U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

REPORT BMS75

Survey of Roofing Materials in the North Central States

by

HUBERT R. SNOKE
and LEO J. WALDRON

NATIONAL
BUREAU OF STANDARDS

The program of research on building materials and structures, carried on by the National Bureau of Standards, was undertaken with the assistance of the Central Housing Committee, an informal organization of governmental agencies concerned with housing construction and finance, which is cooperating in the investigations through a committee of principal technicians.

CENTRAL HOUSING COMMITTEE ON RESEARCH, DESIGN, AND CONSTRUCTION

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The Forest Products Laboratory of the Forest Service is cooperating with both committees on investigations of wood constructions.

[For list of BMS publications and directions for purchasing, see cover page III]

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

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Foreword

This report is the third of a series issued by the National Bureau of Standards on surveys of the weathering qualities and extent of use of roofing materials in different sections of the country.

Reports published previously are: BMS6, Survey of Roofing Materials in the Southeastern States, and BMS29, Survey of Roofing Materials in the Northeastern States. The present paper describes the results of a similar survey in the North Central States. Frequent reference is made in this report to the reports on previous surveys.

A tabulation, by States, of the kinds of roofing materials that were found on more than 8,000 rural and small-town dwellings, along approximately 3,000 miles of highway in the North Central States, is included; also, a summation of the kinds of roofing used on almost 29,000 dwellings along more than 7,000 miles of highway in the 32 States covered by the 3 surveys.

More than 400 photographs, showing types of weathering of roofing materials, and features of design and construction, were taken in the course of this survey. Of these, 48 have been selected for publication.

Lyman J. Briggs, *Director*.

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ABSTRACT

A survey of the weathering qualities and extent of use of the various roofing materials on dwellings in the North Central States is described, with numerous references to similar surveys made previously in the Southeastern and Northeastern States.

Detailed studies of roofing materials in Pittsburgh, Pa.; Cincinnati and Toledo, Ohio; Grand Rapids and Lansing, Mich.; Chicago, Ill.; Milwaukee, Wis.; St. Paul, Minn.; Bismarck, N. Dak.; Sioux Falls, S. Dak.; Omaha, Nebr.; Kansas City, Moberly, and St. Louis, Mo.; and Indianapolis, Ind., are reported.

A tabulation, by States, of the kinds of roofing materials used on more than 8,000 rural and small-town dwellings, along approximately 3,000 miles of highway between the cities listed above, is included; also a summary of the kinds of roofing materials used on almost 29,000 rural and small-town dwellings along 7,000 miles of highway in the 32 States covered by the three surveys.

Forty-eight photographs, illustrating type of weathering of roofing materials, and features of design and construction of roofs, are shown.

I. INTRODUCTION

The general research program of the National Bureau of Standards on building materials and structures includes, as part of the work on roofs and roofing materials, comprehensive surveys of the various types of roofing materials used in locations typical of widely differing climatic conditions in the country.

The first of these surveys, made in April 1938, covered the following States: Virginia, North and South Carolina, Georgia, Florida, Alabama, Tennessee, Kentucky, and West Virginia. Another survey, made in September and October 1938, covered Delaware, Pennsylvania, Connecticut, Massachusetts, New Hampshire, Maine, Vermont, and New York. The results of these surveys have been published, respectively, as Building Materials and Structures Report BMS6, Survey of Roofing Materials in the Southeastern States,[1] and Building Materials and Structures Report BMS29, Survey of Roofing Materials in the Northeastern States.[2]

The present report described a similar survey in the following cities: Pittsburgh, Pa.; Chicago, Ill.; Milwaukee, Wis.; St. Paul, Minn.; Toledo and Cincinnati, Ohio; Lansing and Grand Rapids, Mich.; Bismarck, N. Dak.; Sioux Falls, S. Dak.; Omaha, Nebr.; Kansas City, Moberly, and St. Louis, Mo.; and Indianapolis, Ind. It includes also a report on the extent of use of the different roofing materials, classified roughly by appearance, on rural dwellings along the highways between the cities visited. This survey was made from August 12 to September 24, 1940, and involved approximately 4,600 miles of travel.

Reference to the previous surveys is frequently made in this report. For convenience, the survey in the Southeastern States is referred to as BMS6 and that in the Northeastern States as BMS29.

Another report, Building Materials and Structures Report BMS57, Roofing in the United States—Results of a Questionnaire,[3] summarizes the replies to a questionnaire on general roofing practices and conditions throughout the entire country, furnished by representatives of the Home Owners' Loan Corporation and Federal Housing Administration in 48 States and the District of Columbia. This report is referred to as BMS57.

Space is not available in this report to deal at length with the history, methods of production, composition, etc., of the various kinds of roofing materials. A list of selected references to the literature on roofing materials is given at the end of the report.

II. METHODS OF MAKING THE SURVEY

The methods of making this survey, insofar as they concerned weathered roofing materials, were essentially the same as those followed in the two previous surveys. They are discussed in detail in BMS6 and BMS29, so that only a brief outline is necessary here.

All travel was by automobile. A count was made of the roofs on rural dwellings along the highways traveled (reported in table 2) and the kind of roofing materials used.

As in the previous surveys, local representatives of the Home Owners' Loan Corporation assisted in collecting data on roofs of different kinds and known history. Many of these representatives had spent considerable time in work preliminary to this survey, and had prepared lists of roofs that included all kinds of materials.

The offices of the Federal Housing Administration were visited in Pittsburgh, Pa.; Milwaukee, Wis.; Omaha, Nebr.; Kansas City and Saint Louis, Mo.; and Indianapolis, Ind. The problems and practices in the use of roofing materials on new construction were discussed with representatives of this organization and new developments were inspected.

General roofing policies and practices were discussed with men in the Division of Agricultural Engineering at Michigan State College and the University of Minnesota. The Forest Products Laboratory at Madison, Wis., was also visited.

Plants manufacturing roofing materials were visited in Minneapolis, Minn.; Cincinnati, Ohio; and Moundsville, W. Va.

Acknowledgment is made to all who furnished assistance in this work, particularly to representatives of the Home Owners' Loan Corporation to whom had been assigned the preparatory work in each city; and to the numerous roofing contractors who furnished trucks and ladders, without which it would have been impossible to conduct the investigation.

[1] Price 15 cents. See cover page III.
[2] Price 10 cents. See cover page III.
[3] Price 10 cents. See cover page IV.

III. EXTENT OF USE AND APPEARANCE OF THE VARIOUS ROOFING MATERIALS IN RURAL DISTRICTS AND SMALL TOWNS IN THE NORTH CENTRAL STATES

1. General

A wide range in roofing materials in rural districts and small towns characterizes the territory covered by this survey. Availability of materials and climatic conditions apparently are the chief governing factors. In Maryland, Pennsylvania, and Ohio, which are relatively close to slate-producing districts, slate has been used widely in the past, but more recently asphalt shingles have largely superseded this material.

Throughout the rural sections of Michigan, Indiana, Illinois, and Missouri, wood shingles predominated formerly, and are still used to a considerable extent, although asphalt shingles and roll roofings are now used to a greater extent than wood shingles. Considerable quantities of diamond-point and fancy-patterned roll roofings are used in these states as a reroofing material over weathered wood and asphalt shingles. Individual shingles laid by the Dutch-lap, hexagonal, and wide-space methods, which are used frequently for reroofing along the Eastern Coast, have practically no use in this territory.

