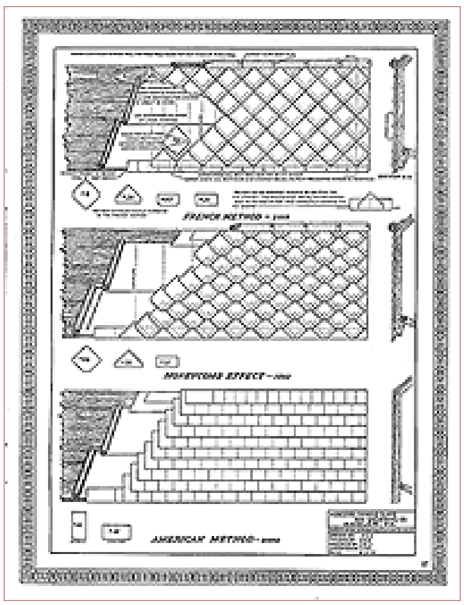
ROOFING FOR HISTORIC BUILDINGS

Asbestos-Cement Shingles

The Asbestos Shingle, Slate, and Sheathing Company touted the advantages of their shingles with depictions of successful installations in their 1927 promotional catalog and price list. (**The Catalog of Johns-Manville Building Materials, Home Owners' Catalogue, A Guide to the Selection of Building Materials Equipment and Furnishings**, F. W. Dodge Corporation, 1936. Courtesy of The Sweet's Group-The McGraw-Hill Companies, Inc.)

In the United States, mechanized production of asbestos-cement shingles began in the first decades of the 20th century, following Austrian Ludwig Hatschek's invention of a process in 1900 to manufacture rolled and pressed asbestos-cement sheets. Hatschek's patent, reissued in United Stated in 1907, led to a rapid proliferation of the new shingles. One early American manufacturer, Eternit, took their company name from the title Hatschek had given his process.

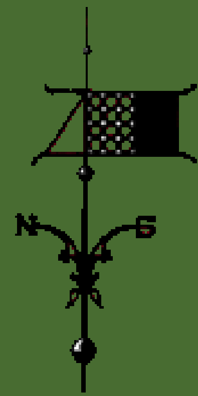
Made from asbestos, an inorganic, fibrous mineral, and Portland or hydraulic cement, asbestos shingles were lightweight, economical, and fireproof. Manufacturers promoted their shingles as substitutes for traditional roofing materials such as slate, wood, and clay.



Manufacturers of asbestos-cement shingles and other asbestos building products appealed to architects and builders directly with extensive advertising campaigns. These drawings accompanied Architects's Specification included in a publication of the Asbestos Shingle, Slate & Sheathing Company. [click image for larger view]

The Asbestos Shingle, Slate and Sheathing Company proclaimed in 1910: " ...these Asbestos Singles or Slates are so immeasurably superior in point of practical merit to that of any natural slating that nothing remains to be said."

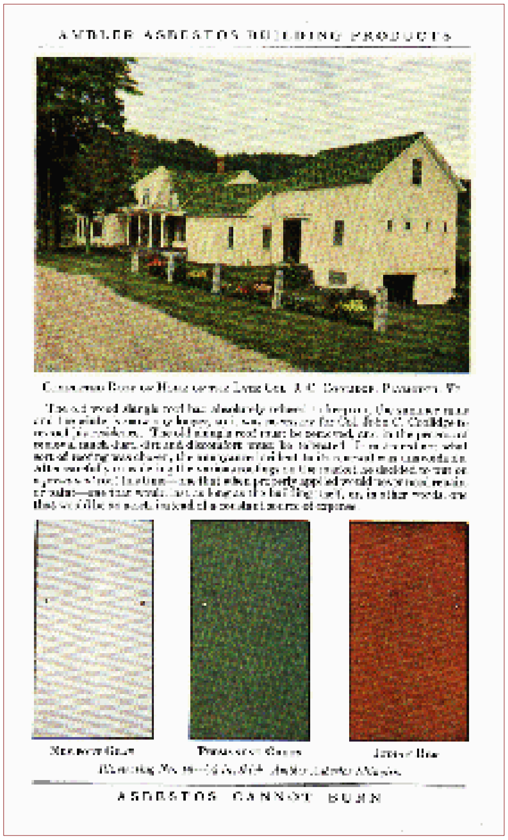
A variety of shingle colors could be created by adding pigments to the wet mix before pressing or by rolling pigments onto the surfaces of shingles. Colors imitating slates, including Indian Red and Newport Gray, were common, but many other colors were available. Manufacturers assured potential customers that their shingles were colorfast. Unfortunately, many early asbestos-cement shingles faded over time, causing Columbia professor H. Vandervoort Walsh to exclaim in 1922: "For this reason we see on every hand red asbestos-shingle roofs which have bleached to sickly and thirsty pinks."



Concrete Roofing Tile

Not all cementitious roofing products were asbestos-based. Concrete roofing tiles, which date from the 1840s, were produced in Germany by Adolph Kroher, a manufacturer of cement and concrete products, who developed a machine and process for pressing concrete tiles that resembled shingles. In the United States, as the concrete industry developed in the first decade of the 20th century, cast-in-place concrete roofing systems - and systems assembled with concrete slabs - evolved. The American Cement Tile Manufacturing Company, for instance, advertised "Cementile," a large (2 feet by 5 feet by 1 1/2 inches) steel-reinforced cement tile roofing, or slab, in the 1929 issue of **Sweet's Architectural Catalogue**. "Cementile" was offered as a flat sheet for sheathing or as an interlocking tile for a finished, watertight roof covering. Such roofing products found principal application for industrial buildings. Smaller concrete roofing tiles were available in the United States from companies such as Hawthorne in Chicago by the late1920s. Hawthorne's roofing tiles, available in no fewer than fourteen colors, simulated Spanish and French Clay tiles. Unlike asbestos-cement shingles, which were nailed in place, concrete tiles were interlocking and laid on hanger strips. Hip and ridge tiles were nailed in position and holes were then pointed with matching mortar.

