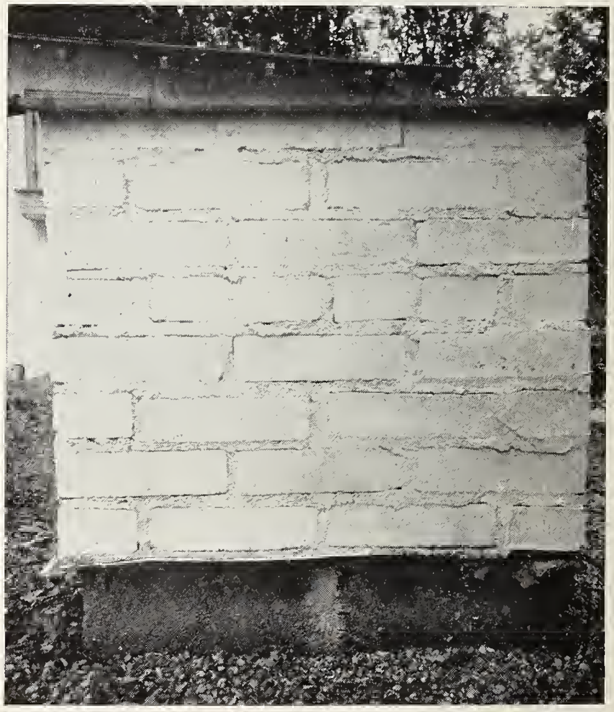

FIGURE 11.—*Specimen of new common brick to which two coats of rubber-base solution-type paint were applied directly.*

FIGURE 12.—*New common brick specimen painted with two coats of rubber-emulsion paint.*

Figure 12 shows the film breakdown which occurred when two coats of rubber-emulsion type paint were applied directly to a wall specimen of new common brick. The coating first broke into small flakes and then eroded to the extent that some of the bricks are completely exposed.

(e) *Whitewash*

Whitewash was applied to three wall specimens, one each of new common brick, stone-concrete block, and cinder-concrete block. The specimens weathered by definite erosion, slight to definite scaling, and slight flaking, and received an average general rating of "Fair" or a numerical rating of 4. All specimens were rated "Fair" on appearance while two were rated "Fair" and one "Poor" or numerically 4 and 3 on durability. The spreading rate of whitewash averaged 209 sq ft/gal for the first coat and 320 sq ft/gal for the second or finish coat. Initial reflectance readings were 82 percent. No table is given for the results of tests of whitewash because of the small number of tests made, and no photographs were taken of these specimens.

3. WALL SPECIMENS

Wall specimens were rated on two bases of evaluation: Performance of coatings on commonly painted wall surfaces and performance of coatings on wall surfaces not usually painted. Stone- and cinder-concrete block, new common brick, lightweight-aggregate-concrete block, and cast concrete were rated in the order named on the basis of paint performance or general serviceability of the paint. This included the coverage, hiding power, color retention, and weathering properties of the coatings. New cement-asbestos shingles and badly stained used common brick are not usually painted, therefore, in the rating for these few specimens consideration was given to the painting surface as well as to the paint performance.

(a) *Performance of Coatings on Commonly Painted Surfaces*

(1) *Stone-concrete Block*

Stone-concrete block wall specimens rated first as a painting surface for all types of paints including cement-water, resin-emulsion, oil-base, synthetic rubber, and whitewash. The block used for these tests were of uniform, open texture, light in color, and free of foreign substances such as iron particles which might cause disintegration or staining.

For a durable and decorative coating on exterior walls of stone-concrete block, cement-water paints may be used. Synthetic-rubber or resin-emulsion paints applied to stone-concrete surfaces give adequate performance when brushed or sprayed directly on the block, but much better results are obtained if a grout or cement-water paint is used as a base coat. For satisfactory performance of an oil-base paint, voids in the block must first be filled with cement-water paint or grout. Whitewash applied directly on the block will give reasonable serviceability.

(2) *Cinder-concrete Block*

Provided the cinder-concrete block is first given a grout coat, it may be satisfactorily coated with either cement-water paints or organic finishes.

Cement-water paints prove durable when applied directly to cinder-concrete block, but they may have poor decorative properties if the block to which they have been applied contains small particles of iron. Wind-driven rain penetrating the block will corrode these particles of iron causing them to "bleed" through the coating. This mars the appearance of the surface, although it does not necessarily impair its wearing properties. Application of a first coat of grout helps to correct such a condition by filling the cracks and voids, making the block less permeable to moisture. For block manufactured from magnetically cleaned cinders, this condition does not exist and therefore two coats of cement-water paint will be adequate to provide a finish that is both protective and decorative.