In the sections of Wisconsin, Minnesota, North and South Dakota, Iowa, Nebraska, and Kansas, that were visited, wood shingle roofs outnumber all other types. This is particularly true of the rural sections and small towns in North and South Dakota. In traveling from Bismarck, N. Dak., to Sioux Falls, S. Dak., by the routes listed in table 1, 564 wood shingle roofs were counted in 369 miles with no roofs of any other type.

2. Routes Followed in Making the Survey

Table 1 lists the cities in which studies were made and the routes between cities in the order they were traveled.

Table 1.—*Routes traveled in making this survey*

Cities	Routes [1]
Washington, D. C., to Pittsburgh, Pa	240, 15, (16), (316), 30.
Pittsburgh, Pa., to Toledo, Ohio	(356), 422, 224, 20.
Toledo, Ohio, to Grand Rapids, Mich	223, 127, 16.
Grand Rapids, Mich., to Chicago, Ill	(21), 31, 20.
Chicago, Ill., to Milwaukee, Wis	41.
Milwaukee, Wis., to St. Paul, Minn	18, 12.
St. Paul, Minn., to Bismarck, N. Dak	52, 10.
Bismarck, N. Dak., to Sioux Falls, S. Dak	10, 83, 12, 281, 212, 81, 14, 77.
Sioux Falls, S. Dak., to Omaha, Nebr	77, 75, 6.
Omaha, Nebr., to Kansas City, Mo	73, 40.
Kansas City, Mo., to Moberly, Mo	24.
Moberly, Mo., to St. Louis, Mo	63, (22), 54, (19), 40.
St. Louis, Mo., to Indianapolis, Ind	40.
Indianapolis, Ind., to Cincinnati, Ohio	52.
Cincinnati, Ohio, to Wheeling, W. Va	22, 40.
Wheeling, W. Va., to Washington, D. C	40, 240.

[1] State highways in parenthesis; all others are U. S. highways.

A map of the territory covered is shown in figure 1.

Figure 1.—*North Central States covered by the survey.*

3. Extent of Use of Particular Materials in Rural Sections

In table 2 are tabulated, by States, the kinds of roofing materials used on dwellings in the rural sections along the routes listed in table 1.

The condition of each kind of rural roof was classified roughly as "good" or "poor", this classification being based entirely on appearance and, in most cases, made by observation from the highway of only one side of the roof.

TABLE 2.—*Roofing materials in rural sections of States traversed*

[The general condition of the roof is indicated as "good" or "poor"]

State	Asphalt shingles			Wood shingles			Slate			Sheet metal			Roll roofing			Cement-asbestos			Metal shingles			Tile			Total
	Good	Poor	Total	Good	Poor	Total	Good	Poor	Total	Good	Poor	Total	Good	Poor	Total	Good	Poor	Total	Good	Poor	Total	Good	Poor	Total	
Maryland	177	12	189	15	27	42	46	7	53	167	29	196	33	29	62	25	1	26	27	5	32	1	0	1	601
Pennsylvania	327	35	362	12	19	31	262	60	322	96	50	146	66	96	162	56	1	57	4	10	14				1,094
Ohio	427	61	488	127	86	213	674	25	699	203	59	262	31	29	60	61	0	61	1	1	2	2	0	2	1,787
Michigan	356	71	427	227	63	290	7	0	7	37	16	53	59	49	108	12	0	12							897
Wisconsin	187	7	194	461	69	530				38	7	45	30	30	60	6	0	6	1	0	1				836
Minnesota	24	3	27	207	22	229							13	4	17										273
North Dakota	0	1	1	201	93	294							1	1	2				1	0	1				298
South Dakota	4	1	5	525	90	615							1	3	4										624
Iowa	15	5	20	107	18	125							8	5	13	1	0	1	1	0	1				160
Nebraska	30	3	33	56	40	96							5	2	7	2	0	2				1	0	1	139
Kansas	35	12	47	90	40	130				2	0	2	5	2	7										186
Missouri	153	45	198	77	110	187	2	0	2	28	8	36	14	27	41	2	0	2	1	0	1				467
Illinois	164	23	187	31	90	121	1	0	1	11	4	15	35	27	62	15	0	15							401
Indiana	129	11	140	74	81	155	10	5	15	24	10	34	13	10	23	7	1	8	2	1	3				378
Totals	2,028	290	2,318	2,210	848	3,058	1,002	97	1,099	606	183	789	314	314	628	187	3	190	38	17	55	4	0	4	8,141

The counts of rural roofs in the three surveys to date are summarized in table 3.

TABLE 3.—*Summary of counts of roofs in rural sections*

[Miles traveled: Southeast 2,447, Northeast 1,591, North Central 3,014, Total 7,052]

Type of roofing material	Southeast		Northeast		North Central		Total	
	No.	Percent [1]	No.	Percent [1]	No.	Percent [1]	No.	Percent
Sheet metal	3,722	34.9	1,006	9.9	789	9.7	5,517	19.0
Asphalt shingle	2,558	24.0	3,991	39.3	2,318	28.4	8,867	30.6
Roll roofing	1,982	18.6	399	3.9	628	7.7	3,009	10.4
Wood shingle	1,757	16.5	2,779	27.3	3,058	37.6	7,594	26.2
Metal shingle	366	3.4	134	1.3	55	.7	555	1.9
Cement-asbestos	184	1.7	284	2.8	190	2.3	658	2.3
Slate	64	.6	1,546	15.2	1,099	13.5	2,709	9.3
Tile	44	.4	23	.2	4		71	.2
Thatched			2				2	
Total	10,677		10,164		8,141		28,982	
Average number of roofs per mile	4.4		6. 4		2.7		4.1	

[1] Percentage based on the particular survey.

It was noted in BMS29 that approximately 76 percent of the rural roofs in the sections covered by the first two surveys were asphalt shingles, wood shingles or sheet-metal.

It is significant that the total percentages of roofs of these three materials are approximately the same for the three surveys to date, although the proportions of each kind vary widely in the different sections of the country. The total percentages of these three materials are as follows: Southeast, 75.4 percent; Northeast. 76.5 percent; North Central, 75.7 percent; and for the combined surveys, 75.8 percent.

IV. WEATHERING QUALITIES OF ROOFING MATERIALS IN THE NORTH CENTRAL STATES

1. GENERAL DISCUSSION

In the reports of the previous surveys, BMS6 and BMS29, it is stated that "Any discussion of the weathering qualities of roofing materials in a particular section must, of necessity, be couched in the most general terms." In these reports are discussed some of the important factors which have to be considered in studies of the weathering qualities of roofing materials.

1. Weather conditions during and after construction.

2. Influence of the pitch and exposure of a roof on the weathering of the roofing material.

3. Workmanship in applying the roofing material.

4. Varieties of materials, and variations in the design and quality of materials of the same kind.

5. Absence of definite criteria for determining when a roofing material has failed.

Essentially the same roofing materials are used in different sections of the country, but the differences in climate between sections are reflected in differences in roofing practices. In areas where there is much snow, roofs are usually steeply pitched. Wood-shingle roofs have wide use in regions of extreme cold, because of their insulating value. In regions where snow may be accompanied by high winds, wood shingles are always laid on closed decks rather than on shingle lath, and frequently a layer of sheathing paper or saturated felt is placed between the sheathing boards and the shingles.