The hydraulic pressing process enabled the shingles to be given a texture, such as a rough rustic surface or one imitating weathered wood. The many styles and sizes of asbestos-cement shingles available, made possible roofs laid in various methods including American, Dutch Lap, and French (known in several variants as hexagonal, honeycomb or diamond). The French method was particularly popular for asbestos roofing, capitalizing on the economy of the material itself by laying it in an efficient manner requiring minimal overlap. Installation of asbestos shingles was similar to slate. Shingles could be punched, filed, or trimmed to size in the field by roofing contractors. Companies such as behemoth Johns-Manville and The Asbestos Shingle, Slate, and Sheathing in Ambler in Pennsylvania promoted asbestos shingles not only for new construction but also for roofing over existing roofs.



Johns-Manville promoted the direct application of their asbestos-cement shingles over worn roofing in this 1936 catalog. The Dutch Lap roof being applied here was easy to install and utilized a metal "clincher" to anchor exposed corners. (**Home Owners' Catalogue, A Guide to the Selection of Building Materials Equipment and Furnishings**, F. W. Dodge Corporation, 1936. Courtesy of The Sweet's Group-The McGraw-Hill Companies, Inc.) [click image for larger view]

In addition to shingles, corrugated asbestos-cement sheathing, sometimes called asbestos building lumber, was produced by many manufacturers as a substitute for corrugated iron roofing. Used principally for industrial applications, corrugated asbestos could be laid directly on steel roof purlins. Industrial buildings in particular benefited from the fireproofing qualities of asbestos-cement.

Both asbestos-cement shingles--and siding--were produced into the 1980s, testimony to their popularity and affordability. The countless buildings with this roofing material also attest to the durability of the product.

Chicago-based Hawthorne Roofing Tile Company originally manufactured its tile from slabs by a hand-process. These concrete roofing tiles depicted in the 1929 **Sweet's Architectural Catalog** imitated French and Spanish clay tiles. They were produced with automated power-driven equipment, and the colors were impregnated on the tile surface. (**Sweet's Architectural Catalogue, 1939. Courtesy of the Sweet's Group**, McGraw Hill Companies, Inc.) [click image for larger view]

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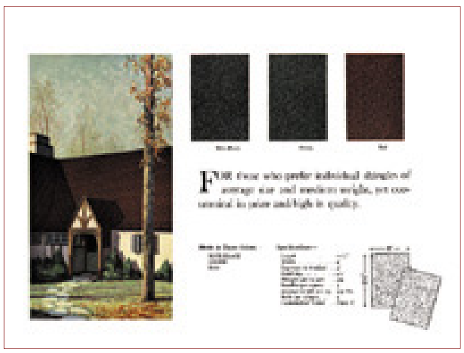
Asphalt Shingles

Asphalt shingles have three major components: asphalt, felts and colored mineral or ceramic granules. Asphalt is a byproduct of petroleum distillation and also occurs in natural deposits. This dense mixture of hydrocarbons provides the waterproofing for the shingle. The felt fibers reinforce and stabilize the asphalt, while the granule aggregates protect the assembly from sun, wind, rain and minor foot traffic.

The Barber Asphalt Co. featured their use of natural asphalt mined from Trinadad Lake in the promotion of their shingles. [click image for larger view]

The roots of asphalt shingles can be found in composition roofing that developed in the United States in the mid-19th century. In the last quarter of the 19th century the site-layered components of built up roofing were adapted to produce a factory assembled product of long strips. Packaged in rolls this material, once called "ready roofing," is now commonly known as "roll roofing." Though naturally occurring asphalt was used early as a waterproof coating, most built-up roofing systems relied on the more abundant coal tar. Asphalt, however, could be processed to be more solid than coal tar, and this solidity was necessary to facilitate the transition from a site fabricated system to a preassembled product. Despite the abundant and affordable asphalt from a growing petroleum industry, the use of natural asphalt was a point of product promotion at least as late as 1930.

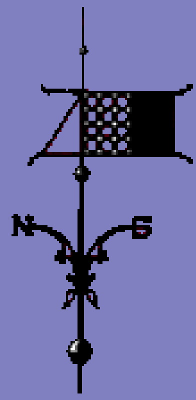


Slate used for the surface aggregate determined the colors of early shingles. [click image for larger view]

The first asphalt shingles were produced in1903 by a roofing contractor and manufacturer of prepared asphalt roofing. Herbert M. Reynolds of Grand Rapids, Michigan, hand cut rolls of "stone surfaced" roll roofing into individual shingles. Early shingles were typically rectangular or hexagonal. The colors, usually red, green or black, were limited by the natural materials used for the granular surface.

The popularity of this product led to the proliferation of shapes and sizes and attachment systems, some of which were patented. The multi-tab strip shingle was a significant development that quickly emerged. It offered the traditional effect of a small shingle with lower installation costs. By 1906 Bird and Son was marketing a notched shingle that had the appearance of two shingles when installed.