Open-textured block, such as the unvibrated type, requires a base coat of grout prior to the use of an organic paint. This type of paint spans but will not fill voids and allows the paint film to break on aging thus leaving openings through which moisture can enter. The grout base should dry for approximately 3 months before applying the oil-base paint, 1 month before applying the resin-emulsion finish, and 3 days before applying the rubber-solution type of paint.

(3) New Common Brick

For open-textured walls, such as new common brick, portland cement-water paints are a durable and decorative coating. Tests indicate that the portland cement content of cement-water paints should be more than 50 percent by weight. On walls where the mortar joints have appreciable voids, a grout should be used or sharp sand should be incorporated in the first coat of cement-water paint. Oil-base or resin-emulsion paints may be used with excellent results over these coatings, provided adequate time is allowed for the base coat to thoroughly dry (approximately 3 months). Rubber-solution paint may be applied over the cement-water or grout base as soon as the base coat has cured (approximately 72 hours).

Resin-emulsion or rubber-solution paints may be applied directly to walls having tight mortar joints. In the case of oil-base paints, the walls should be allowed to age at least 6 months before the paint is applied.

(4) Lightweight-aggregate-concrete Block

Lightweight-aggregate-concrete block were similar in appearance and texture to stone-concrete block and the performance of paints applied to these surfaces was much the same, except for the aggregate block which were coated with rubber-emulsion paint. These paints gave relatively poor performance and, because there was a greater number in proportion of these specimens, the average rating for this group was lowered.

(5) Cast Concrete

The surface of cast-concrete block was rather dense and relatively smooth except for potmarks from air bubbles in the concrete, as shown in figure 4. The cement-water paint film on these surfaces was thin. Because the tops of the block were flat, water ran over the block faces, staining the paint on them with dirt and increasing the rate of erosion.

Oil-base and rubber-solution coatings gave a continuous film over the cast-concrete surfaces which did not readily absorb stain and which on weathering chalked sufficiently to be self-cleaning.

The rate of the resin-emulsion group of paints fell between that of the cement-water and the oil-base paints. They had better decorative properties than the cement-water paints, but their porous films were likely to stain and were subject to erosion.

(b) Performance of Coatings on Surfaces not Usually Painted

(1) Used Common Brick Wall Specimens

The brick used for these tests was badly stained and therefore required special surface preparation which included vigorous wire brushing and in most cases the application of a grout.

The paints which had good sealing properties gave satisfactory results. As these paints are relatively expensive, and as a great amount of paint was required to adequately seal the uneven surface of the brick, a grout coat was applied. The grout coat produced a more even-textured surface and used less of the more costly materials.

Oil-base and rubber-solution paints as well as resin-emulsion paints applied over a primer gave satisfactory results and, as could be expected, the cement-water paint was poor.

Figure 13 shows the effective sealing properties of two coats of rubber-solution paint on used common brick. On this specimen, a grout coat was first scrubbed on to give a more even

FIGURE 13.—*Specimen of used common brick to which two coats of rubber-base solution-type paint were applied over grout.*

FIGURE 14.—*Specimen of used common brick to which two coats of cement-water paint were applied directly.*

Scaling and staining of paint film are shown.

surface after which two coats of rubber-solution type paint were applied. With the exception of slight scaling on the lower edge of the first course, this paint coating was in very good condition after 30 months of exposure. There was no indication of staining or lack of adhesion as was observed when a similar stained surface was coated with a porous paint.

Figure 14 shows the inadvisability of using cement-water paint on badly stained used common brick. The darker areas illustrate where the paint failed to bond with the foreign material on the brick and the gray areas are brown discolorations which penetrated through the cement-water coating from the brick surface. The few light areas show satisfactory bonding and the absence of bleeding or staining indicating that the surface of the brick so covered was suitable for this type of paint.

These results may be of value in painting stained chimneys, garage walls, and similar surfaces. No table is given for results of tests of used common brick wall specimens.

(2) New Cement-asbestos Shingle-faced Wall Specimens

The cement-asbestos shingles used as facing on the wall specimens were new. Normally, such shingles would not be painted until after they had weathered. At the time the project was started, however, they were the only shingles available, and it was belived that information on the performance of paints applied to these shingles might be helpful.

As illustrated in figure 15, the shingles offered an excellent painting surface in that their reflectance was approximately the same as the paints, the surfaces were of uniform porosity, and the joints were so constructed that water could not infiltrate behind the paint film.

Two coats of rubber-solution paint gave excellent hiding and good durability.