It does not always follow that similar conditions in two areas will produce the same roofing practices in both. Throughout the New England States the practice of using a wide metal or roll roofing eaves strip with shingle-type roofs is quite common. This practice was not observed in any of the North Central States, although the weather conditions in some of these states are as severe as in New England.

In subsequent sections the weathering characteristics of the roofing materials that are used principally in the North Central States are discussed and, where possible, are illustrated by means of photographs. No attempt has been made in this discussion to differentiate between brands of roofing materials.

2. Discussion of Particular Materials

(a) *Asphalt Shingles and Roll Roofings.*

It was observed in the previous surveys that asphalt-prepared roofings weather less rapidly in the Northern than in the Southern States, the difference in a material between the two areas being mainly one of degree rather than of the kind of weathering. These observations were confirmed in the present survey. During this survey some asphalt shingles were found that were older than any previously seen, and probably as old as any in the country. Asphalt shingles were first manufactured regularly in Grand Rapids, Mich., about 1910 or 1911. Figures 2 and 3 illustrate roofs in Grand Rapids and Zeeland, Mich., respectively, that were reported to have been in use since 1911. These roofs were both of individual shingles applied by the American method. The shingles were made on a comparatively heavy felt base and with a thick asphalt coating that permitted a large quantity of mineral surfacing material. When examined they were quite brittle. Several shingles in figure 2 have been broken, but a very considerable part of the granular surfacing has been retained. Figures 4 and 5 illustrate the northern and southern exposures, respectively, of a roof composed of similar shingles after exposure of approximately 27 years in Grand Rapids.

It should be noted in figures 2 and 3 that the shingles are laid so that the spaces between shingles in one course are placed in the center of the shingles in the next course below. This was the first method used for the application of individual shingles. Figures 4 and 5 illustrate a method that was developed later, in which the space between two adjacent shingles is placed to one side of the center of the shingle in the next course below. Shingles laid by both of these methods provide three layers of fabric over the greater part of the roof area. With those laid as in figures 2 and 3, a small part of the area is covered by only a single layer of fabric, whereas with the method illustrated in figures 4 and 5 no part is covered by fewer than two layers.

No attempt has been made to estimate the probable useful life of asphalt shingles in the North Central States. The shingles are marketed in many different weights and designs and are subject to so many other variables that any general estimate would be meaningless. However, some decided variations were noted in the weathering of shingles in different sections of this territory. An attempt has been made to illustrate some of these variations by photographs of individual asphalt shingles laid by the American method in different locations. Each of these illustrations has been chosen to indicate an approach to the maximum rather than the minimum service that can be expected.

Invariably, the asphalt shingles having the longest service life that have been observed in any locality have been individual asphalt shingles laid by the American method.

Figures 2 to 5, already discussed, are roofs in Grand Rapids and Zeeland, Mich., after 29 and 27 years of exposure. Other illustrations, with the location followed by the number of years of exposure are figure 6, Pittsburgh, Pa., 20 years; figure 7, Toledo, Ohio, 24 years; figures 8 and 9, northern and southern exposures, respectively, Milwaukee, Wis., 20 years; figure 10, Omaha, Nebr., 20 years; figure 11, St. Louis, Mo., 17 years; figure 12, India-

FIGURES 2 to 7.—*Asphalt shingles (individual shingles applied by the American method).*

Figures 2 and 3, exposed 29 years in Grand Rapids and Zeeland, Mich., respectively; 4 and 5, northern and southern sections, respectively, of a roof after approximately 27 years of exposure in Grand Rapids, Mich.; 6, exposed 20 years in Pittsburgh, Pa.; 7, exposed 24 years in Toledo, Ohio.

napolis, Ind., 18 years; figure 13, Cincinnati, Ohio, 16 years.

The same types of weathering were observed in this as in the previous surveys. Shingles and roll roofings under normal weathering retain their mineral surfacing granules for long periods. Eventually, however, oxidation of the asphalt coating in which the granules are embedded lessens the bond between the coating and granules. The mechanical action of

Figures 8 to 13.—*Asphalt shingles (individual shingles applied by the American method).*

Figures 8 and 9, northern and southern sections, respectively, of a roof after 20 years of exposure in Milwaukee, Wis.; 10, exposed 20 years in Omaha, Nebr.; 11, exposed 17 years in St. Louis, Mo.; 12, exposed 18 years in Indianapolis, Ind.; 13, exposed 16 years in Cincinnati, Ohio.

rain, snow and wind assists in removing the granules. When they begin to disappear, the weathering process is accelerated because the asphalt coating weathers more rapidly when exposed directly to the sunlight than when it is protected by the granules.

Prepared roofings and shingles that have been exposed for long periods become quite hard and brittle, mainly owing to oxidation of the asphalt coating and saturant. Most of the shingles illustrated in figures 2 to 13 were very brittle. This is not objectionable, provided they are not subjected to high winds which may break the tabs, as shown in figure 3.

Very little blistering of asphalt coatings was observed in the northern cities of the territory covered by this survey but in Kansas City, St. Louis, Indianapolis, and Cincinnati, this feature was observed.

Asphalt shingles and roll roofings have had very wide use in the cities covered by this survey, with the exception of Bismarck, N. Dak., and Sioux Falls, S. Dak. As in other territories they have been used to a considerable extent as reroofing materials over wood shingles. Individual shingle roofs laid by the Dutch lap, hexagonal and wide-space methods, which are reroofing methods, are not used nearly so commonly as in the northeastern and southeastern sections.

Mineral-surfaced roll roofings with the exposure edge cut to form a pattern when the roof is laid are used to a much greater extent, however. These are usually 18 inches wide and are used only for reroofing. The most common is the diamond point roofing, with a serrated edge, as illustrated in figure 14. Note in this illustration that the roofing weathered most where it was bent slightly in conformity with the butts of the wood shingles underneath.

In general, mineral-surfaced roll roofings do not give as long service as asphalt shingles, mainly because they provide but a single layer of fabric over the greater part of the roof area. As with asphalt shingles, roll roofings older than any seen in the previous surveys were observed in this one. A few of these are illustrated in figures 15 to 18. These have also been chosen to illustrate an approach to the maximum service that may be expected: Figure 15, Toledo, Ohio, 20 years; figure 16, Milwaukee, Wis., 20 years; figure 17, Omaha, Nebr., 12 years; figure 18, Moberly, Mo., 12 years; figure 19, Milwaukee, Wis., 19 years. All of these were applied over wood shingles. The roofings in figures 16 and 18 show damage caused by hailstones.

Asphalt shingles are used to a great extent on low-cost housing projects involving single-family dwellings. On those financed with loans insured by the Federal Housing Administration, the shingles must weigh at least 210 pounds per square applied.

(*b*) *Wood Shingles*

Many more roofs of wood shingles were observed in the territory covered by this survey than in those of the previous ones. The census of rural roofs showed wood shingles to be the predominating roofing material in 8 of the states included in the survey, and in the whole rural survey more roofs of wood shingles were observed than of any other kind. The wide use of wood shingles is readily explained. Throughout the greater part of this territory they were used almost exclusively up to about 25 years ago. Michigan, Wisconsin, and Minnesota produced great quantities of wood shingles, and in these states, as in the Dakotas, their ready availability and adaptability to the climatic conditions promoted their wide use. Their use in built-up areas has been limited by fire regulations. Most large cities have adopted regulations forbidding the use of wood shingles within certain fire zones. Some cities have established three kinds of zones; the first requiring fireproof roofing materials; the second, fire-resistant materials; and the third, unrestricted.