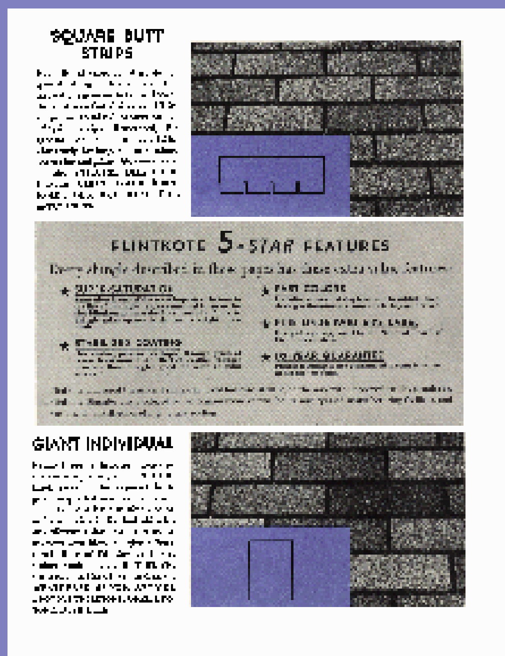
Numerous factors contributed to the increased use of asphalt shingles in the 20th century. Made of non-strategic materials and easier to transport than wood or slate, they met the constraints imposed during World War I. More flame resistant than wood, they were promoted in response to a 1916 publication of the National Board of Fire Underwriters urging the



Shapes

Shapes manufactured by the Flintkote Company during the 1940s.

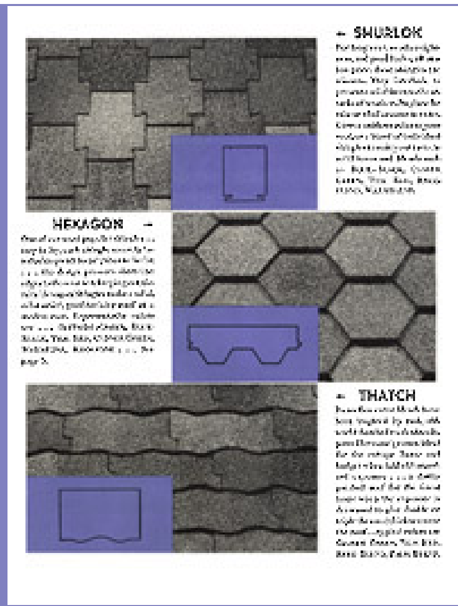
[click images for larger views]

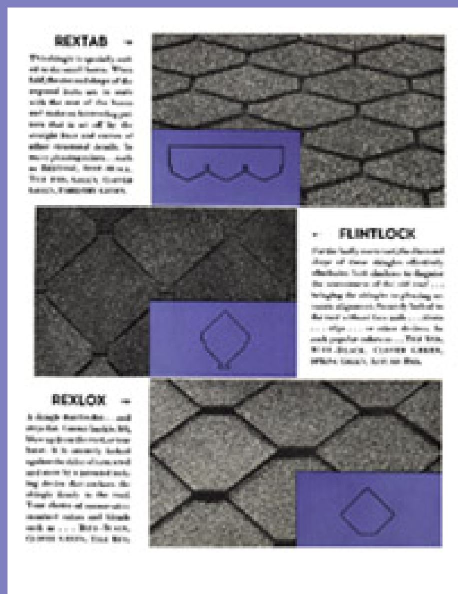


Sears, Roebuck and Co. promoted the quality of asphalt shingles used on many of the homes in their **1926 Catalogue of Houses**. (Courtesy of The Anthenaeum of Philadelphia and Dover Publications, Inc. New York.) [click image for larger view]

elimination of wood shingles as a fire hazard. Additionally, asphalt shingles gained a cost advantage over other materials. As improvements in manufacturing processes made asphalt shingles cheaper, increased labor costs made installation of traditional materials more expensive.

The variety of shingle shapes and sizes peaked by 1930, and by 1935 all major manufacturers were offering a 12 by 36 inch multiple tab shingle that is the standard today. At the same time the introduction of ceramic granules allowed a wider range of color choices that were often mixed to produce a blended shingle. The most significant recent change in the product itself is the replacement of organic felts with fiberglass mats resulting in a stronger, more durable shingle.





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ROOFING FOR HISTORIC BUILDINGS

Clay Tile

The origins of clay tile can be found in both China and the Near East, with surviving artifacts of roofing tile dating to 2,500 BC. From these locations, it spread throughout Asia and Europe. European settlers brought this tradition to the New World, and the earliest settlements like those on Roanoke Island in North Carolina, Jamestown in Virginia, and St. Marys in Maryland have yielded specimens of roof tiles from archeological investigations. Tile was also used very early by the Spanish and French in the South and West.

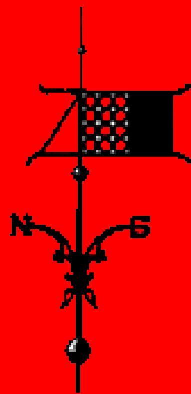
The tile roof on Stadt Huys (City Hall), New Amsterdam may have been imported, but by the time of its construction in 1641-42 tile was probably available from a tile yard up the Hudson in Rensselaerwyk. (Image courtesy of the Museum of the City of New York)

Both time and place are important determinants in the history of tile roofing in America. Tiles were first imported, but by 1650 they were being produced in the upper Hudson River Valley, and several factories were in operation at the time of the American Revolution. Fire was probably the single most important factor in popularizing tile for roofing in this country. Devastating urban fires in the 17th century prompted regulations that encouraged the use of tile as a fireproof roofing. The use of tile roofing began to decline during the first quarter of the 19th century as new fire resistant materials became available and tile roofs were viewed as clumsy and unattractive. However, by the middle of the 19th century, the popularity of revival styles, particularly Italianate, Gothic, and Romanesque, created new interest in tile roofs.

The development of architectural terra cotta as a significant building material, the mechanization of tile production and the growth of rail transport aided a gradual resurgence of tile roofing. It was during the first few decades of the 20th century that the revival styles, drawn from the Mediterranean and the American Southwest, gave tile its broadest use. Today tile can most commonly be found in the Southwest and coastal South where its suits both the popular architectural images and regional climates.

The barrel tile roof on Vizcaya contributes to the image of an Italian Renaissance palace so grandly realized in this Miami, Florida mansion completed in 1916.

