U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

REPORT BMS6

Survey of Roofing Materials in the Southeastern States

by HUBERT R. SNOKE
and LEO J. WALDRON

NATIONAL
BUREAU OF STANDARDS

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Foreword

The present paper describes the results of a survey of the weathering qualities and extent of use of the various roofing materials on dwellings in nine Southeastern States. This survey, which was made with the cooperation of representatives of the Reconditioning Section, Home Owners' Loan Corporation, involved approximately 3,500 miles of travel by automobile.

The results of detailed studies of roofing materials on new and old constructions in representative cities are included, as well as a tabulation, by States, of the kinds of roofing materials used on more than 10,000 rural and small town dwellings along approximately 2,500 miles of highway. More than 400 photographs, showing types of weathering of roofing materials, and features of design and construction of roofs, were taken in the course of this survey. From these, 48 have been selected for publication.

It should be emphasized that the observations that are recorded in the present report apply only to the territory covered by this survey. It is planned to supplement this work with similar surveys in other sections of the country.

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 Southeastern States is described. Detailed studies of roofing materials in Greensboro, N. C., Columbia, S. C., Savannah and Atlanta, Ga., Jacksonville and Orlando, Fla., Birmingham, Ala., Knoxville, Tenn., and Charleston, W. Va., are reported. A tabulation, by States, of the kinds of roofing materials used on more than 10,000 rural and small town dwellings, along approximately 2,500 miles of highway, is included. Forty-eight photographs, illustrating types 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, a comprehensive survey of the various types of roofing materials used, with observations on their weathering qualities, on roofs of known history, in locations typical of widely differing climatic conditions in the country. It was decided that surveys of this kind would give information of more direct value than would accelerated-weathering tests in the laboratory.

This paper describes a survey of the weathering qualities of roofing materials commonly used in the following cities: Greensboro, N. C.; Columbia, S. C.; Atlanta and Savannah, Ga.; Jacksonville and Orlando, Fla.; Birmingham, Ala.; Knoxville, Tenn.; and Charleston, W. Va.; with estimates on the extent of use of the various materials in these cities. There is also included a report on the extent of use of the different roofing materials on rural dwellings along the highways between the cities that were visited. A distance of approximately 3,500 miles was traveled in this survey, from April 4 to 27, 1938.

It cannot be emphasized too strongly that the observations on the weathering characteristics of roofing materials that are recorded in this paper apply only to the territory covered by this survey. Obviously, these observations should be the same where conditions of exposure elsewhere are identical, but it is equally obvious that they would not be the same for different conditions of exposure.

II. METHOD OF MAKING THE SURVEY

1. Extent of Use of Roofing Materials in Rural Sections

All travel in connection with this survey was by automobile. In order to determine the extent of use of the different roofing materials on dwellings in the rural sections and small towns, an actual count was made of all roofs along the highways traveled. The record was kept on special forms, each covering 50 miles of highway, forms also being changed at State lines to permit tabulation by States.

No attempt was made to record the condition of roofs in the rural sections, although some obvious facts concerning the weathering characteristics of the various materials were noted.

2. Study of the Weathering Qualities and Extent of Use of Roofing Materials in Urban Centers

One of the chief difficulties in making a survey of this kind is that of obtaining roofs of known history for examination. This difficulty was eliminated to a considerable extent in this survey by the cooperation of representatives of the Home Owners' Loan Corporation, both in Washington, and in the regional, State, and district offices in the various cities.

The exact procedure was as follows: The chief of the Reconditioning Section, Home Owners' Loan Corporation, in Washington, through his regional reconditioning supervisors, notified the State reconditioning supervisors of the dates of arrival of representatives of the Bureau, and requested that they have available on those dates: (a) Some person who was thoroughly familiar with the city, and with local conditions of construction; (b) a list of roofs of different kinds and of known history; (c) a list of prices and costs of application of roofing materials used locally; (d) locations of low-cost housing projects; (e) names of several reputable roofing contractors; and (f) a ladder and means of transporting it.

Acknowledgment is here made to the representatives of the Home Owners' Loan Corporation, both in Washington and in the field, for their wholehearted cooperation in this work.

In each city, a short time was spent in discussing the details of the investigation with representatives of the Home Owners' Loan Corporation and then, with them, in discussing roofing practices with local roofing contractors. Actual inspections were then made of as many roofs as time would permit, followed by a general tour of the city, including long-established and new subdivisions to determine roughly the extent of use of the various roofing materials. While preliminary lists of roofs had been prepared in most locations, it was also a regular practice to request permission to examine any roofs that looked particularly interesting. In no case was permission refused.

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

1. Factors Which Affect the Choice of Roofing Materials in Rural Sections

Initial cost is undoubtedly the greatest single factor in the selection of roofing materials for rural dwellings in the Southeastern States. While the area covered included some of the most productive farming sections in the country, by far the greatest number of roofs tabulated were on dwellings in the very lowest price classes. Direct evidence that cost is the most important consideration is furnished by the fact that the use of the more expensive materials, such as slate and tile, is practically negligible in the rural districts. Availability of particular materials is another important factor. Wood shingles and shakes have had wide use in the past in sections where cypress, pine, and chestnut have been produced. It is worthy of note, however, that but very few (not over 10) new wood-shingle roofs were observed in the whole area.

Appearance is apparently of little influence in the majority of cases, but it was definitely evident that the more attractive roofings were used on dwellings whose general appearance was better than the average. Rural dwellings are not subject to fire regulations, other than those imposed by increased insurance rates for nonfireproof materials. No doubt the fire resistance of metal roofs has been of considerable influence in their wide use.

2. Factors Which Affect the Choice of Roofing Materials in Small Towns

The factors which influence the use of particular materials in small towns are essentially the same as those in large cities, though probably not in the same degree. Cost is the most important consideration, for the more expensive materials are found on dwellings in the higher price classes. Appearance is undoubtedly a greater influence than in the rural areas.

Maintenance cost in a very strong factor in small towns such as are found in the mining sections of Kentucky and West Virginia, where practically all dwellings in many villages are owned by coal companies.

3. Territory Covered and Routes Followed in Making Survey

A map of the territory covered and a list of the cities and routes in the order they were traveled, are given below.

States covered by survey.

Cities	Routes [1]
Washington, D. C., to Greensboro, N. C.	1 and 70.
Greensboro, N. C. to Columbia, S. C.	220, 1, 15, and 76.
Columbia, S. C. to Savannah, Ga.	(3) and (33).
Savannah, Ga. to Jacksonville, Fla.	17.
Jacksonville, Fla. to Orlando, Fla.	1 and 92.
Orlando, Fla. to Birmingham, Ala.	441, 19, 27, 84, and 31.
Birmingham, Ala. to Atlanta, Ga.	78.
Atlanta, Ga. to Knoxville, Tenn.	41, (71), and 11.
Knoxville, Tenn. to Charleston, W. Va.	(33) and 119.
Charleston, W. Va. to Washington, D. C.	60, 11, and 211.

[1] State routes in parentheses, all others are U. S. routes.

4. Extent of Use of Particular Materials in Rural Sections and Small Towns

Table 2 is a tabulation, by States, of the kinds of roofing materials used on dwellings in rural sections and small towns along the routes listed in section III (3).