For a primer, one coat of this paint proved satisfactory under oil-base or resin-emulsion paint.

Good results were also obtained by applying two coats of either oil-base or resin-emulsion paints. In fact, any organic paint designed for use on masonry is satisfactory for application on shingles.

At the end of the test period the paint coatings were very satisfactory both in appearance and durability, the only evidence of breakdown being chalking and slight erosion.

Because cement-water paints do not contain an organic binder, they are not suitable as a coating for new cement-asbestos shingles and therefore were not applied to this group of wall specimens. Test results are given in table 11.

VI. SUMMARY AND RECOMMENDATIONS

Considering the physical properties of the various structures and the number of coats of paint applied, cement-water paints as a class

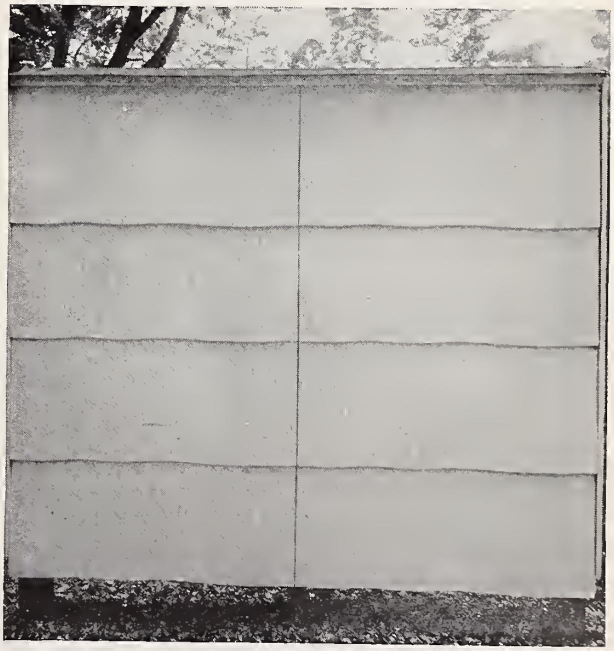

FIGURE 15.—*Cement-asbestos shingle wall specimen to which two coats of rubber-base solution-type paint were applied.*

give best results with oil-base, resin-emulsion, and synthetic rubber-base paints following in that order.

The masonry wall specimens rated as follows: (1) New cement-asbestos shingle-faced wall specimens, (2) stone-concrete block, (3) cinder-concrete block, (4) new common brick, (5) lightweight-aggregate-concrete block, (6) cast concrete, and (7) used common brick wall specimens.

Cement-water paints are a decorative and durable coating on exterior walls. The method of applying and curing cement-water paints and the conditions under which painting is done are more important than the composition of the paints, but the portland cement content should not be less than 65 percent by weight of the total paint.

The use of sharp sand in cement-water paint or a priming coat of grout improves the durability of subsequent organic coatings on open-textured walls or those having cracks or other defects.

Ordinary white portland cement or admixtures of cement and lime also give good results. For improved decorative value, the cement coating can be painted with an exterior masonry oil-base, resin-emulsion, or rubber-solution paint.

Cement-water paints should be used for the initial painting of new masonry with the possible exception of cast concrete poured against oiled forms. Further coatings are not necessary, but can be used if desired. A synthetic rubber paint can be applied immediately after the cement-water paint dries, but it is recommended that the cement-water paint age for at least 2 weeks before application of resin-emulsion paints and 3 months before the application of oil-base paints.

Resin-emulsion paints have good decorative qualities and are durable on exterior masonry walls. For open-textured surfaces and brick walls having cracks around the mortar joints, the surface should be treated with a base coat of grout or cement-water paint containing sharp sand before resin-emulsion paint is applied. Resin-emulsion paints have good hiding power and are easy to apply by brush or spray to damp or dry walls. New masonry walls should be allowed to age for at least 3 weeks before painting.

Oil-base paints can be used on open-textured masonry surfaces that have been treated to prevent infiltration of moisture or on close-textured masonry. Both should be allowed to age for a period of from 6 to 12 months before painting. It is essential that walls be dry at the time of painting and be so constructed or so treated as to remain dry after painting. If these coatings are applied to a wet wall or one that becomes wet through structural defects, early failure by scaling and flaking may occur.

Oil-base paints have good serviceability and weather by chalking. This property tends to make them self-cleaning and lessens their tendency to be discolored by dirt and stain.