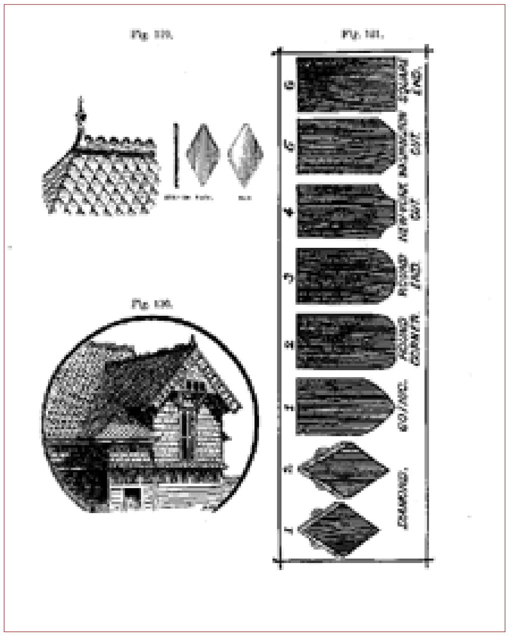
Tiles are distinguished by their shape and the way they overlap. The simplest are flat tile laid like shingles with staggered joints and less than half their surface exposed to weather. A tile system made up of alternating convex and concave or flat surfaces, generally referred to as pantile, may be formed by separate tiles (Barrel, Mission, Greek, Roman) or a single S-shaped tile (Spanish). These are laid with less overlap of each course than a shingle tile but include a side to side overlap. Interlocking tiles have mated ridges and grooves at their edges, thereby reducing the amount of overlap needed to achieve a weathertight surface. Reducing the lap decreases overall weight of the roof and the need for heavier framing. The interlocking feature was only practical with the precision brought by late 19th century



Manufacturing

Roofing tile begins as raw clay that is processed by drying, pulverizing, mixing with water and kneading. It is then shaped into tiles, dried and fired. In the latter half of the 19th century mechanization was introduced incrementally to what was largely a manual operation. Even as steam power was applied to the rollers that pulverized the clay and the pug mill that mixed and kneaded it, clay continued to be pressed into molds by hand. In the 1870s machines were developed that delivered and mechanically pressed slices of clay into a mold. The installation of such presses at the Celadon plant in Alfred, New York, reportedly increased daily production tenfold. Other advances allowed shapes such as a shingle or barrel tile to be cut directly from extrusions, a process commonly used today.

The kilns depicted in this drawing from an 1876 atlas have been loaded with tile and the open ends walled up with bricks. Fires for such kilns were lighted and kept slowly burning for the first five hours, and then progressively increased for the next thirty-three hours. Toward the end of the firing, the mouths of the kiln were stopped with ashes to prevent the flow of air from cooling the oven too quickly. A typical kiln consumed approximately four tons of coal per firing to produce hard fired tiles. (click image for larger view)



Outside of the Southwest, these tiles depicted in an 1884 publication are typical of what were in common use at that time. The diamond is an interlocking tile while the others are simply shingle tiles with shaped butts. [click image for larger view]

advances in manufacturing. It became common for most flat tiles as well as surface grooved French tiles and is also a feature of some pantiles.

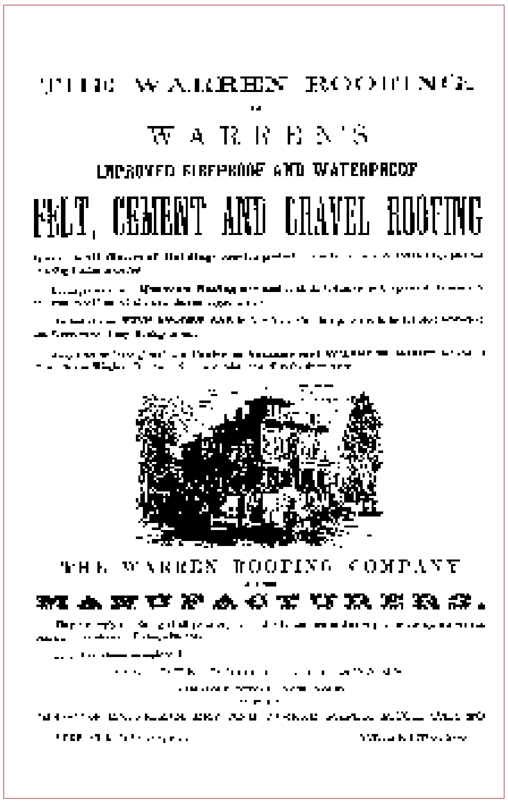
Most clay tiles are nailed or wired to sheathing or battens, but lugs on the back of some tiles allow the weight of the tile itself to hold it in place on low slope roofs. Mortar is sometimes added, particularly on pantiles, to hold tile in place and make the system more watertight and wind resistant. The barrel tiles of the southwest were historically laid in a full bed of mud mortar without additional fasteners. Tile as a material often outlasts its attachments, if not the building itself, a point made in an 1884 treatise, Bricks, Tile, Terra Cotta, Etc.: "After doing service on one structure it can be taken off and used on other buildings."

ROOFING FOR HISTORIC BUILDINGS

Composition

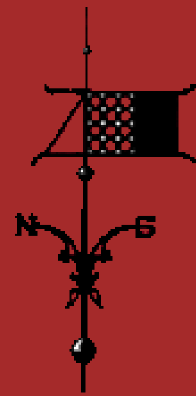
Composition or built-up roofing is a multi-ply system of fabric or paper, a viscous waterproofing substance, and a mineral aggregate. Historically, various materials have been used for each of these components. Paper, pasteboard, canvas, burlap, and felt have all served as the base membrane. These materials were often dipped in the waterproofing coating before being applied to the roof. The availability of felt in rolls facilitated the mechanization of this saturation process, and felt became the standard base. Pine tar, natural asphalt, coal tar and asphalt were the major materials to be effective as the waterproofing that saturated the base sheets and adhered the layers. Sand, gravel or slag provided the top surface. Though there is no evidence of their success, numerous other materials were tried as components, many as part of patented formulas: woven strips of paper or twine, sawdust, china clay, plaster of Paris, cattle hair, gum shellac, boiled linseed oil, boiled fish oil, and blood.