Table 2.—*Tabulation, by States, of the kind of roofing materials used*

State	Miles	Asphalt shingles	Wood shingles	Slate	Cement-asbestos shingles	Metal sheet	Metal shingles	Roll roofing	Tile	Total
Virginia (W)	250	140	43	14	4	797	40	68	1	
Virginia (E)	200	328	24	33	7	363	26	110		
Virginia (total)	450	468	67	47	11	1,160	66	178	1	1,998
North Carolina	221	678	269	7	9	357	84	29	1	1,434
South Carolina	263	102	294	2	3	330	22	18		771
Georgia (SE)	140	36	76		21	191	8	17	1	
Georgia (SW)	50	13	47		2	67	5	8		
Georgia (N)	150	517	258	2	4	291	41	131		
Georgia (total)	340	566	381	2	27	549	54	156	1	1,736
Florida	421	105	128	1	46	204	47	99	28	658
Alabama	300	229	460	4	50	466	36	92	2	1,339
Tennessee	133	218	85		30	272	53	16	10	684
Kentucky	178	87	51		7	238	2	610		995
West Virginia	141	105	22	1	1	146	2	784	1	1,062
Total	2,447	2,558	1,757	64	184	3,722	366	1,982	44	10,677

Summary of rural count

Miles covered	2,447
Sheet metal roofs	3,722
Asphalt shingle roofs	2,558
Roll roofing roofs	1,982
Wood shingle roofs	1,757
Metal shingle roofs	366
Cement-asbestos roofs	184
Slate roofs	64
Tile roofs	44
Total	10,677

This count was not limited to dwellings actually on the highways, but included all that were visible in passing. In small villages of 20 or 30 dwellings, usually all would be included, and in some larger villages, notably mining towns in West Virginia and Kentucky, where practically all dwellings were roofed with the same materials, as many as 200 roofs might be listed in a single town. Larger towns and cities were not included, the count being stopped in the suburbs of the larger centers.

5. Summary of the Extent of Use of the Various Roofing Materials in Rural Sections and Small Towns in the Southeastern States

The foregoing summary is essentially a count of the roofs used on rural dwellings, except in Kentucky and West Virginia, where 610 and 784 roll roofings are tabulated, respectively. Roll roofings were practically negligible in the strictly rural sections of these States, most of these roofings having been tabulated in mining villages. The addition of these villages indicates many more roofs per mile than are actually found on the routes traveled in these States.

Only the most general observations were possible on the weathering qualities of roofing materials in rural sections and small towns. Certain facts that were obvious are: (a) Practically no new wood-shingle roofs are being constructed; (b) V-crimp and corrugated galvanized metal roofs are most widely used in the rural sections. The vast majority of these roofs on the cheaper dwellings are unpainted; and (c) the increasing popularity of aluminum paints for metal roofs on more expensive rural dwellings was evident in the Shenandoah Valley of Virginia, where the standing-seam metal roofs on many fine old homes have been coated recently with paints of this type.

IV. WEATHERING QUALITIES OF ROOFING MATERIALS IN THE SOUTHEASTERN STATES

1. General Discussion

Any discussion of the weathering qualities of roofing materials in a particular section of the country must, of necessity, be couched in

the most general terms. Many factors other than the actual materials used must be considered in studies of the durability of roofs. No two conditions of exposure are ever identical. Thus, two dwellings may be built side by side, of the same materials and design; one may remain dry throughout the building operations, whereas the wood sheathing on the other may be thoroughly soaked by several days of rain; one may be shaded by trees which protect it from the effect of sunlight, but subject it to damage from falling branches, whereas the other may receive the full effect of sunlight. These roofs, in all probability, will show different weathering characteristics. The same materials on roofs of different pitch will behave differently, a fact that can be observed frequently where the same material is used for the steeply pitched main roof sections and the lower-pitched porch roofs. The northern exposure of a roof is invariably less severe than the southern exposure.

Faulty workmanship probably causes more premature roof failures than faulty materials. A roof well laid with inferior materials will give good service as long as the material will withstand the effects of weathering, but a roof improperly laid with good materials will probably give poor service from the beginning.

When the materials used for roofing are considered, the problem becomes even more complicated. Asphalt shingles can be obtained in a wide variety of shapes and colors, and in weights ranging from 125 to 325 pounds per square when laid on a roof; slate for roofing purposes is produced in several localities in a variety of sizes, weights, and colors; metal shingles may be of terneplate, commonly known as "roofing tin";[1] galvanized steel, copper, or zinc, in numerous shapes and designs; and sheet-metal roofs may be of "roofing tin," galvanized steel, copper, etc., of different weights of coatings and gages of metal, and laid on the roof by a number of different methods. This multiplicity applies equally to other kinds of roofing materials.

Another factor which precludes definite and positive statements concerning the "life" of any particular roofing material is the difficulty of determining just when a roof has failed and exactly what constitutes a failure in a roofing material. Theoretically, a roof that does not admit water might be considered serviceable, yet roofs may be serviceable and still not be satisfactory. Appearance is a factor that is becoming increasingly important in choosing roofing materials, but it is a variable factor that cannot be weighted generally.

It can be readily understood, therefore, that no positive statement can be made concerning the probable service that a given, general type of roofing material will render in a particular locality. However, some of the materials, as classes, do show different weathering characteristics in different locations. An attempt has been made to discuss, and illustrate by means of photographs, certain of the weathering characteristics of the roofing materials used in the Southeastern States. No attempt is made in this discussion to differentiate between manufacturers of roofing materials.

2. Discussion of Particular Materials

(a) *Asphalt Shingles and Roll Roofings*

Asphalt shingles have been developed chiefly within the past 30 years, yet today they are used more generally on dwellings in urban centers throughout the Southeastern States than any other roofing material. Because of this wide use, these materials will be considered in greater detail than other roofings.

In a previous paper on accelerated-weathering tests of asphalt shingles,[2] types of weathering were discussed under the following headings: Color changes, blistering, pitting, loss of granules, cracking, warping, behavior of back coating, slippage, and water absorption. No definite report could be made on color changes of roofing granules in this survey, because original shingles were not available for comparison. The covered portion of a shingle is usually stained by the back coating of the shingle which covers it, so that it cannot be taken as a true standard for color. However, considerable fad-

[1] No distinction is made in this discussion between steel or wrought-iron sheets coated with tin only, "bright tin sheets," which were sold formerly as "roofing tin," and present-day "roofing ternes" or "terneplate" made by coating steel sheets with an alloy containing about 80 percent of lead and 20 percent of tin.

[2] Hubert R. Snoke and Braxton E. Gallup, J. Research NBS 18, 669 (1937) RP1002.

ing was noted, particularly in certain natural green and blue-black granules.

No slippage of the top asphalt coating was noted in any locality, but considerable blistering of back coatings was seen. Figure 1 illustrates this type of behavior. In some cases the butts of shingles laid recently had become cemented to those underneath so tightly that they could not be lifted.

Blisters in the top coating of asphalt shingles were found quite frequently. These varied from scarcely detectable small blisters to the large tent-like ones which covered a considerable area. They were not confined to particular types of shingles or granules, or to any particular location. However, they were noted on shingles surfaced with buff granules, or blends of other granules with buff, more frequently than on others. Also more shingles with blisters were observed in Orlando, Fla., than in any other location. Figure 2 shows typical blisters on an asphalt-shingle roof near Charleston, W. Va. This roof was surfaced with a blend of granules of different colors and had been exposed about 3½ years. Some slight buckling can be noticed in several of these shingles, apparently caused by the use of unseasoned lumber for sheathing.

Pitting, which is a further development of blistering, was observed in all degrees. Figure 3 shows pits from small blisters and figure 4 the type formed by large blisters.

Loss of granules accompanies all types of advanced weathering. Figure 5 illustrates shingles that have weathered badly, but which are just beginning to show a decided loss of granules. Figure 6 shows shingles that have lost not only granules but practically all of the coating asphalt. This illustration was typical of numerous old asphalt-shingle roofs that were observed, mostly of individual shingles laid by the American method. Note that most of the shingles show no curling or buckling. This roof, in Savannah, Ga., was 15 years old, and, as reported by the owner of the dwelling, did not leak.