Practically all of the wood shingles used at present in the territory covered by this survey are of western red cedar, which is very resistant to weathering. They are almost invariably applied on a tight sheathing deck in locations subject to severe winters accompanied by much snow. The sheathing provides additional heat insulation and prevents the infiltration of finely powdered snow during high winds. In Omaha, Kansas City, St. Louis, Indianapolis, and Cincinnati, wood shingles are usually applied on spaced sheathing. No appreciable difference has been noted in the rate of weathering of those applied on shingle lath and on tight sheathing. It is believed that shingles of the proper size and grade will render satisfactory service when applied by either method.

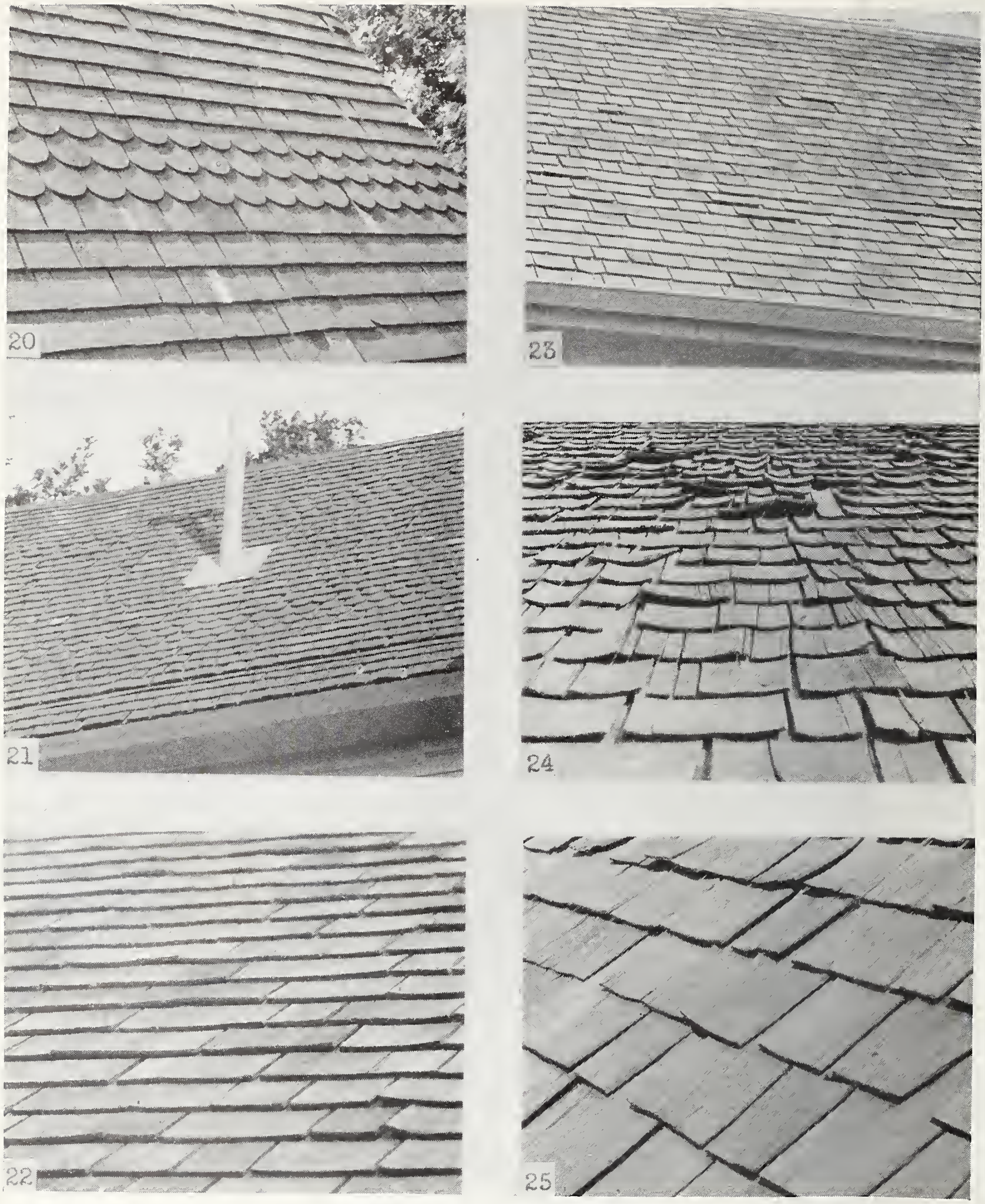
The greatest differences that have been noted in the weathering of wood shingles have not

FIGURES 14 to 19.—*Mineral-surfaced, asphalt-prepared roll roofings.*

Figure 14, diamond-point roofing; 15, exposed 15 years in Toledo, Ohio; 16 and 19, exposed 20 and 19 years, respectively, in Milwaukee, Wis.; 17, exposed 12 years in Omaha, Nebr.; 18, exposed 12 years in Moberly, Mo.

been due to climatic conditions but rather to differences in the quality or grade of the shingles.

Intense competition and disregard of proper grading rules, for a number of years has resulted in the wide distribution of inferior shingles. These included shingles that were too thin and consequently had a tendency to curl, also flat grain shingles, and those containing sapwood and knots. A great many of the roofs between



FIGURES 20 to 25.—*Wood shingles.*

Figures 20 and 21, northern and southern sections, respectively, of a roof after approximately 50 years of exposure in Bismarck, N. Dak.; 22, loose nails where butts of shingles had been nailed; 23, thin (6/2) shingles exposed 11 years in Sioux Falls, S. Dak.; 24 and 25, southern and northern sections, respectively, of a roof after approximately 30 years of exposure in Omaha, Nebr.

10 and 20 years old that were examined in this survey were of inferior quality.

Although inferior shingles may be obtained today, it is by choice rather than from necessity. The Commercial Standard CS31–38 for wood shingles, adopted for red cedar shingles in 1931, revised to include California redwood and tidewater red cypress shingles in 1933; and reaffirmed in 1935 and 1938, provides a minimum specification for the highest commercial grade of sawn wood shingles of the above species. This is known as No. 1 Grade in American Lumber Standards. It covers length, width, thickness, grain, characteristics, color, packing, and the grading tolerances for these requirements.

Commercial standard shingles are required to be 100 percent heartwood and strictly vertical, or edge-grained. The minimum length is 16 inches, with other standard lengths of 18 and 24 inches. Minimum width for shingles less than 24 inches long is 3 inches; for those 24 inches and longer the minimum width is 4 inches.

The thickness of shingles is determined at the butt ends, and is expressed as the number of pieces necessary to constitute a definite unit of thickness, as "4/2" indicates that four butts measure 2 inches, or "5/2¼" that five butts measure 2¼ inches. The minimum thickness of 16-inch shingles is 5/2.

Figures 20 and 21 represent the northern and southern exposures, respectively, of a wood shingle roof in Bismarck, N. Dak., reported to be 50 years old. These were heavy, red cedar shingles of good grade, which showed considerable weathering, particularly on the southern exposure, but which were in a satisfactory condition when examined. A number of broken shingles had been replaced recently on the southern exposure, and on the northern exposure practically all of the butts had been nailed down. This practice is not generally recommended because of the tendency of the exposed nails to become loose, as illustrated in figure 22. These shingles were not weathered badly, after 15 years of exposure in Omaha, Nebr., but they had shown some tendency to warp and had been nailed through the butts. After further exposure, a number of these nails became loose and each nail hole became a potential leak.