Pine tar and gravel were combined for roofing both in Europe and the United States in the 1870s. In 1800 pine tar was applied to canvas at the Octagon House in Washington, D. C., where it provided the roof covering for seventeen years. Evidence of similar systems used elsewhere in the early 19th century is very limited. In the 1840s a method learned from a roofer in Newark became the basis for a roofing business begun in Cincinnati by Samuel M. and Cyrus M. Warren. They met with success, as did others in the northeast, applying roofs of heavy paper, covered with pine tar and sprinkled with sand. The significance of the Warrens was the innovation they brought to the system. From experiments begun in 1847, they successfully replaced increasingly costly pine pitch with coal tar, a by-product of manufacturing illuminating gas from coal. Their continued development of the product and expansion to other cities assured the Warrens' status as leaders in the industry. They were the first in the 1850s to distill coal tar, producing a superior refined tar. Later they found that natural asphalt from Pitch Lake in Trinidad could produce an easy-to-mix roofing pitch when combined with petroleum tar, a by-product of oil refining.



This advertisement offering both roofing materials and installation appeared in the late 1860s. It touted the many advanatages of a composition roof. [click image for larger view]

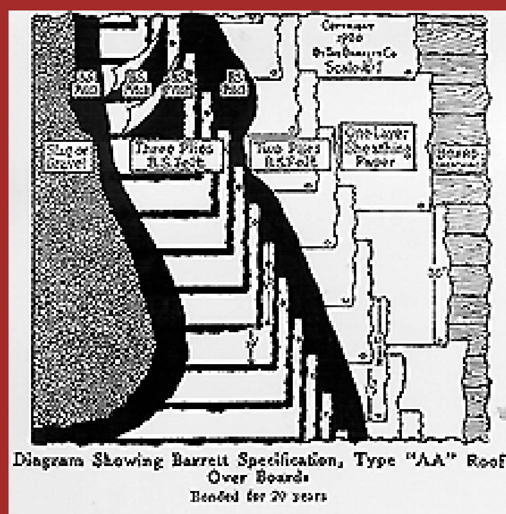
The potential of composite roofing was apparent to many, and the number of related patent applications exploded in the 1860s and 1870s. The developments in composition roofing were well timed to meet the mid-19th century increase in the use of flat and low-sloped roofs. The only alternative



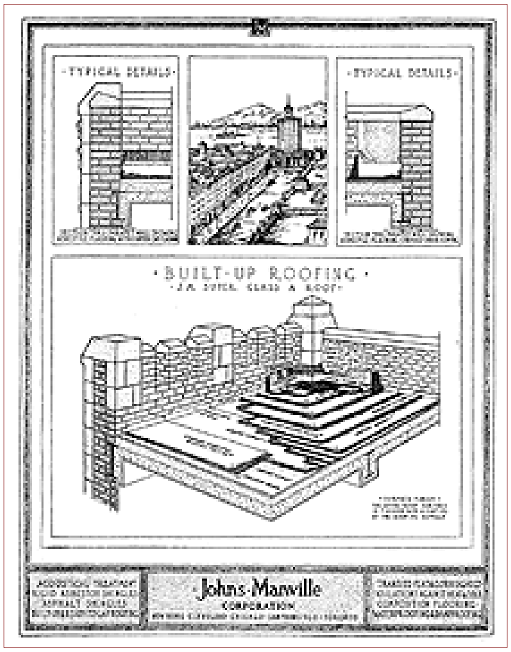
Standards

As the materials and technology of composition roofing evolved, the number of manufacturers and installers proliferated. There was little done in the 19th century to assure the quality delivered by either. Making matters worse, many companies asserted that their products could be applied by anyone. As a result, many roofs performed poorly. Because composition roofing was a multi-component system of varied materials and methods, successful performance was hard to predict.

Samual Barrett, a Chicago roofing product manufacturer, made the first significant effort to set standards for the industry. "Barrett Specifications" were compiled in 1906, providing minimal guidelines for the materials and application of a gravel or slag roof. His generic



(**Sweet's Architectural Catalogue**, 1929. Courtesy of The Sweet's Group, The McGraw-Hill Companies, Inc.) [click image for larger view] for such roofs at that time was metal, which depended on the performance of the many fabricated seams that joined the small sheets. The relative merits of metal and composition roofing were constantly debated. Henry Hudson Holly writes in 1878: "Metals are the best covering for roofs that are inclined to be flat...composition - such as tar or other materials - we would not advise on good work, as its only merit is its cheapness." Ignition and spread of fire were important issues in the debate. A 1911 test by Underwriters Laboratories rated the fire retardant qualities of "good slag and gravel roofs" in a class with inferior roofing materials. Nevertheless, in 1912 the National Board of Fire Underwriters considered approved composition roofs together with metal, slate and tile the best for fireproof construction. The issue seems to have been settled in1916 when composition roofs met the requirements of both fireproof and fire retarding classes of the Board's rating system.