Loss of granules caused by mechanical damage is illustrated in figure 7. Note the badly weathered condition of the shingles on the porch roof as compared with those on the roof of the house. Water falling from the main roof section to the porch roof has been the principal cause of the more advanced weathering of the latter, though the difference in the pitch of the two roofs may have been partly responsible.

Loss of granules, accompanied by curling, in a segregated section of a roof is illustrated in figure 8. Apparently this type of failure is caused by a defect in the sheet from which the shingles are cut as it comes from the machine. These shingles may have been cut from the sheet longitudinally, with the butts taken from the edge of the sheet. The shingles from the defective section are placed in the same bundle and consequently are segregated on the roof. Another common type of weathering, including loss of granules and curling, is illustrated in figure 9, where one tab of each shingle has lost granules and curled. In each case the tab that is affected is at the end of a shingle, that section probably being taken from the edge of the sheet.

Cracking of shingles was observed only in those that were weathered so badly that all the coating and granules were gone and the felt was disintegrated. Typical alligatoring of the asphalt coating, which develops into cracks, is shown in figure 10, representing shingles approximately 15 years old in Columbia, S. C. The section of the roof where this photograph was taken was protected from the sunlight.

Illustrations of warping or curling have been noted under loss of granules above. Warping due to no fault of the shingles is shown in figure 11, where apparently the use of wet or unseasoned lumber under the shingles was responsible.

Asphalt shingles are frequently laid over weathered wood or asphalt shingles when used for reroofing. When laid over wood shingles, any curled shingles should be removed or nailed down, and beveled wood strips inserted at the butts to insure a smooth surface and permit proper nailing of the asphalt shingles. Individual shingles laid by the Dutch lap or hexagonal methods, which give but single coverage over a large proportion of the roof area, are used frequently for reroofing. Difficulties that may be encountered with single-coverage shingles laid directly over wood shingles are illustrated in figures 12 to 16, inclusive. Figure 12 shows the curled corner of a wood shingle that

has worn a hole through the single thickness of asphalt shingle over it. Figure 13 shows a nail that had been used to fasten down the corner of a wood shingle but which has worked loose and been forced through the asphalt shingle. Both of these were taken on a roof 6 years old, in Columbia, S. C. Figure 14 shows a section of the same roof damaged by winds. Figures 15 and 16 show sections of an asphalt shingle roof 10 years old, in Orlando, Fla. These were heavy-weight shingles, 10 by 14 inches in size, laid directly over weathered wood shingles to give but single coverage over a section about 5 by 6 inches in size. The wood shingles under these asphalt shingles had almost completely disintegrated. Apparently in this case water had been driven under the asphalt shingles and wetted the wood shingles, which remained wet for a comparatively long time. Moisture from the wood shingles entered the asphalt shingles through the thin layer of asphalt coating on the back and under the hot sun, caused blisters. The blisters, composed of a thin layer of asphalt, soon broke open and exposed the felt to the weather.

No attempt will be made to estimate the probable life of asphalt shingles in the various cities visited. In each city, however, the oldest roofs found were of individual shingles, laid by the American method. These shingles were the first produced, so that naturally they should be the oldest. Yet it is believed that individual asphalt shingles, laid by the American method, provide the most satisfactory asphalt shingle roofs today because, when laid properly, they afford triple coverage over practically the whole area of the roof. Roofs laid with shingles of this type are illustrated in figures 5, 6, 10, 17, and 18. Figures 5 and 17 represent the northern and southern exposures, respectively, of a roof 13 years old, in Savannah, Ga., laid with heavy-weight asphalt shingles. Figure 6 is a 15-year roof of the same type in the same city. Figures 10 and 18 represent shaded and unshaded sections of a roof laid by the same method in Columbia, S. C. Numerous roofs so constructed were found in Birmingham, Ala., some of which were in fairly good condition after 15 years, and one after about 17 years had weathered approximately the same as the 13-year roof in Savannah. In Charleston, W. Va., the oldest roofs of this type were found on dwellings erected by the Federal Government in 1918. Most of these dwellings had been reroofed recently, but several that had not been were reported as not leaking. Practically all of the surfacing granules and asphalt coating had disappeared from these roofs.

The above illustrations were chosen to show specific types of weathering and to give some idea of the service that may be expected from asphalt shingles. It is not intended to convey the impression that all asphalt shingles will show severe weathering in a relatively short period. Figure 19 shows an asphalt shingle roof in Jacksonville, Fla., that was 12 years old and was still in very good condition. Figure 20 is a 10-year roof in Greensboro, N. C., that was in good condition. Both of these were of strip shingles.

It was noted that asphalt shingles weather more rapidly the farther south they are exposed. From many observations, it is obvious also that the greater the weight of asphalt shingles per unit area of roof, the better the service.

Mineral-surfaced asphalt-prepared roll roofing exhibits essentially the same types of weathering as asphalt shingles, although the roll roofing apparently is more susceptible to blistering than the asphalt shingles. Figure 22 shows large blisters, almost natural size, with one broken blister. Figure 23 shows a crack in mineral-surfaced roofing. Both of these were taken on a roof about 4 years old in Jacksonville, Fla.

In general, asphalt shingles give longer service than the mineral-surfaced roll roofing because the latter affords but single coverage. Roll roofing is difficult to apply without wrinkles, but when laid properly may outlast some improperly laid shingles, particularly those of lighter weight.

Smooth-surfaced roll roofing weathers more rapidly than the mineral-surfaced roofing because the asphalt coating is exposed directly to the action of sunlight and moisture. Faulty application causes failure in many of these roofs. Figure 25 illustrates smooth-surfaced asphalt-prepared roll roofing, well applied, that shows very little weathering after 5 years' exposure in Orlando, Fla. Figure 43 illustrates a 4-year roof, improperly applied, in the same city.

(*b*) *Wood Shingles*

Work on wood shingles in this investigation was limited to such observations as were necessary for a comparison of them with other roofing materials. Practically no opportunity was given to examine wood shingles, since all the cities visited either prohibit or strictly limit their use. Some very old wood shingle roofs were observed in each locality. Cypress shingles produced locally in some sections were reported to have given particularly good service.

(*c*) *Cement-Asbestos Shingles*

The oldest cement-asbestos roof of known history that was inspected was on the ocean front at Daytona Beach, Fla., and hence was subject to very severe conditions of exposure. This roof was 27 years old, and, except for a few broken shingles, appeared to be in good condition. See figure 28. The owner reported that most of the breakage had been caused by walking upon the roof, but that a few shingles had been broken recently at the nail holes by corrosion of the shanks of the galvanized nails that were used to fasten them. Close examination of these shingles shows a considerable degree of weathering on the surface. That is, the surface was roughened somewhat and the asbestos fibers were plainly visible (fig. 29), but weathering had not progressed to the extent that the exposed portion of a shingle appeared thinner than the unexposed portion. These shingles were 16 by 16 inches in size and were laid by the American method with a 7-inch exposure.

The type of weathering described above is typical of old cement-asbestos shingles examined in each of the locations visited. Since these materials have had but a limited use, except in Savannah, Ga., comparatively few cement-asbestos roofs were examined critically. Most of the older roofs were laid by the French or hexagonal method, while many of the newer roofs are being laid by the Dutch lap method.

In general, these shingles have given excellent service. Like other rigid roofing materials they are subject to damage when limbs of trees or other heavy objects fall upon them, or when they are walked upon directly; also by the shrinkage of wet or unseasoned lumber in the roof structure. The most noticeable effects of weathering are color changes. The color is applied to many of the colored shingles as an extremely thin coating which weathers badly in a comparatively short time. This was particularly noticeable in the green shingles. All types appear to collect considerable dust and dirt which give the shingles a dingy appearance after long exposure. Since it is unusual for all sections of a roof to have the same conditions of exposure, some sections may remain comparatively clean, while the original color of other sections may be entirely hidden.