Figure 23 is a roof of wood shingles after about 11 years of exposure in Sioux Falls, S. Dak. These were shingles of good quality, except that the butts were too thin. The shingles shown in figure 23 were about 6/2, six butts in 2 inches.

Figure 24 shows the southern exposure of a wood-shingle roof after approximately 30 years of service in Bismarck, N. Dak. The northern exposure of this roof, on which the shingles showed less curling, and with fewer of them cracked, is illustrated in figure 25. These shingles also show plainly the erosion caused by long exposure.

Figure 26 illustrates a roof of thin, poorly graded shingles after 18 years of exposure in Milwaukee, Wis. This roof was on 1 of 20 dwellings that had been erected at the same time, and when examined, all but 2 of them had been reroofed.

That the thickness of shingles is an important factor is further illustrated by figure 27, in which the shingles were almost 1 inch thick at the butts. They had been exposed for 15 years in Omaha, Nebr., yet the roof had the appearance of a new one. Shingles that remain flat after long exposure present a lesser fire hazard than those that are warped and curled.

Figure 28 is an excellent example of poorly graded shingles, with edge and flat grain shingles mixed. One shingle in the second course shows a knot at the end of the exposed butt.

Figure 29 is representative of several hundred roofs 14 years old in Cincinnati, Ohio. These were first-grade shingles and, generally, have withstood weathering very well. Figure 30 is a close-up of some of these shingles showing that they are all edge grain.

Figure 31 shows wood shingles laid to simulate the appearance of a thatched roof. By this method the shingles are laid with very small exposure so that they usually give excellent service. The roof illustrated was 17 years old

(*c*) *Cement-Asbestos Shingles*

Cement-asbestos shingles have been used throughout this territory for a number of years, but in only one city, Omaha, Nebr., do cement-asbestos roofs constitute a considerable percentage of the total number of roofs. Their use has been mainly on dwellings in the medium price classes, although at present newer types of cement-asbestos shingles, laid by the American method, are being used on more expensive dwellings. Shingles laid by the Dutch lap and

FIGURES 26 to 31.—*Wood shingles.*

Figure 26, thin, poorly graded shingles, exposed 18 years in Milwaukee, Wis.; 27, heavy shingles exposed 15 years in Omaha, Nebr.; 28, poorly graded shingles; 29 and 30, first-grade shingles exposed 14 years in Cincinnati, Ohio; 31, shingles laid to simulate a thatched roof.

hexagonal methods are being used on dwellings in the lower price classes.

The oldest cement-asbestos shingles, observed in several locations, make a diamond pattern when laid. Several roofs of these shingles that had been exposed for approximately 30 years appeared to be in good condition, and were reported to have given no trouble except when some of the shingles were damaged by being walked upon.

The effect of weathering of cement-asbestos shingles observed in this survey was similar to that seen in the previous surveys; that is, on long exposure the surface became roughened somewhat, and the asbestos fibers were plainly visible. It has not been possible to establish differences in the rates of weathering of cement-asbestos shingles in different localities.

Figure 32 is a close-up of hexagonal pattern shingles after 15 years of exposure in Pittsburgh, Pa. These shingles showed considerable surface weathering, no doubt accentuated by the industrial atmosphere, but they were not badly discolored and appeared in good condition. The dark sections of these shingles were made by embedding mineral granules in the surface.

Figure 33 illustrates the oldest cement-asbestos shingles that were observed. They showed considerable surface weathering and discoloration after 30 years service in Toledo, Ohio. Several cities that had suffered severe hail storms during the past years were visited in this survey. Cement-asbestos shingles were reported in each case to have been damaged very little if at all.

Figure 34 illustrates cement-asbestos shingles laid by the American method after 10 years of exposure in Milwaukee, Wis. The corners of these shingles had been broken purposely when they were laid.

Figure 35 shows cement-asbestos shingles laid by the Dutch-lap and hexagonal methods on a group of new dwellings in Omaha, Nebr.

(d) Slate

In the cities included in this survey, excepting Pittsburgh, Pa., and Cincinnati, Ohio, slate roofs were observed only on dwellings in the higher price classes. This is undoubtedly due to the high transportation costs from the slate-producing areas in the East.

Slate that has been used has been mainly from the East Pennsylvania quarries in Lehigh and Northampton counties, and from quarries in Vermont where colored slates are produced.

The weathering of slates from the different producing areas has been discussed in BMS29. The types of weathering observed in the present area were the same as those described in the report on the Northeastern States, and it was not possible to distinguish differences in the degree of weathering of slate in the two areas.

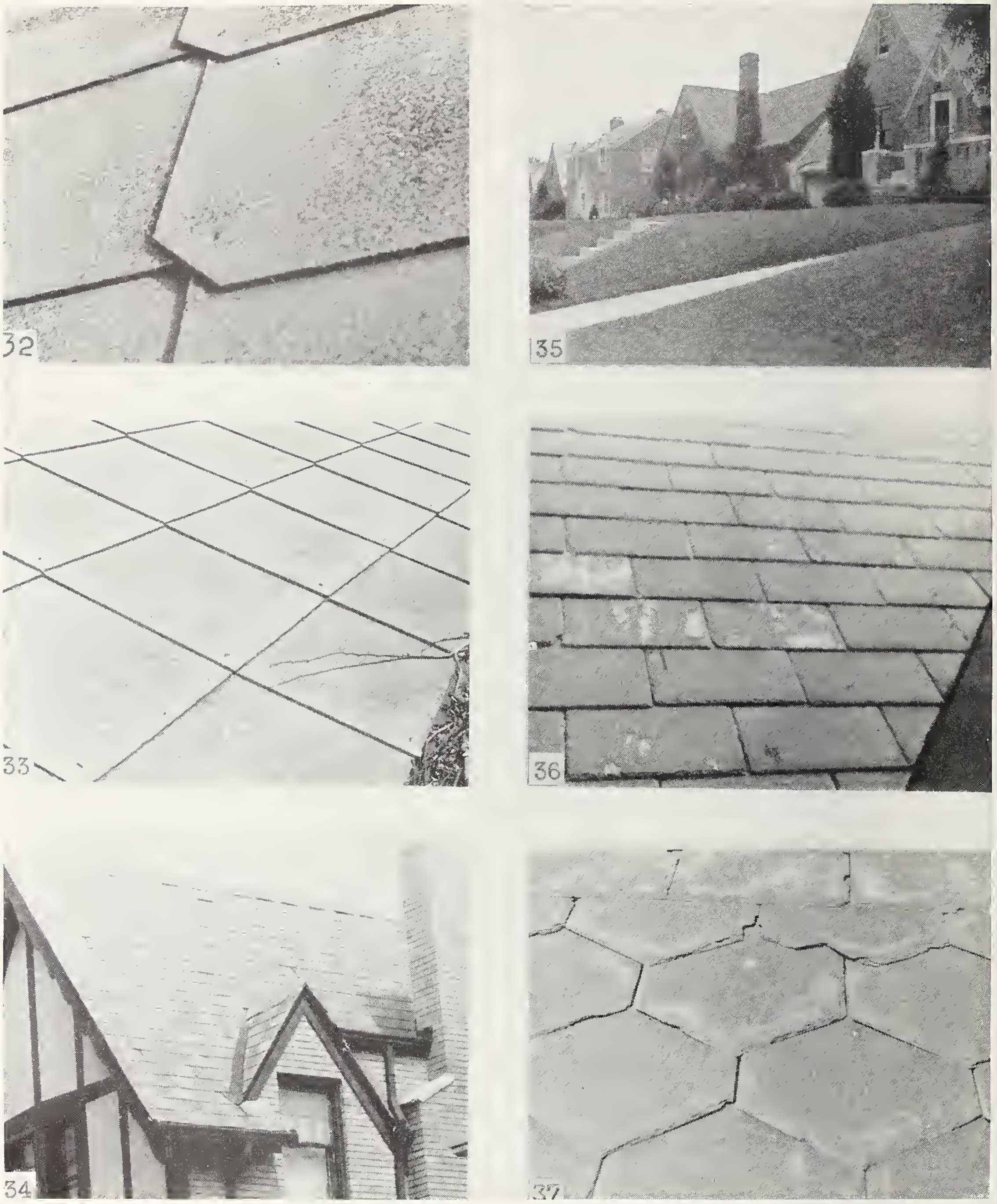
The condition of slate roofs in Pittsburgh, Pa., can be taken as representative of this material in severe industrial atmospheres. Slate roofs which have been widely used in this city since about 1894, probably total about 75 percent of all dwelling roofs at present. That fact, and the fact that slate is being used in about the same proportion today indicates that it is a satisfactory material in industrial locations.