The specification for this built-up roof being advertised in 1929 called for it to be: "Applied only by the manufacturer or by approved roofing contractors." The materials consisted of asphalt-impregnated asbestos-based roofing felt and asphalt-based roofing cement. "No slag or gravel is ever used or needed on a Johns-Manville Roof." [click image for larger view]

Built-up roofing came to dominate the commercial roofing market and remains in use today.

specifications were later made specific to a system of Barrett products, the whole of which he backed up with a bond. Other manufacturers followed his lead promoting their products with brand-specific specifications. In 1916 Barrett tightened his quality control by offering the guaranty bond only on roofs applied by contractors whom he approved. Other companies went further and only bonded installations that their own inspectors oversaw. By the1920's, detailed, lengthy texts of brand specific specifications filled manufacturers' product information. Manufacturers' specifications and approved contractors continue to be a part of the commercial roofing industry.

ROOFING FOR HISTORIC BUILDINGS

Metals

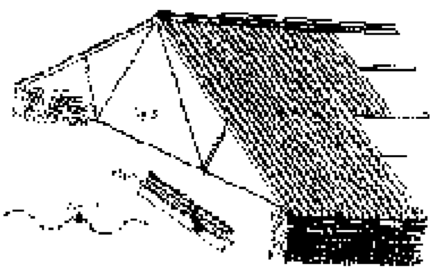
Metals are useful both as the roof surface itself, and as important components such as flashings, valleys and gutters on roofs of other materials. The malleability of metal allows it to be formed and joined making it useful for weatherproofing the junctures and angles on roofs. These same properties also make it suitable for roofing curved and irregular surfaces and for roofing where the pitch is too low for simple overlapping material to provide waterproofing.

This advertisement from an 1888 publication of house designs, **Homes of Today**, offered stamped shingles in four materials. [click image for larger view]

As with other roofing materials, the earliest uses of metals for American roofing employed imported products. Lead, copper and tin plate most often came from Great Britain, while the first zinc came from Belgium. As mines and mills opened in the United States, domestic production replaced imports. In the case of tin, the success of domestic production depended on the advantage of a tariff on imported tinplate imposed by the McKinley Bill of 1890.

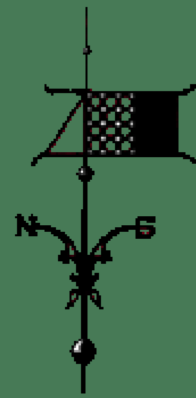
Several factors contributed to the popularity of metal roofing throughout much of the 19th and early 20th centuries-it was lighter than slate or tile, it offered more fire protection than wood, and most metals were less expensive than slate or tile.

Metals are applied to roofs as shingles and as pre-formed and site-formed sheets. The first metal shingles were small flat rectangles; surviving examples from 1819 at the University of Virginia in Charlottesville were interlocked at the sides with folded edges and simply lapped at top and bottom. Not until the 1870s was mass production applied to metal shingles. Stamping sheets of metal was an innovation that added rigidity to a thin material and facilitated interlocking edges, reducing needed lap and preventing wind lift. Patterns were frequently patented and were produced in iron, tinplate, galvanized steel or copper.



The corrugated sheets of "Patent Galvanized Iron" produced by Marshall Lefferts & Brother are shown in their 1854 catalog, where it is pointed out that the supporting framing may be one-fourth as heavy as would be required for slate. [click image for larger view]

Sheets of iron were first pre-formed by corrugation in England in 1828. American manufacturers were producing corrugated roofing from both plain and galvanized iron by mid-19th century. Corrugation added stiffness, making the material self-supporting over longer spans and eliminating the need for sheathing or closely-spaced framing. Thus, corrugated

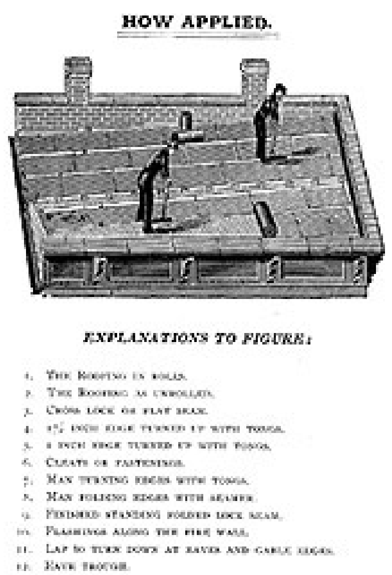


Aluminum

The small amount of aluminum manufactured before the turn of the century limited its application as a building material. Its early use in 1890 on the roof of Philadelphia's City Hall combined it with copper, and it quickly failed. By the 1920s the material was better understood, and Alcoa was marketing both rolled aluminum sheets and an interlocking shingle for roofing in natural and painted finishes. Difficult to solder, aluminum roofing relied on mechanical joints and pitch to shed water.

Copper

The New York City Hall (1764) was a notable early use of copper for roofing. Though copper roofs were installed on many important buildings in the early 1800s, it was infrequently used until the latter 19th century, when the Lake Superior mines opened in Michigan's Upper Peninsula. Even then copper was more often used for flashings, gutters and downspouts than for roofing. Copper has always been an expensive choice for roofing, but it is easily worked, does not need a coating and weathers attractively. These factors all contribute to copper's use most often and to greatest advantage on the ornamental roofs of major public buildings.



This illustration from the 1893 catalog of a Philadelphia manufacturer describes the application of a roof made from their iron or steel that had been seamed into rolls at the factory, from sheets measuring 26x104 iinches. The technique would have been the same for a roof of tinplate, terne plate or copper. [click image for larger view]

iron was well suited for inexpensive, quickly assembled buildings, making it a common material for the construction that accompanied the California Gold Rush. Later in the century, manufacturers offered flat sheets with edges pre-formed for standing seams or in a V shape as economical alternatives to onsite fabrication.