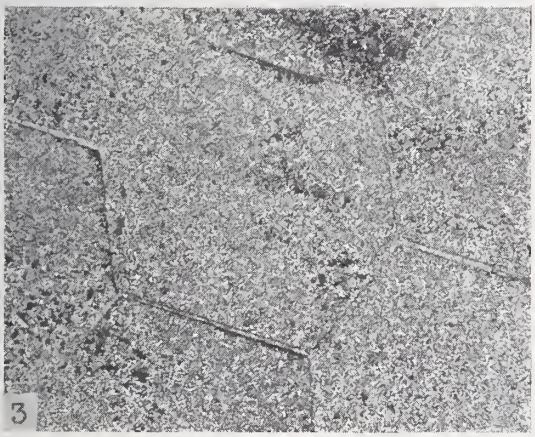
Differences in the degree of weathering of roofings of this type, exposed for approximately the same periods, could not be determined in the short time spent in the various locations. It is doubtful if this would have been possible in a more exhaustive study.

(*d*) *Slate*

Slate roofs, usually considered as permanent, may show decided weathering characteristics. Obviously it would be impossible to secure complete data on slate roofs 50 or more years old; yet certain slates, regardless of age, may be identified. Among these are the colored slates from the Vermont area. These are used to a very limited extent in the South, usually on the more expensive dwellings, because the freight charges make their cost very high. Apparently they withstand weathering well.

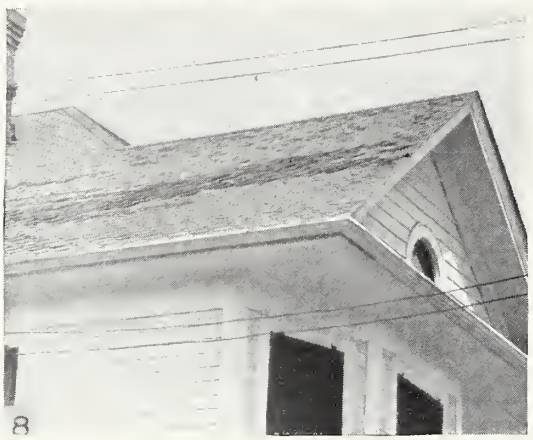
Other slates not difficult to recognize and probably used more extensively through the South than any others were unfading slates from Virginia. Slate has been quarried in Virginia since 1787 and many very old slate roofs in the Southern States are from this area. They show little or no change in color on long exposure

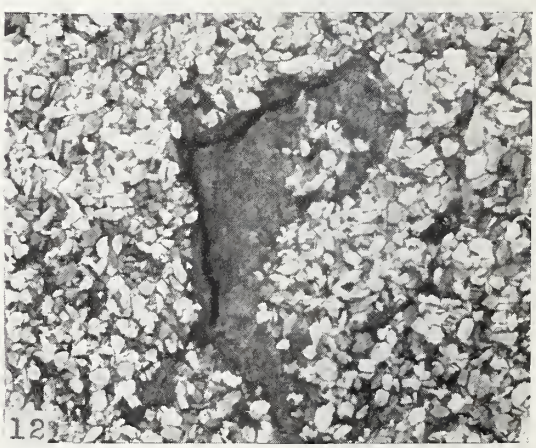
A number of very old slate roofs that had weathered to a brownish color were found in Atlanta, Ga. These slates were reported as coming from the Rockmart quarries in Georgia. Some fading slates from the Eastern Pennsylvania quarries were also observed, the roof on the old court house in Orlando, Fla., apparently being of this type. This roof is about 45 years old and is in good condition except that the slates show considerable fading. Figure 30 shows a roof of Vermont slate, in good condition after 30 years of exposure in Orlando, Fla.



FIGURES 1 to 6.—*Asphalt shingles.*

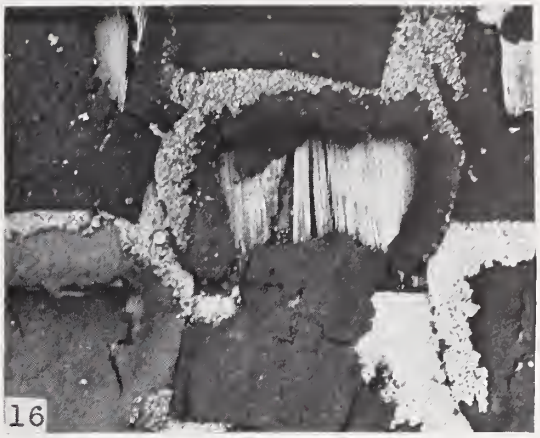
Figure 1, blisters on back coating of shingle exposed 10 years in Orlando, Fla.; 2, blisters on shingles exposed 3½ years near Charleston, W. Va.; 3, pits from small blisters. Shingles exposed 10 years in Orlando, Fla.; 4, pits from large blisters. Shingles exposed 12 years in Columbia, S. C.; 5, slight loss of mineral surfacing granules. Northern exposure of a roof in Savannah, Ga., 13 years old. See figure 17; 6, almost complete loss of mineral surfacing granules and asphalt coating on shingles exposed 15 years in Savannah, Ga.

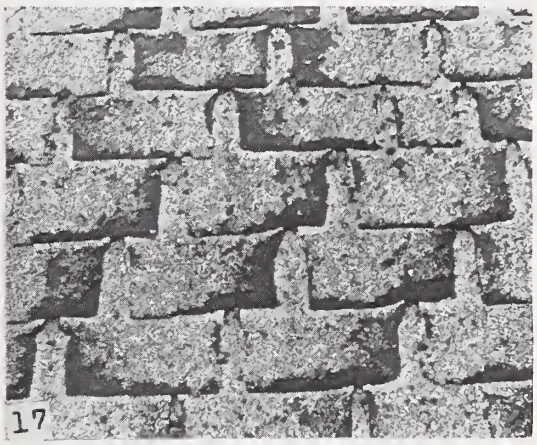




FIGURES 7 to 12.—*Asphalt shingles.*

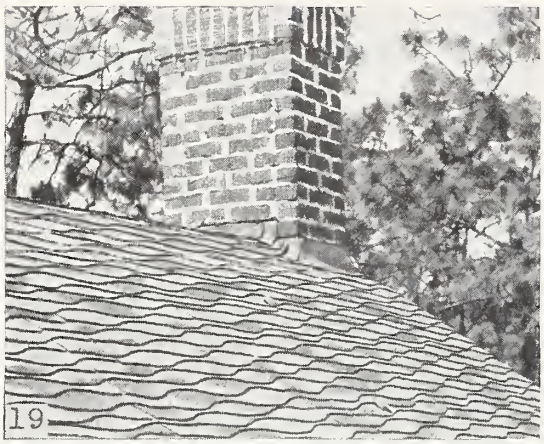
Figure 7, re-cover shingles exposed 7 years in Greensboro, N. C. Note difference between main roof section and porch roof; 8, loss of mineral surfacing granules, with curling of shingles, in a segregated section of a roof; 9, loss of mineral surfacing granules, with curling of shingles, after 12 years of exposure in Orlando, Fla.; 10, alligatoring of asphalt coating. Shaded section of a roof exposed 15 years in Columbia, S. C. See figure 18; 11, warping of shingles exposed 3½ years near Charleston, W. Va. Probably caused by wet or unseasoned lumber; 12, close-up of damage to an asphalt shingle laid over a wood shingle. Photograph taken after about 6 years of exposure.