A grout composed of portland cement and sharp sand is recommended as a base coat on open-textured surfaces such as stone- and cinder-concrete block, lightweight-aggregate-concrete block, and new and used common brick with joints which have not been tooled. The grout should be allowed to age at least 90 days. It may be applied immediately upon erection of the wall or at any time during the aging period of from 6 to 12 months.

If there is a possibility that the wall is damp or contains soluble salts, a protective primer, such as rubber-solution paint, should be used as a first coat over the grout. In this case, one coat of the oil-base paint should be sufficient to give a good finish. Two coats, however, will give greater durability.

Synthetic-rubber paints may be applied to either dry or slightly damp wall surfaces but should not be used on wet surfaces as excessive moisture may prevent adequate bond. These paints are of two types, rubber-emulsion and rubber-solution.

The samples of rubber-emulsion paint were received directly from the manufacturer and represented experimental studies rather than commercial products available for over-the-counter sales.

The rubber-solution type is similar in composition to an oil paint except that a rubber resin is used in the vehicle in place of synthetic or natural resin. It may be brushed or sprayed and can be used either as a protective primer

TABLE 11.—*Test results of paints on cement-asbestos shingle-faced wall specimens*

Wall specimens	Number of test walls	Paint designation	Spreading rate (Average)		Initial reflectance (Average)	Appearance					Durability					General rating (Average)
			Primer	Finish coat		VG	G	F	P	VP	VG	G	F	P	VP	
			sq ft/lb	*sq ft/lb*	*Percent*											
CA-1	4	*SR-1; O-1; O-4;* unpainted.	213	302	76	----	4	----	----	----	2	2	----	----	----	8
CA-2	4	*SR-1; O-1; O-4;* unpainted.	218	320	76	----	4	----	----	----	2	2	----	----	----	8
CA-3	2	Surface treated at the factory.	----	----	77	----	2	----	----	----	2	----	----	----	----	8
CA-4	3	*SR-3; SR-1; O-1.*	227	338	78	----	3	----	----	----	1	1	1	----	----	7

under oil-base or resin-emulsion paint or as a complete paint system. Two coats give adequate hiding and good durability. On open-textured surfaces, cement-sand grout should be used and allowed to dry from 3 to 6 days. Rubber-solution paint is particularly suitable for application on cement-asbestos shingles or siding, but will give good service on other masonry surfaces.

Grateful acknowledgment for technical assistance in the preparation of this report is made to Eugene F. Hickson, Chief of the Paint Section, and Edward J. Schell of the Building Practices and Specifications Section of the National Bureau of Standards and to Louise D. C. Nobel and Edith R. Meggers of the same section for their painstaking effort in reviewing this publication.

APPENDIX

The graph in this appendix presents the results of investigations of some of the same masonry surface coatings which were discussed in the body of this report except that the specimens were subjected to out-of-door weathering conditions for a total of 6 years instead of three. The graph does not include exposure data for as many test specimens as the main part of the report because a portion of the test field was dismantled to make room for activities in connection with the war effort, but a sufficient number of specimens remained to give the representative performance of these masonry paints and to substantiate the indications shown by the 3-year atmospheric exposure tests.