Unlike the simple lapped installation used for corrugated or V-edge sheets, most site-formed metal roofing utilizes various folded, interlocking joints to create a weatherproof covering. Metals that can be fused (lead) or soldered (tin, terne, zinc, copper) can have sealed joints, thus removing slope as a factor in the water-shedding performance of the assembly. Solder was usually applied to seal interlocked seams that had been folded flat. Flat seams joined small sheets of metal to cover curved shapes or very low-sloped roofs. They were also used to create long strips of a metal such as tinplate, which was only available as small sheets. When the long strips were laid parallel to the slope of a roof (minimum 2 in 12 slope), the long edges could be joined without solder if the joints were raised above the rest of the roof surface as a rib. Usually the adjacent edges were folded over each other creating a standing seam. Many metals were used for this common roof. Variations on the system formed the seam over battens or used separate cap pieces to join the bent edge flanges. Although requiring slightly more material, a standing seam better accommodates the expansion and contraction of metal than does a flat seam roof.

Copper was put to effective use on the roof of the 1913 Handley Library in Winchester, Virginia. (NPS photo) [click image for larger view]

metals continued. . .

Coated Ferrous Metals

Plating protected the base metal from rust and allowed the material to be soldered.

Iron

Both iron and steel without any plating were used for roofing. The Philadelphia home of the mill owner who rolled the first sheet iron in the United States was roofed in the material around 1794. Iron replaced slate on the White House in 1804. Because it was available in large sheets, rather than the small sheets used for plated material, it required fewer joints. Some manufacturers produced factory painted material, but late19th century accounts indicate that paint was an inadequate defense against the corrosive effects of the atmosphere in industrial regions.

Lead

The earliest use of lead for roofing in this country may have been at Rosewell, an 18th-century plantation house at Whitemarsh, Virginia. It was widely used before the American Revolution for flashings, downspouts and gutters on the best buildings. In the United States, lead never achieved the popularity it had in Europe. Installed on early Federal buildings in Washington, D.C., it failed to perform well. Expansion and contraction due to temperature changes produced fatigue, and on steep roofs the effect of gravity caused creep.In the 20th century lead found additional application as a coating for both steel and copper.

Zinc

Rolled sheet zinc appeared in the United States in 1816, as roofing in New York and as downspouts and gutters in Baltimore. Though more than seventy houses in New York had zinc roofs by 1837, it was out of favor by 1840. The popularity of the material was cyclical in the next decades, never matching iron and steel with their various coatings.

Tin and Terne

Tin-plated iron appeared as a roof covering in the United States at the beginning of the 19th century. Thomas Jefferson chose it for Monticello in 1800. Tin was often referred to as "bright tin" to distinguish it from the lead-tin mixture, terne (meaning "dull"in French). Because the plating process required that the base iron be dipped into molten tin, it could only be produced in small sheets. The sheets measured 10 by 14 inches in the 1830s, but by the 1870s, advances in manufacturing increased the size to 20 by 28 inches. Tin's availability and reasonable cost made it a very common roofing through much of the 19th century. It could be quite durable, but only if kept well painted.

Painting the verandah roof in stripes following the seams in the metal was a fashionable treatment before the Civil War. Manufacturers and technical manuals recommended painting the underside of the metal as well as applying two or three coats to the top. Paints of iron oxide in linseed oil and white lead paint were variously recommended. Since the iron oxide produced a red or brown color, the stripes depicted would have required a tinted white lead paint. (Courtesy of The Athenaeum of Philadelphia) [click image for larger view]

Terneplate was first produced in United States in New York in 1825. Joseph Truman

Galvanized

Iron or steel are galvanized by coating them with zinc. Rather than producing the simple coating created by tinplating, a rust resistant alloy of the two metals forms on the surface. In 1839, two years after galvanizing was patented in Europe, the material was used on the roof of the Merchants Exchange in Manhattan. Though the sheet iron was hand dipped in the zinc, much as it was in tin, larger sheets were used (24 by 72 inches in the 1850s). This meant fewer joints, and when used as corrugated sheets, less supporting framing. Even as the production of galvanized iron and steel roofing products increased, the price remained higher than that of other metals. The price differential did not shrink sufficiently for galvanized roofing to exceed tin and terneplate in popularity until the 20th century.

Enameled

Enameled steel as a building component came to this country by way of Germany at the end of the 19th century. Shingles of enameled steel were exhibited by a German industrialist at the 1893 World's Columbian Exposition. The first American production was in 1924 by the Columbian Enameling and Stamping Company, which roofed a house in Terra Haute, Indiana, with enameled shingles. Commercial markets developed by 1930, and enameled shingles became popular for use on service stations and chain restaurants. Except for the 2500 Lustron houses manufactured in the late 1940s, the material was rarely used in residential applications.

Downing describes the chevron patterned roof of his Design XXXI, "Villa in the Pointed Style," from **The Architecture of Country Houses** published in 1850: "The roof may be covered with zinc laid on a ribbed sheathing, without soldering so as to allow it to expand and contract without detriment."(Courtesy of The Athenaeum of Philadelphia) [click image for larger view]

of Philadelphia patented the lead coating of tinplate in 1831. Later production combined the lead and tin into a single coating. Called variously "leaded plate," "roofing tin", and "roofing plate," terne was cheaper than a pure tin coating, but its properties were very similar. Domestic production of terne was twice that of tin when it was chosen to roof the buildings of the 1893 World's Columbian Exposition. In the next few decades terne replaced tin completely in American production as steel replaced iron as the base metal.