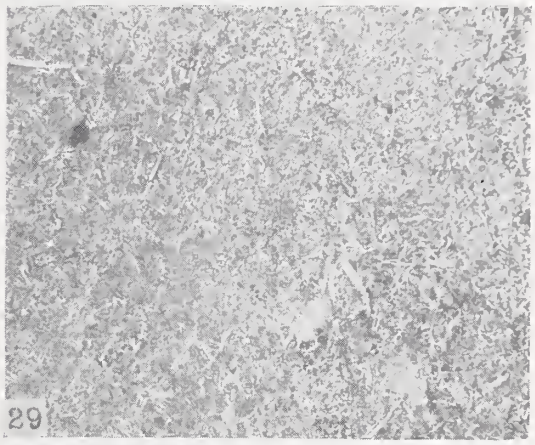
FIGURES 13 to 18.—*Asphalt shingles.*

Figure 13, close-up of damage to an asphalt shingle from a wood shingle nail. Same roof as in figure 12; 14, asphalt shingle roof damaged by wind. Same roof as in figures 12 and 13; 15, badly weathered asphalt shingles laid directly over wood shingles, after 10 years of exposure in Orlando, Fla.; 16, close-up of a section of the roof shown in figure 15; 17, severe weathering of shingles. Southern exposure of a section of the roof shown in figure 5; 18, severe weathering accompanied by loss of granules and asphalt coating. Unshaded section of the roof shown in figure 10.



FIGURES 19 to 24.—*Asphalt shingles and roll roofings.*

Figure 19, asphalt shingles in good condition after 12 years of exposure in Jacksonville, Fla.; 20, asphalt shingles in good condition after 10 years of exposure in Greensboro, N. C.; 21, valley formed by interlacing butts of asphalt shingles; 22, blisters in mineral-surfaced asphalt-prepared roll roofing exposed 4 years in Jacksonville, Fla; 23, crack in mineral-surfaced asphalt-prepared roll roofing. Same roof as in figure 22; 24, mineral-surfaced asphalt-prepared roll roofing made to simulate asphalt shingles.

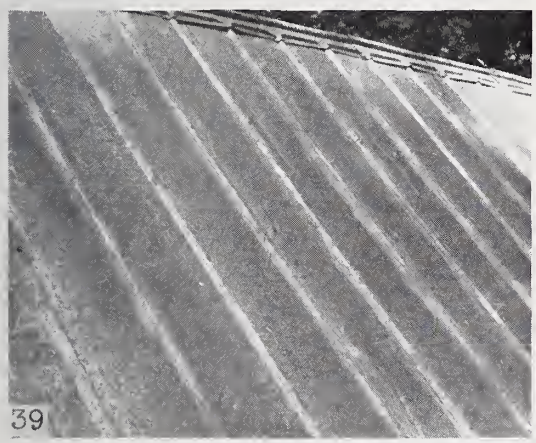


FIGURES 25 to 30.—*Asphalt-prepared roll roofing, cement-asbestos shingles, and slate.*

Figure 25, smooth-surfaced asphalt-prepared roll roofing, exposed 5 years in Orlando, Fla.; 26, smooth-surfaced asphalt-prepared roll roofing, vertical application. Atlanta, Ga.; 27, smooth-surfaced asphalt-prepared roll roofing, vertical and horizontal application. Atlanta, Ga.; 28, cement-asbestos shingle roof, exposed 27 years in Daytona Beach, Fla.; 29, close-up of cement-asbestos shingles from roof shown in figure 28; 30, slate roof exposed 30 years in Orlando, Fla.

FIGURES 31 to 36.—*Slate, tile, and thin copper.*

Figures 31 and 32, sections of a badly weathered slate roof after 10 years of exposure in Alderson, W. Va.; 33, ceramic tile roof after 15 years of exposure in Jacksonville, Fla.; 34, cement-tile roof after 15 years of exposure in Columbia, S. C.; 35, thin copper roof exposed 5 years in Orlando, Fla., 36, thin copper roof installed recently in Jacksonville, Fla.



FIGURES 37 to 42.—*Sheet metal and metal shingles.*

Figure 37, metal shingles on roof for 25 years in Savannah, Ga ; 38, metal shingles on roof for 3 years in Savannah, Ga.; 39, V-crimp metal roof in Birmingham, Ala.; 40, corrugated-metal roof in Orlando, Fla.; 41, standing-seam metal roof in Savannah, Ga.; 42, metal shingles on roof in Columbia, S. C.

FIGURES 43 to 48.—*Chimney flashings.*

Figure 43, roll roofing turned up as flashing; 44, asphalt shingle used as flashing; 45, metal flashing; 46, saturated-felt flashing; 47, plastic flashing; 48, metal flashing.

Figures 31 and 32 show almost complete deterioration of ribbon slates [3] after about 10 years of exposure in West Virginia.

Slate is another rigid roofing material that is subject to breakage by heavy objects falling upon it or by being walked upon directly. It may also be damaged if it is laid on wet or unseasoned lumber, particularly if the nails are driven too tightly. When laid properly, and of a proper grade, slate has given very satisfactory service. Differences in the degree of weathering of the various slates in the different locations could not be distinguished.

(*e*) *Tile Roofing*

Ceramic (clay) tile roofs, used only slightly in the locations visited, appeared to have given excellent service. Damage to them from actual weathering is very slight, but they are also subject to breakage by heavy objects falling upon them or by being walked upon directly. No differentiation in the degree of weathering of these materials could be determined in the various cities. Figure 33 shows a heavy mission tile roof 15 years old in Jacksonville, Fla.

Cement tile roofs, manufactured in a number of southern cities, are used to a greater extent than the ceramic tiles. They are extremely heavy and, because their surfaces are somewhat rough and porous, they have a tendency to collect dust and dirt. Figure 34 shows a roof of this type, 15 years old, in Columbia, S. C.

(*f*) *Metal*

The climatic conditions in the Southeastern States are very favorable toward the durability of metallic roofings, particularly galvanized materials, which probably explains the reason such materials give satisfactory results. More corrosive conditions prevail along the seacoast, which tend to decrease the life of unpainted metallic materials whereby the item of adequate maintenance becomes an important factor in governing the life of the material. Little evidence was found where expansion and contraction were important considerations in causing premature failures of metal roofs. Apparently this factor has been taken care of properly in the design of the roofing material and its subsequent installation.

Only a small amount of sheet copper of the conventional weight used normally for roofing was found in this survey, and its use was restricted to monumental buildings, churches, post offices, etc. A type of new roofing material that is being used in Florida, and also in some other sections of the country, is made from copper sheet, weighing approximately 3 ounces per square foot. It is applied in long lengths, parallel with the eaves, in widths of 1 to 1½ feet. It is given a shingle appearance either by crimping or by the insertion of lath at regular intervals. Sheets of electrolytically deposited copper were originally applied as roof coverings in Florida some 4 or 5 years ago and a few of these roofs were inspected at Orlando, Fla. Apparently they have given satisfactory service to date, though this particular variety of sheet is not used at the present time (fig. 35). Rolled copper sheet, backed with either paper or asphalt-saturated felt, has been used for 2 years and makes an attractive roof, as shown in figure 36. The short time it has been used precludes any prediction as to its behavior over a long period.

Metal shingles are used to a limited extent in most sections of the South. The older type of embossed or stamped design can be found in most communities. Satisfactory service for periods of 20 to 30 years has been rendered by these shingles when they are painted periodically, with numerous cases where the life has extended up to 50 years. Figure 37 shows an installation of these shingles, approximately 25 years old. Figure 38 shows an installation of a new and attractive design of painted galvanized shingle that is finding considerable use at the present time. A large number of dwellings were found around Savannah, Ga., where these shingles had given satisfactory service for periods up to 10 years, with little or no maintenance. A few cases were found, however, where paint failure through peeling had occurred after

[3] "Bands of different color, texture, and composition in slate are commonly called ribbons. The most common ribbons are darker in color than the main part of the slate and vary in width from a fraction of an inch up to several inches." D. W. Kessler and W. H. Sligh, BS J. Research 9, 381 (1932) RP477.