Because of the accumulation of soot and dirt on most slate roofs in Pittsburgh very little could be learned of the weathering characteristics of the different kinds of slate. Figure 36, which is typical of many slate roofs more than 40 years old, shows some flaking of the surface layer, leaving white or gray patches exposed. These slates were from the Lehigh-Northampton region.

Figure 37 shows typical fading of eastern Pennsylvania slates after exposure of 40 years in Omaha, Nebr.

Figure 38 is a roof of colored slate from Vermont, also in Omaha, that was 40 to 45 years old. The slates on this roof were in excellent condition, but there had been some failure of the nails that were used to fasten them.

Variations in the conventional method of laying slate were observed in Cincinnati, Ohio, where they have been used to a considerable extent. By these methods the amount of slate per unit area of roof is reduced by substituting asphalt-prepared roofing for a part of the slate. Courses of asphalt-prepared roofing of the same width as the slate, or wider, are laid alternately with the courses of slate and the slates in one course are lapped at about 3 inches over those in the next course below. This method of laying is illustrated by the edge of the roof shown in figure 39. Figure 40 shows a roof laid by one of these methods, after 5 years of service. The owner of this roof shown in figure 40 reported that it had been entirely satisfactory.



Figures 32 to 37.—*Cement-asbestos shingles and slate.*

Figures 32 to 35, inclusive, cement-asbestos shingles; 32, after 15 years in Pittsburgh, Pa.; 33, after 30 years in Toledo, Ohio; 34, after 10 years in Milwaukee, Wis.; 35, new dwellings in Omaha, Nebr., roofed with cement-asbestos shingles; 36 and 37, eastern Pennsylvania slate, 36, after more than 40 years in Pittsburgh, Pa.; 37, after 40 years in Omaha, Nebr.

(*e*) *Built-up Roofing*

As in the previous surveys, no detailed study of built-up roofs was made in this survey. It is expected that a later publication will discuss the weathering qualities of built-up roofs. Material for this report is being obtained from inspections by competent engineers of roofs on Govern-

Figures 38 to 43.—*Slate and tile.*

Figures 38 to 40, slate; 38, Vermont slate exposed 40–45 years in Omaha, Nebr.; 39 and 40, slate roofs in which asphalt-prepared roofing is substituted for part of the slate; 41, shingle-tile roof exposed 35 years in Omaha, Nebr.; 42, glazed tile 16 years old in Indianapolis, Ind.; 43, cement-tile roof in Sioux Falls, S. Dak.

ment-owned buildings throughout the country.

(*f*) *Tile*

Tile roofs in the area covered by this survey were observed mainly on the more expensive dwellings. All types of tile roofs were observed, but shingle tiles apparently predominated on the more recent dwellings. Of par-

FIGURES 44 to 49.—*Metal roof, flashings, and valleys*

Figure 44, heavily galvanized roofing exposed 46 years in Southern Illinois; 45, absence of chimney flashing on wood-shingle roof; 46 and 47, respectively, low, step flashing and high metal flashing; 48, valley made by interlacing asphalt shingles; 49, divided metal valley.

ticular interest were the highly glazed tiles that do not change in appearance over long periods of exposure.

Considerable damage to cement tile roofs was reported in the locations subject to severe hailstorms.

Figure 41 illustrates a shingle-tile roof after 35 years of exposure in Omaha, Nebr. These tiles were 12 inches long and were exposed 5 inches. The edge of the dormer roof shows how they were applied. Figure 42 shows a roof of glazed tile 16 years old, in Indianapolis, Ind. This roof had the appearance of a new one.

Figure 43 illustrates a cement tile roof in Sioux Falls, S. Dak. The area of this roof was 16 squares. The owner reported that it had been necessary to replace 112 tiles in this roof after a severe hailstorm several years ago.

(g) *Metal*

As had been stated in reports of the previous surveys, it is practically impossible to state definitely the life, in years, of various metallic roofing materials. Their durability is determined largely by the character of the material, character of the coating, if a coated sheet is used, conditions of exposure, and degree of care and maintenance.[4]

The evidence obtained to date in this work indicates that suitably selected metallic roofing which is properly cared for, will render satisfactory service under normal conditions of exposure. Figure 44, of a heavily galvanized corrugated roof on a farm building in southern Illinois after 46 years of exposure, illustrates the long service that can be expected from galvanized metal with a heavy coating of zinc.

3. Flashings, Valleys, Gutters, and Downspouts

These items, invariably present on most roofs, are made principally from sheet metal. Sheet copper, galvanized iron or steel, roofing terne, and asphalt-roll roofing were found to be used. The present-day trend to the use of pitched roofs in residential construction, with a minimum of slopes and components, has simplified greatly the prevention of the leaks that were usually associated with the older type of roofs.

In general, it was observed that while care is usually exercised in the design and construction of these accessories, subsequent periodic maintenance is not always carried out. This often leads to premature failure, particularly where ferrous sheet materials are employed.

(a) *Flashings*

Copper, terne, and galvanized iron or steel are widely used for chimney and vent flashings. A few cases were observed of the use of roll roofing for chimney flashings; also where no flashings were used on either wood-shingle roofs (fig. 45) or asphalt-shingle roofs. This practice affords, generally, only temporary protection from leakage, particularly if plastic cement is utilized for sealing the shingles or roll roofing to the chimney.

On some of the older dwellings that are located close to industrial plants corrosion troubles have been encountered with metallic flashings, but on many of the newer residential buildings these difficulties have been minimized by locating the newer residential sections at greater distances from manufacturing areas, and by adequate painting.

The height of metallic chimney flashings appears to vary considerably between various sections, from the low-stepped type (fig. 46) to the high type (fig. 47).

(b) *Valleys*

Copper, galvanized metal, terne, and roll roofing are used most frequently for valley flashing. Asphalt shingles, are frequently laced or overlapped to produce closed valleys, particularly on some of the newer types of residential construction, figures 46 and 48. Open valleys are usually narrow and occasionally are divided if metal is used for their construction (fig. 49).