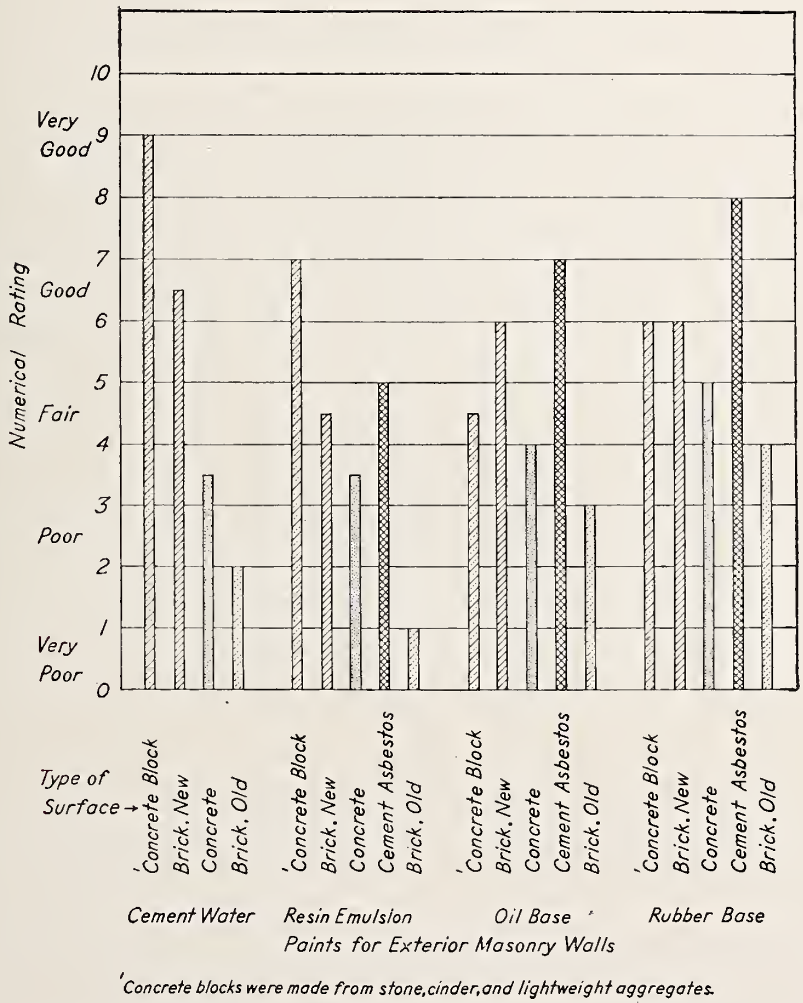

FIGURE 16.—*Results of 6-year atmospheric exposure tests of paints for exterior masonry walls.*

Washington, June 13, 1947.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1947—748523

BUILDING MATERIALS AND STRUCTURES REPORTS

[Continued from cover page II]

BMS32	Structural Properties of Two Brick-Concrete-Block Wall Constructions and a Concrete-Block Wall Construction Sponsored by the National Concrete Masonry Association	15¢
BMS33	Plastic Calking Materials	15¢
BMS34	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 1	15¢
BMS35	Stability of Sheathing Papers as Determined by Accelerated Aging	*
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	*
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	*
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	15¢
BMS44	Surface Treatment of Steel Prior to Painting	10¢
BMS45	Air Infiltration Through Windows	15¢
BMS46	Structural Properties of "Scott-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.	15¢
BMS49	Metallic Roofing for Low-Cost House Construction	15¢
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	*
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	15¢
BMS64	Solar Heating of Various Surfaces	*
BMS65	Methods of Estimating Loads in Plumbing Systems	15¢
BMS66	Plumbing Manual	*
BMS67	Structural Properties of "Mu-Steel" Prefabricated Sheet-Steel Constructions for Walls, Partitions, Floor, and Roofs Sponsored by Herman A. Mugler	15¢
BMS68	Performance Test for Floor Coverings for Use in Low-Cost Housing: Part 3	20¢
BMS69	Stability of Fiber Sheathing Boards as Determined by Accelerated Aging	10¢
BMS70	Asphalt-Prepared Roll Roofings and Shingles	20¢
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	25¢
BMS79	Water-Distributing Systems for Buildings	20¢
BMS80	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 4	15¢
BMS81	Field Inspectors' Check List for Building Constructions (cloth cover, 5 x 7½ inches)	20¢

*Out of print.

[List continued on cover page IV]

BUILDING MATERIALS AND STRUCTURES REPORTS

[Continued from cover page III]

BMS82	Water Permeability of Walls Built of Masonry Units	20¢
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	*
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	15¢
BMS88	Recommended Building Code Requirements for New Dwelling Construction With Special Reference to War Housing	*
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	30¢
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¢
BMS96	Properties of a Porous Concrete of Cement and Uniform-Sized Gravel	10¢
BMS97	Experimental Dry-Wall Construction With Fiber Insulating Board	10¢
BMS98	Physical Properties of Terrazzo Aggregates	15¢
BMS99	Structural and Heat-Transfer Properties of "Multiple Box-Girder Plywood Panels" for Walls, Floors, and Roofs	15¢
BMS100	Relative Slipperiness of Floor and Deck Surfaces	10¢
BMS101	Strength and Resistance to Corrosion of Ties for Cavity Walls	10¢
BMS102	Painting Steel	10¢
BMS103	Measurements of Heat Losses From Slab Floors	10¢
BMS104	Structural Properties of Prefabricated Plywood Lightweight Constructions for Walls, Partitions, Floors, and Roofs Sponsored by the Douglas Fir Plywood Association	25¢
BMS105	Paint Manual	$1.00
BMS106	Laboratory Observations of Condensation in Wall Specimens	*
BMS107	Minimum Requirements for New Dwelling Construction	20¢
BMS108	Temperature Distribution in a Test Bungalow With Various Heating Devices	10¢
BMS109	Strength of Houses: Application of Engineering Principles to Structural Design	**
BMS110	Paints for Exterior Masonry Walls	10¢

*Out of print.

**Now in print.