"When exposed to the weather the ribbons in the 'soft-vein' slate of Pennsylvania decompose more readily than the clear stock. In side walks, made of ribboned slate, deep grooves have commonly resulted from the weathering of the ribbons. The ribbons in the 'hard-vein' slate of Pennsylvania resist weathering." Oliver Bowles, Bulletin 218, U. S. Bureau of Mines, p. 11 (1922).

4 or 5 years. Instances of the buckling and warping of isolated individual shingles of the older stamped type were observed on some dwellings, caused either by faulty installation or by movement of the sheathing boards.

The V-crimp type of galvanized roofing, even when unpainted, appears to give satisfactory service and the majority of installations are relatively free from unsightly corrosive products which characterized the corrugated material to a certain extent. While it is possible that this may be due in some measure to the fact that the latter type preceded the V-crimp material, it is not believed that it is entirely a matter of age. Initial rusting was found almost invariably on the top of the corrugations. Figures 39 and 40, respectively, show installations of these two types of materials. Usually V-crimp roofing is installed over "open slat decks" or close-sheathed decks, with recent practice calling for the use of asphalt or asbestos felt laid over the latter type of deck. High winds cause lifting from the deck of improperly secured sheets, with subsequent leakage. Also, considerable difficulty has been experienced with some of the older designs of V-crimp sheets from water that either blows into or seeps through the joint, a condition which is said to be eliminated by recent methods of holding the sheets together.

Many old roofs of standing-seam "roofing tin," figure 41, were found in most sections. Where properly protected by paint at all times they give many years of service. A considerable number of flat-seam tin roofs were observed at Birmingham, Ala., that had been given but one recoating of paint since their initial installation some 10 or 12 years ago.

3. Flashings, Valleys, Gutters, and Downspouts

These items, while of vital consideration in the study of roofing materials, could not be given detailed consideration in this survey because of lack of time. It was practically impossible to secure definite information concerning the durability of the materials used for flashings, valleys, gutters, and downspouts. Some general observations follow:

(*a*) *Flashings*

With the exception of Knoxville, Tenn., and Charleston, W. Va., it was apparent that very little attention was paid to chimney and vent flashings except on the more expensive dwellings Figures 43 to 47 represent some typical installations of flashings which illustrate this point. Figure 48 shows proper application of a metal flashing, except that one section of the metal has pulled loose from the chimney. Note the entire absence of chimney flashings in figure 7.

Asphalt-prepared roll roofing, tin, galvanized metal, and copper are all used for flashings. The use of copper is very limited. Asphalt-prepared roll roofing and "roofing tin" are used most frequently with asphalt roll roofing and shingles and wood shingle roofs; galvanized metal with galvanized sheet-metal and shingle roofs.

(*b*) *Valleys*

Valleys, usually listed as "valley flashings," are constructed of the materials listed above, "roofing tin" being used most frequently. Mineral-surfaced roll roofings and tin are used most frequently with asphalt shingle roofs though a great number of valleys on roofs of this type are formed by interlacing the butts of the asphalt shingles, as illustrated in figure 21. Copper is used with the more expensive roofing materials. Galvanized metal is used almost exclusively with galvanized sheet metal and metal shingle roofs.

(*c*) *Gutters and Downspouts*

Most gutters and downspouts are constructed of galvanized metal. Tin is used to a lesser extent, and copper infrequently, usually on the more expensive dwellings. In some cities, notably Knoxville, Tenn., and Charleston, W. Va., built-in, concealed gutters, lined with "roofing tin," have been used extensively.

Gutters and downspouts are omitted in a large percentage of the dwellings in the Southeastern States, particularly on dwellings of moderate cost. They are used but rarely on the cheaper dwellings in cities and in the rural sections.

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

1. Factors Which Affect the Choice of Roofing Materials Generally

Any discussion of the distribution of roofing materials in a particular section of the country should give some consideration to the factors which influence the choice of these materials. Unquestionably, cost is a deciding factor in most cases. The first cost is influenced to a considerable degree by nearness to sources of supply and the cost of application of the material. Cost of maintenance is as important as first cost and, with some types of roofing materials, may well exceed the first cost over the period of the useful life of a roof. Fire resistance is another important consideration, most cities having definite regulations concerning the types of roofing materials that are permitted within city limits; also, the cost of fire insurance is greater with materials of lower fire resistance. Finally, appearance has always been an important factor in the choice of a roofing material and is apparently becoming increasingly more important.

2. Factors Which Affect the Choice of Particular Materials

That certain roofing materials, such as slate and ceramic tile, should have but slight use throughout the Southeastern States is readily understood. They are classed definitely among the more expensive materials, and their use is confined generally to the more expensive dwellings. This is proof that they are considered satisfactory from the standpoint of appearance and service.

Asphalt shingles are used more widely in urban centers in the Southeast than any other roofing material. They have been made readily available at a reasonable price in every locality, and the cost of application has been kept comparatively low. The cost of maintenance of an asphalt shingle roof is practically negligible, in fact, manufacturers recommend that no attempt be made to recoat weathered asphalt shingles. They have come into their greatest popularity during the period when many of the cities have been prohibiting or limiting the use of wood shingles, and thousands of dwellings have been reroofed with asphalt shingles laid directly over weathered wood shingles. The variety of colors has been a strong factor in making them widely used.

Asphalt roll roofings, both smooth and mineral-surfaced, are less expensive than asphalt shingles, and are used generally on dwellings of lower-cost construction.

Mineral-surfaced asphalt roll roofings made to imitate the appearance of asphalt shingles are used to a considerable extent. Lines formed by granules of contrasting color simulate the cut-out sections of shingles. See figure 24.

Cement-asbestos shingles have not been used to any considerable extent except in a few locations. They are more expensive then asphalt shingles and, like slate and ceramic tile, have been used most frequently on the more expensive dwellings. At present, however, they are being used more generally on all classes of dwellings.

Cement tiles are used to a considerable extent in several cities where they are produced locally. They require a very heavy roof structure so that the cost of a complete roof with these materials is greater than with lighter materials of about the same initial cost. Because of their weight, excessive freight rates limit their distribution.

The use of wood shingles in urban centers is practically negligible since every city either prohibits them entirely or limits their use to certain areas. Insurance rates are higher on dwellings roofed with wood shingles.

Metal roofs furnish an interesting study from the standpoint of distribution. They have been made readily available and, excepting such materials as copper and zinc, have been priced moderately, both as regards first cost and application. Galvanized iron and "roofing tin" roofs require regular maintenance, but will render indefinite service if properly maintained. Apparently social influence and appearance have been strong factors in restricting the use of metal roofings. Metal is used largely on the very cheapest dwellings in most southern cities so that it has come to be classed as a cheap material. From the standpoint of appearance, there has been little to recommend it,

either in the various galvanized sheets or the metal shingles that were produced formerly. Improper methods of application rendered the sheet roofings unsightly and the conventional patterns of stamped shingles had little appeal. More recently manufacturers of metal roofings have been giving considerable attention to the appearance of their products, so that today there are produced sheet-metal roofs of low cost that provide a very pleasing appearance, some in the form of the ever-popular standing seam. Considerable progress has been made also with metal shingles, some shingles that are now on the market being practically indistinguishable from slate. The popularity of these shingles is shown by their use on dwellings costing up to $20,000 in the section where they are produced.

3. Distribution of Roofing Materials in the Cities Covered by This Survey

(a) *Greensboro, N. C.*

(1) *New construction.*—Asphalt shingles predominate. One new development (built privately) of about 50 dwellings, ranging in price from $5,000 to $7,000, was roofed entirely with asphalt shingles. Some other dwellings costing up to $12,000 were also roofed with asphalt shingles.

Slate, tile, and cement-asbestos roofings are used on the more expensive dwellings.