(c) *Gutters and Downspouts*

These accessories are widely used on houses in the North-Central Section. Most gutters and downspouts are constructed of either copper or galvanized metal, the former material being confined usually to houses in the higher-priced classes. Pole and hidden gutters are found on a few of the older houses but are seldom used on new ones.

Observations indicated unsatisfactory service from metallic gutters and downspouts in some sections, particularly those close to large industrial areas where the atmosphere is contaminated with industrial gases which cause rapid deterioration of the metal. This was true in

[4] Building Materials and Structures Report BMS 49, Metallic Roofing for Low-Cost House Construction. Price 10¢. See cover page IV.

the Pittsburgh, Pa., area where metal gutters are being largely replaced with fir.

V. EXTENT OF USE OF THE VARIOUS ROOFING MATERIALS IN URBAN CENTERS IN THE NORTH CENTRAL STATES

1. Factors Which Affect the Choice of Roofing Materials Generally

This subject is discussed in considerable detail in BMS6 and BMS29 so it will be treated only briefly here. Initial cost, cost of maintenance, fire resistance, and appearance are factors that influence the choice of roofing materials generally. Availability, insurance rates, and city regulations also govern the extent of use of the various materials to a considerable degree. While most materials may be used in any location if given proper care, some materials are much better suited than others for particular weather conditions, so that climate is one of the more important considerations.

2. Distribution of Roofing Materials in the Cities Included in This Survey

Data obtained by the questionnaire method, reported in BMS57, indicate that the Mississippi River divides the country roughly into two sections as regards the present distribution of roofing materials, with wood shingles predominating west of the Mississippi River, and asphalt shingles east of it. At the time this survey was made, asphalt shingles predominated in most of the cities visited, both on new and old dwellings, with a considerably quantity of asphalt-prepared roll roofings used mainly for reroofing over wood and asphalt shingles.

Wood shingles were formerly used more extensively than any other material in all of the cities visited, with the probable exception of Pittsburgh, Pa., until about 20 years ago, or when asphalt shingles began to have general use. Wood-shingle roofs still predominate in Bismarck, N. Dak., Sioux Falls, S. Dak., and Kansas City, Mo.

The rather widespread adoption by most cities of regulations prohibiting the use of wood shingles in congested areas, or requiring that existing wood-shingle roofs be covered with a fire-resisting material, contributed greatly to the use of asphalt shingles and asphalt-prepared roll roofings. In the older sections of most of these cities there are thousands of old wood-shingle roofs covered with these materials. In some cases, the first asphalt roof has been re-covered with another asphalt roof.

Except in the cities listed above, and in Omaha, Nebr., asphalt shingles are being used on most new dwellings in the lower price classes. This does not necessarily mean only in the lowest price classes, because in some cities, particularly in Chicago, Ill., whole subdivisions were observed where asphalt shingles were being used on dwellings selling for $10,000 to $11,000.

Omaha, Nebr., is outstanding for its wide use of cement-asbestos shingles on new dwellings selling for $6,000 and more. Cement-asbestos shingles have been very popular in Omaha for a number of years.

In comparison with other materials, metal roofing finds little use in any of the cities covered in this survey. Some relatively old terne roofs were found in the older sections of most of the cities visited. An occasional roof of terne, copper, metal shingles or metal tile was found scattered throughout the older residential sections. Small districts were occasionally found within a given district where relatively flat roofs, either built-up or terne are used.

VI. ROOFING COSTS IN URBAN CENTERS IN THE NORTH CENTRAL STATES

The prices, as of the approximate date of this survey including cost of application, per square (100 square feet of roof surface) for each of the materials listed in table 4 were furnished by representatives of the Home Owners' Loan Corporation in Pittsburgh, Pa.; Cincinnati and Toledo, Ohio; Indianapolis, Ind.; Grand Rapids, Mich; Chicago, Ill.; St. Paul, Minn.; Sioux Falls, S. Dak.; Omaha, Nebr.; and Kansas City, Moberly, and St. Louis, Mo. The range in costs is shown in the columns marked "minimum" and "maximum." The minimum and maximum costs were distributed among the different cities and were not confined to a particular one. The average cost shown is the average for all of the cities.

TABLE 4.—*Costs of roofing materials, including application per square, on a simple pitched roof with no valleys, but including chimney flashings*

[Data supplied by the Home Owners' Loan Corporation [1]]

Materials	Weight per square	Cost per square		
		Minimum	Maximum	Average
Asphalt shingles:				
Giant individual, 12 by 16 in., American method	*Lb.* 325	$9.50	$16.00	$12.25
Standard individual, 9 by 12¾ in., American method	255	8.50	13.50	10.90
Four-tab square butt strip 12½ by 36 in	266	8.25	12.50	10.20
Three-tab square butt strip 12 by 36 in. overlay	211	7.75	12.75	9.35
Two-tab hexagonal strip 11⅓ by 36 in	167	6.50	10.00	7.70
Individual re-cover, Dutch lap	125 to 140	5.25	9.50	7.25
Individual re-cover, hexagonal	125 to 140	5.25	9.50	7.30
Asphalt roll roofing:				
Mineral-surfaced	90	3.90	5.25	4.65
Smooth-surfaced	55	3.25	4.70	4.00
Cement-asbestos shingles (gray color only):				
American method		18.00	31.50	22.25
Hexagonal method		11.00	17.75	14.85
Dutch-lap method		11.50	17.75	15.40
Slate		20.00	30.00	24.55
Wood shingles		6.85	12.50	10.35
Metal roofing:				
Shingles (galvanized)		10.00	30.00	16.55
Five V-crimp sheets (galvanized)		6.75	22.00	11.75
Standing-seam "tin," 25 lb, unpainted		16.00	45.00	22.05
Flat lock and soldered "tin," 25 lb, unpainted		16.00	42.50	24.70
Tile roofing:				
Ceramic-shingle tile		19.00	43.00	33.30
Cement tile		18.00	31.50	25.80
Built-up roofing:				
Five-ply coal-tar pitch, surfaced with slag or gravel		6.50	14.00	10.80
Five-ply asphalt, surfaced with slag or gravel		7.25	14.00	10.75

[1] August–September 1941.

VII. SUMMARY

1. Distribution

The initial cost and the cost of maintenance, including fire insurance, availability, and appearance largely govern the choice of roofing materials on dwellings in the lower price classes. The more expensive materials, which are usually heavier and require a stronger supporting structure, are normally found on the dwellings in the higher price classes.

Roofs of asphalt shingles, wood shingles and sheet metal are found on approximately 76 percent of the rural dwellings along the routes traveled in the three surveys to date. Sheet-metal roofs predominate on low-cost rural dwellings in the Southeastern States; asphalt shingles on dwellings of the same class in the Northeastern States; and wood shingles in the North Central States. The use of wood shingles increases as one travels toward the northwest. They are used almost exclusively on both the rural and urban dwellings in North Dakota.

Asphalt-prepared roll roofings have been used extensively for reroofing throughout most of the North Central States. Large quantities of these roll roofings have one edge cut to form a regular pattern. These roofings are apparently more popular than the single-coverage shingles generally employed for reroofing over wood shingles in the Southeastern States, and to a smaller extent in the Northeastern States.

Fewer metal roofs were observed on dwellings in the North Central States than in the Southeastern or Northeastern States. Some very old tin and galvanized-iron roofs remain.

A comparatively large number of slate roofs, many of them very old, were found throughout Pennsylvania and Ohio in both the rural and urban sections.