One new apartment-type development, containing 86 apartments, and built at an average cost of $5,400 per family unit, was roofed with cement-asbestos shingles laid by the Dutch lap method on the pitched sections and with a five-ply coal-tar-pitch built-up roof, surfaced with ground granite chips, on the flat sections.

(2) *Old construction.*—Most of the older dwellings of medium cost were roofed originally with wood shingles. Practically all of these wood shingle roofs have been replaced or recovered with asphalt shingles. In many cases individual asphalt shingles laid by the Dutch lap or the hexagonal method have been used for roofing directly over weathered wood shingles. Slate, tile, and cement-asbestos shingles have been used chiefly on the more expensive dwellings.

In the cheaper sections, sheet-metal roofings predominate. In the cheapest dwellings these were mainly V-crimp and corrugated sheets, with some asphalt-prepared roll roofings and asphalt shingles. Several hundred dwellings owned by a large textile company were all roofed with metal shingles of a conventional design, painted with an aluminum paint over red lead.

A number of slate roofs, reported to be about 25 years old, were observed.

(b) *Columbia, S. C.*

(1) *New construction.*—Asphalt shingles predominate. In one new subdivision of several hundred dwellings of brick and stone construction, and ranging in price from $4,750 to $5,500, all the roofs were of asphalt shingles.

The use of slate, tile, and cement-asbestos shingles is confined almost entirely to the more expensive dwellings.

(2) *Old construction.*—Practically the same conditions exist in Columbia as in Greensboro; that is, asphalt shingles have been used to replace or re-cover wood shingles which were used formerly on most dwellings of medium price. Some metal roofs, mostly standing-seam sheets and shingles, were observed. Several dwellings roofed with large tin shingles, illustrated in figure 42, give the appearance of a standing-seam roof. These are manufactured in South Carolina and have not been distributed widely.

On the cheapest dwellings, V-crimp and corrugated sheet metal roofings predominate, with some metal shingles, asphalt-prepared roll roofings and shingles. A few dwellings with cement tile were observed.

(c) *Savannah, Ga.*

(1) *New construction.*—Savannah is a city in which metal roofs definitely predominate. Metal shingles are used widely on new construction regardless of price class. (See fig. 38.) Some asphalt and cement-asbestos shingles have been used on dwellings constructed recently, probably in about equal proportions.

(2) *Old construction.*—Most of the older metal roofs in Savannah are of the standing-seam type, painted, though metal shingles have been used to a considerable extent. Cement-asbestos shingles probably rank next to metal roofings in

number, having been imported in large quantities from Germany a number of years ago and used on dwellings of every price class. Asphalt shingles have had comparatively little use. As elsewhere, a few slate and tile roofs were observed on more expensive dwellings.

In the cheaper sections, the roofs are largely V-crimp and corrugated galvanized sheets.

A few very old wood shingle roofs were observed.

(*d*) *Jacksonville, Fla.*

(1) *New construction.*—The wide variety of types of roofings on new construction in Jacksonville makes any estimate of the proportions of the various kinds difficult. Probably asphalt shingles have the greatest use, with cement-asbestos and metal shingles being also used widely. There are more tile roofs than in any of the other cities visited.

One slum-clearance project with apartment-type buildings was inspected. This development houses 215 negro families at a rental of from $2.90 to $4.55 per week. Low-pitched roofs of interlocking terra-cotta tile are used on this project.

(2) *Old construction.*—The statement concerning the kinds of roofing materials on new construction applies also to old construction. Asphalt and metal shingles account for a large proportion of the roofs in Jacksonville. Mineral surfaced asphalt-prepared roll roofing, laid in hot asphalt, on saturated felt nailed to board sheathing, is used to a considerable extent.

Some time was spent in Jacksonville in the examination of a comparatively new roofing material, 3-ounce copper backed up with a heavy paper or cardboard, and laid in long sheets. It was reported that about 200 dwellings have been roofed with this material during the past 2 years. It has been used chiefly for reroofing.

(*e*) *Orlando, Fla.*

(1) *New construction.*—Practically all moderately priced dwellings that have been constructed in Orlando recently are roofed with asphalt shingles. Some slate, tile, cement-asbestos, and metal-shingle roofs were observed.

(2) *Old construction.*—Asphalt shingles have been used very extensively, both as an original roofing material and for reroofing over wood shingles. Orlando was reported to have had a decided building boom about 12 years ago and practically all dwellings constructed at that time were roofed with asphalt shingles. A few old slate, tile, and cement-asbestos roofs were observed.

Approximately 200 dwellings have been roofed with thin sheet copper within the past 2 years. Most of these were reroofing jobs.

V-crimp and corrugated galvanized metal roofings and asphalt-prepared roll roofings are divided about evenly in the cheapest sections of the city. Asphalt and metal shingles have had slight use. A few old wood shingle roofs were observed.

(*f*) *Birmingham, Ala.*

(1) *New construction.*—Asphalt shingles are used largely on dwellings of moderate cost, though metal roofings, a number of which are manufactured in Birmingham, are used to a considerable extent. On more expensive dwellings constructed recently, colored slate and shingle tiles are used extensively. Cement tile, manufactured in Birmingham, also has notable use.

Two Government low-cost housing projects were visited in the vicinity of Birmingham. One contains about 300 4-, 5-, and 6-room detached dwellings of brick, frame, and shingle construction, all roofed with one of the newer types of galvanized shingles. The other contained about 140 detached dwellings roofed with redwood shingles.

(2) *Old construction.*—Asphalt shingles have been used chiefly, both originally and for reroofing.

Sheet metal, metal shingles, asphalt shingles, and roll roofings are used extensively in the lower-priced sections. One group of about 4,000 dwellings, all with metal roofs, is under single management. A few old wood shingle roofs were observed.

(*g*) *Atlanta, Ga.*

(1) *New construction.*—Dwellings of moderate price are practically all roofed with asphalt shingles. Two recent developments were observed, comprising several hundred dwellings, all roofed with asphalt-strip shingles. One

group ranged in price from $2,500 to $4,000, the other from $4,500 to $8,000.

Colored slate is used quite extensively on the more expensive dwellings. Tile and cement-asbestos shingles are used to a limited extent.

(2) *Old construction.*—The striking feature of roofing in Atlanta is the very extensive use of roll roofing on older dwellings. It is used principally for reroofing and is not confined to any particular price class, but in sections whole blocks of dwellings of moderate price are roofed with this material. The roll roofing is laid vertically from ridge to eaves on most reroofing jobs. Workmanship on these roofings seems to have been particularly good in Atlanta. See figures 26 and 27.

Several developments built from 10 to 15 years ago were roofed entirely with asphalt shingles.

A considerable number of old slate roofs were noted. Many of these had weathered to a rusty brown color and were reported to be of slate produced from the Rockmart quarries in Georgia. Metal roofings are not used to any considerable extent in Atlanta. When metal is used it is mainly on the cheaper dwellings. Probably the popularity of roll roofing is responsible for the limited use of metal.

Practically no wood-shingle roofs were observed.

(*h*) *Knoxville, Tenn.*

(1) *New construction.*—Asphalt shingles are used most frequently, though a number of new dwellings that were roofed with cement-asbestos shingles were observed. All of the 291 dwellings in the town of Norris, about 25 miles from Knoxville, built to house the families of men who built Norris Dam, are roofed with wood shingles.

(2) *Old construction.*—Asphalt shingles have had wide use in Knoxville, probably more than any other single material, on new construction and as a reroofing material. Numerous slate roofs from 25 to 50 years old and many wood shingle roofs were observed, probably more of these, all old, than in any other city visited. A few metal roofs were seen, mostly standing-seam sheets and the older conventional type metal shingles.

In the cheapest sections asphalt roll roofing and sheet metal predominate.

(*i*) *Charleston, W. Va.*

(1) *New construction.*—Asphalt shingles are used most extensively on moderately priced dwellings. About 300 dwellings in one new development and about 40 in another, are roofed almost entirely with asphalt shingles. Slate and ceramic tile are also used to a considerable extent on more expensive dwellings. Apparently cement-asbestos and metal roofings are but slightly used.

One group of about 150 low-cost dwellings, located about 35 miles from Charleston, built recently by the Federal Government, is roofed entirely with asphalt shingles.

4. Summary of Extent of Use of the Various Roofing Materials in Urban Centers in the Southeastern States

(*a*) *New Construction*

Apparently from 50 to 75 percent of all dwellings constructed recently in the cities visited are roofed with asphalt strip shingles, and it is probable that the larger figure is more nearly the correct one. Apparently cement-asbestos shingles and metal shingles are increasing in use, as are cement tiles. Slate and heavy ceramic tiles are confined largely to the more expensive dwellings.

(*b*) *Old Construction*

Wood shingles, chiefly cypress and pine, apparently predominated in these cities before the advent of asphalt shingles. Most dwellings that were roofed originally with wood shingles are now roofed with asphalt shingles, frequently laid over the weathered wood shingles. Metal shingles of the older types have been used to a considerable extent, also standing-seam metal roofs, on dwellings of moderate price. The

less expensive forms of galvanized metal roofings are used on dwellings of lower cost in about the same quantities as asphalt roll roofings and shingles.

Slate and tile roofs account for a relatively small percentage of the total number. Slate was apparently used more often in former years on dwellings of moderate cost.

Cement-asbestos shingles have been used to the greatest extent in seaport cities such as Savannah, Ga., and Jacksonville, Fla., large quantities of these shingles having been shipped to these cities.

5. Costs of Roofing Materials, Including Cost of Application, in Urban Centers in the Southeastern States

The price, including cost of application, per square (100 sq. ft. of roof surface) for each of the materials listed in table 3 was furnished by representatives of the Home Owners' Loan Corporation in Greensboro, N. C., Columbia, S. C., Savannah and Atlanta, Ga., Jacksonville, Fla., Birmingham, Ala., and Knoxville, Tenn. The range is shown in the columns marked "maximum" and "minimum." The maximum and minimum costs were distributed among the different cities and were not confined to any particular one. The average cost shown is the average for all of the cities.

Table 3.—*Costs of roofing materials and application, per square, on a simple pitched roof with no valleys, but including chimney flashings*

[Data obtained from the Home Owners' Loan Corporation]

Materials	Weight per square	Cost per square		
		Minimum	Maximum	Average
Asphalt shingles:	*Pounds*			
Giant individual, 12″×16″, American method	325	$9.50	$14.50	$10.65
Standard individual, 9″×12¾″, American method	255	8.25	13.50	9.45
4-tab square butt strip, 12½″×36″	266	8.25	10.40	9.00
3-tab square butt strip, 12″×36″ overlay	211	6.75	9.10	7.95
2-tab hexagonal strip, 11⅓″×36″	167	5.25	7.15	6.35
Individual recover—Duteh lap	125 to 140	5.25	6.90	5.85
Individual recover—hexagonal	125 to 140	5.25	6.80	5.90
Asphalt roll roofing:				
Mineral-surfaced	90	3.00	6.50	4.35
Smooth-surfaced	55	2.50	5.90	3.55
Cement-asbestos shingles (gray color only):				
American method		13.75	24.00	19.00
Hexagonal method		9.50	15.25	12.35
Dutch lap		10.80	16.75	13.00
Slate		14.00	40.00	21.00
Wood shingles		6.00	15.00	9.15
Metal roofings:				
Shingles (galvanized)		7.50	12.50	9.05
Five V-crimp sheets (galvanized)		6.00	7.15	6.40
Standing seam "tin" 25 lb., unpainted		8.25	14.00	11.70
Flat loek and soldered "tin", 25 lb., unpainted		9.25	15.00	12.80
Tile roofing:				
Ceramic shingle tile		14.40	30.00	20.20
Cement tile		14.00	22.50	16.75
Built-up roofing:				
Five-ply coal-tar-piteh, surfaeed with slag or gravel		6.75	12.00	9.55
Five-ply asphalt, surfaeed with slag or gravel		7.00	12.00	9.65

The *National Bureau of Standards* was established by act of Congress, approved March 3, 1901, continuing the duties of the old Office of Standard Weights and Measures of the United States Coast and Geodetic Survey. In addition, new scientific functions were assigned to the new Bureau. Originally under the Treasury Department, the Bureau was transferred in 1903 to the Department of Commerce and Labor (now the United States Department of Commerce). It is charged with the development, construction, custody, and maintenance of reference and working standards, and their intercomparison, improvement, and application in science, engineering, industry, and commerce.

SUBJECTS OF BUREAU ACTIVITIES

Electricity
- Resistance Measurements
- Inductance and Capacitance
- Electrical Instruments
- Magnetic Measurements
- Photometry
- Radio
- Underground Corrosion
- Electrochemistry
- Telephone Standards

Weights and Measures
- Length
- Mass
- Time
- Capacity and Density
- Gas Measuring Instruments
- Thermal Expansivity, Dental Materials, and Identification
- Weights and Measures Laws and Administration
- Large Capacity Scale Testing
- Limit Gages

Heat and Power
- Thermometry
- Pyrometry
- Heat Measurements
- Heat Transfer
- Cryogenics
- Fire Resistance
- Automotive Power Plants
- Lubrication and Liquid Fuels

Optics
- Spectroscopy
- Polarimetry
- Colorimetry and Spectrophotometry
- Optical Instruments
- Radiometry
- Atomic Physics, Radium, and X-Rays
- Photographic Technology
- Interferometry

Chemistry
- Paints, Varnishes, and Bituminous Materials
- Detergents, Cements, Corrosion, Etc.

Chemistry—Continued
- Organic Chemistry
- Metal and Ore Analysis, and Standard Samples
- Reagents and Platinum Metals
- Electrochemistry (Plating)
- Gas Chemistry
- Physical Chemistry
- Thermochemistry and Constitution of Petroleum

Mechanics and Sound
- Engineering Instruments and Mechanical Appliances
- Sound
- Aeronautic Instruments
- Aerodynamics
- Engineering Mechanics
- Hydraulics

Organic and Fibrous Materials
- Rubber
- Textiles
- Paper
- Leather
- Testing and Specifications
- Fiber Structure
- Organic Plastics

Metallurgy
- Optical Metallurgy
- Thermal Metallurgy
- Mechanical Metallurgy
- Chemical Metallurgy
- Experimental Foundry

Clay and Silicate Products
- Whiteware
- Glass
- Refractories
- Enameled Metals
- Heavy Clay Products
- Cement and Concreting Materials
- Masonry Construction
- Lime and Gypsum
- Stone

Simplified Practice
- Wood, Textiles, and Paper
- Metal Products and Construction Materials

Simplified Practice—Continued
- Containers and Miscellaneous Products
- Materials-Handling Equipment and Ceramics

Trade Standards
- Wood, Wood Products, Paper, Leather, and Rubber
- Metal Products
- Textiles
- Apparel
- Petroleum, Chemical, and Miscellaneous Products

Codes and Specifications
- Safety Codes
- Building Codes
- Building Practice and Specifications
- Producer Contacts and Certification
- Consumer Contacts and Labeling

Office
- Finance
- Personnel
- Purchase and Stores
- Property and Transportation
- Mail and Files
- Library
- Information

Shops
- Instrument
- Woodworking
- Glassblowing
- Construction Stores and Tool Room

Operation of Plant
- Power Plant
- Electrical
- Piping
- Grounds
- Construction
- Guard
- Janitorial