2. Weathering

After weathering, asphalt shingles and roll roofings in the North Central States exhibit the same characteristic features as in the Northeastern and Southeastern States. The oldest asphalt-shingle roofs that were examined were 29 years old, of individual shingles, in Grand Rapids and Zeeland, Mich. In this territory were observed many asphalt-shingle roofs older than 20 years, also many roll-roofing roofs up to 20 years old.

Weathering proceeds more rapidly in the southern sections of the North Central States. In cities such as Kansas City and St. Louis, Mo.; Indianapolis, Ind.; and Cincinnati, Ohio most of these roofs are replaced or re-covered within 20 years.

Wood-shingle roofs in fair condition after an exposure of 25 to 50 years were observed, although some were observed that were in poor condition after less than 20 years of exposure. Difference in the grade or quality of the shingles rather than in the exposure conditions is the controlling factor in weathering. Thin shingles, and those that are poorly graded, with knots and sapwood in the sections that are exposed, usually curl and crack within a comparatively short time.

Wood shingles less than 10 years old, or considerably older if they are of first quality, are little affected by hail storms and strong winds.

Slate roofs 50 or more years old are not uncommon. Slates that are classed as nonfading are usually only slightly changed on long exposure. Many old slate roofs fail because of failure of the nails.

VIII. SELECTED REFERENCES [5]

1. *Asphalt Shingles and Roll Roofing:*
   - (a) Herbert Abraham, Asphalts and Allied Substances, 4th ed. (D. Van Nostrand Co., Inc., New York, N. Y., 1937.)
   - (b) O. G. Strieter, *A study of the weathering quality of roofing felts made from various fibers.* J. Research NBS **16**, 511 (1936) RP888. Out of print.
   - (c) O. G. Strieter, *Weathering tests on filled coating asphalts.* J. Research NBS **20**, 159 (1938) RP1073. 10¢.
   - (d) Hubert R. Snoke, Asphalt-Prepared Roll Roofings and Shingles. NBS Building Materials and Structures Report BMS70 (1941). 15¢
   - (e) Hubert R. Snoke and Braxton E. Gallup. *Accelerated weathering tests of mineral-surfaces asphalt shingles.* J. Research NBS **18**, 669 (1937) RP1002. 10¢.
   - (f) Roofing and Shingles; Asphalt - Prepared, Mineral-Surfaced Federal Specification, SS–R–521 (1933). 5¢
2. *Wood Shingles:*
   - (a) J. A. Ferguson, Comparative Durability of Shingles and Shingle Nails, Bulletin 353, Pennsylvania Agricultural Experiment Station, State College, Pa. (1938).
   - (b) Wood Shingles (Red Cedar, Tidewater Red Cypress, California Redwood), NBS Commercial Standard CS31–38 (1938). 5¢
   - (c) Red Cedar Shingle Bureau, Handbook of Red Cedar Shingles, Seattle, Wash. (1940).
3. *Cement-Asbestos Shingles:*
   - (a) Shingles; Roofing, Cement-Asbestos, Federal Specification SS–S–291 (1935). 5¢
4. *Slate:*
   - (a) D. W. Kessler and W. H. Sligh, *Physical properties and weathering characteristics of slate,* BSJ, Research *9*, 377 (1932) RP477. 10¢
   - (b) T. Nelson Dale and Others, Slate in the United States, Bulletin 586, United States Geological Survey (1914). Out of print.
   - (c) Oliver Bowles, The Technology of Slate, Bulletin 218, Bureau of Mines, United States Department of the Interior (1922). 20¢
   - (d) Charles H. Behre, Jr., Slate in Pennsylvania, Bulletin M16, Topographic and Geologic Survey, Department of Internal Affairs, Harrisburg, Pa. (1933).
   - (e) Roofing Slate, NBS Simplified Practice Recommendation R14–28 (1928). 5¢
   - (f) Slate; Roofing, Federal Specification SS–S–451 (1932). 5¢
5. *Tile:*
   - (a) Wolsey Garnet Worcester, The Manufacture of Tiles, fourth series, Bulletin 11, Geological Survey of Ohio, Columbus, Ohio (1910).
   - (b) T. A. Ackworth, Manufacture of Roofing Tile. Maclaren and Sons, Ltd., London, England.
6. *Metal:*
   - (a) National Association of Sheet Metal Contractors, Standard Methods of Sheet Metal Practices, Pittsburgh, Pa. (1938).
   - (b) Burns and Schuh, Protective Coatings for Metals, American Chemical Society Monograph Series 79 (Reinhold Publishing Corp., New York, N. Y., 1939).
   - (c) Leo J. Waldron, Metallic Roofing for Low-Cost House Construction. NBS Building Materials and Structures Report BMS49 (1940). 10¢
   - (d) Terne-Plate (Roofing-Tin), Federal Specification QQ–T–201 (1930). 5¢
   - (e) Roofing Ternes, NBS Simplified Practice Recommendation R30–37 (1937). 5¢
   - (f) Copper and Brass Research Association, Sheet Copper Handbook, New York, N. Y. (1937).
   - (g) American Zinc Institute, Inc., Zinc Workers Manual, New York, N. Y. (1929).
7. *General, Including Built-Up Roofing:*
   - (a) James McCawley, Roofing: Estimating—Applying—Repairing (175 Fifth Avenue, New York, N. Y., 1938).
   - (b) Ernest G. Blake, Roof Coverings (D. Van Nostrand Co., Inc., 1925).
   - (c) Joseph Ross, Waterproofing Engineering (John Wiley and Sons, Inc., New York, N. Y., 1919).
   - (d) Hubert W. Snoke and Leo J. Waldron, Survey of Roofing Materials in the Southeastern States, NBS Building Materials and Structures Report BMS5 (1936). 15¢.

[5] Many public, college, and university libraries throughout the country have the publications of the Bureau and possibly also publications from other branches of the Government. Where prices are given in this list, the publications may be purchased from the Superintendent of Documents, United States Government Printing Office, Washington, D. C. Postage stamps should not be sent.

(e) Hubert R. Snoke and Leo J. Waldron, Survey of Roofing Materials in the Northeastern States, NBS Building Materials and Structures Report BMS29 (1939). 10¢

(f) Leo J. Waldron and Hubert R. Snoke, Roofing in the United States—results of a Questionnaire. NBS Building Materials and Structures Report BMS57 (1940). 10¢

(g) A. D. Edgar and T. A. H. Miller, Roof Coverings for Farm Buildings and Their Repair, Farmers' Bulletin 1751, United States Department of Agriculture (1935). 5¢

(h) Roofing, Siding, and Sheet Metal Work; Dampproofing and Membrane Waterproofing, Navy Department Specification No. 7Yg (1934).

(i) List of Inspected Fire Protection Appliances, published annually by Underwriters' Laboratories, Inc., Chicago, Ill.

(j) Asphalt; (for) Built-Up Roofing, Waterproofing, and Dampproofing, Federal Specification SS-A-666 (1933). 5¢

(k) Pitch; Coal-Tar (for) Mineral-Surfaced Built-Up Roofing, Waterproofing, and Dampproofing, Federal Specification R-P-381 (1933). 5¢

(l) Felt; Asphalt-Saturated Felt (for) Flashings, Roofing, and Waterproofing, Federal Specification HH-F-191 (1933). 5¢

(m) Felt; Coal-Tar-Saturated Felt (for) Roofing and Waterproofing, Federal Specification HH-F-201 (1933). 5¢

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