Emphasizing its two trademark components this enameled shingle was described in the 1929 **Sweet's Architectural Catalogue**: "The base Armco ingot iron and the two coats of Pemco glass fused together at 1600 degrees F., produce a roofing tile extremely durable and of permanent beauty." (**Sweet's Architectural Catalogue**, 1929. Courtesy of The Sweet's Group, The McGraw-Hill Companies, Inc.) [click image for larger view]

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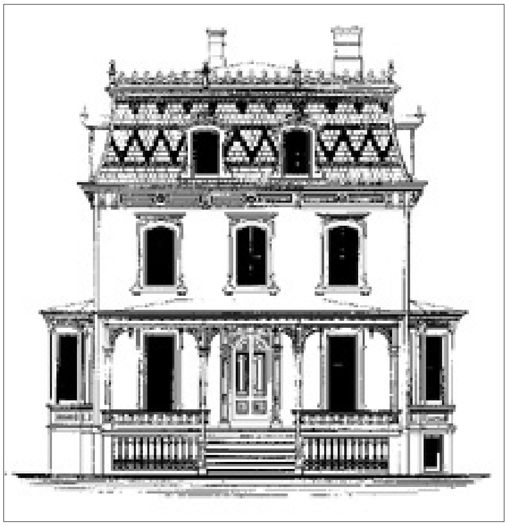
ROOFING FOR HISTORIC BUILDINGS

Slate

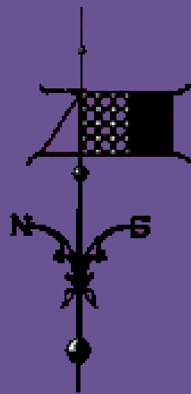
Slate is a fine grained crystalline rock metamorphosed from bedded deposits of clay and silt. It can be worked into shingles readily because it has two lines of breakability: cleavage and grain. These occur generally at right angles to each other and are independent of the original bedding planes. The structure of the bedding remains in some slate deposits as visible bands running across the cleavage. Known as ribbons, these bands may be either weaker or harder than the surrounding slate. Slate's durability as roofing is due to its high strength, low porosity and low absorption rate. Specific mineral components are responsible for the various colors: carbon (black), hematite (red and purple), chlorite and ferrous iron oxide (green). Other minerals, considered impurities (calcite and iron sulfides), are slowly transformed by weathering into gypsum, which expands and causes the slate to delaminate.



Front elevation of a dwelling published in **Supplement to Bicknell's Village Builder**. A specification for one of the designs included this direction for the French roof: "Slate the sides of the roof with slate 5 x 12 inches, cornered as shown on elevation, nailed with galvanized nails; all hips and valleys to be flashed with tin in the best manner." (Courtesy of The Athenaeum of Philadelphia)

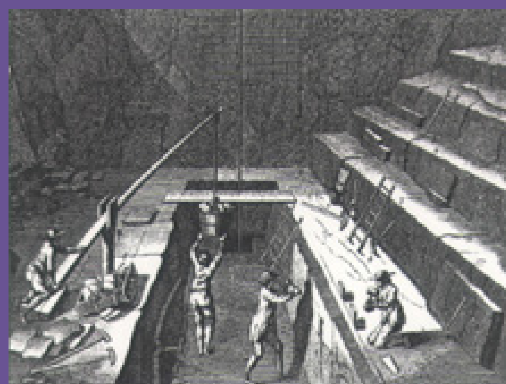
Slate has been used as a roofing material in Europe for hundreds of years, with surviving examples dating to the 8th century. From the 17th to the 19th centuries, most of the roofing slate used in America was imported from North Wales, where slate quarrying was a major industry. Although the first commercial slate quarry in the United States was opened in 1785 in Peach Bottom, Pennsylvania, the industry was limited and local until the second half of the 19th century. At that time the industry grew and matured in response to a growing population, advancements in quarrying technology, an expanding rail system, and the immigration of Welsh slate workers to America.

The United States became a slate exporter after the Civil War, as quarries opened in Vermont, New York, Virginia, and Pennsylvania. Architectural styles of this period emphasized prominent roof lines and decorative patterns, details that were well suited to the varied



Quarrying

Until the 1870s the quarrying of slate changed little from what is illustrated by Diderot in the **Pictorial Encyclopedia of Science Art and Technology** of 1762. Blocks were separated from the floor of the quarry using picks, wedges, prybars and gunpowder, taking maximum advantage of the natural seams in the rock. Windlasses and simple cranes employed man or horse power to lift blocks of slate from the pit. With the Industrial Revolution came mechanical drills and steam-powered stone channeling machines and hoists. Waste associated with blasting was reduced and efficiency increased. Subsequent advances were marked by the introduction of the wire saw in 1926 and the diamond belt saw in 1988.



Mineralogie, Ardoises D'Anjou. Travail de la Carrierre Ouverte et Outils. **Revuell de Planches, sue Les Sciences, Les Arts Liberaux, et Les Arts Mechaniques, Avec Explication**, Diderot-D'Alembert. (Courtesy of NewsBank, Inc.) [click image for larger view]

The Vendor Slate Co. had ten quarries in Pennsylvania, Vermont and New York in 1929. (**Sweet's Architectural Catalogue**, 1929. Courtesy of The Sweet's Group, The McGraw-Hill Companies, Inc.) [click image for larger view]

colors and shapes available in slate. Properties such as nonflammability, durability, minimal maintenance costs, and aesthetic value made slate all the more desirable. Its primary drawback was its weight, making shipping costly and requiring substantial roof framing.

Between 1897 and 1914 production peaked. Later use of slate often employed different thicknesses and colors, and unevenly cut or aligned butts to produce picturesque effects suitable for English revival styles popular in the early 20th century. After 1915 widespread use of slate roofing declined in the United States, due in part to a lack of skilled labor, but more importantly, due to the development of modern, mass produced materials such as asphalt shingles, which seemed the more economical alternative.

A slate is typically attached to wooden sheathing with two nails driven through prepunched holes, though as with tile, it may be wired or screwed to steel angles on a steel framed roof. At the end of the19th century asphalt saturated felt laid over the wood sheathing became a standard part of most slate roof installations. Slate is installed with an overlap that depends on the slope of the roof and requires a minimum pitch (generally 4 inches of rise per 12 inches of run) to effectively shed water. Particularly in coastal areas slate can be found laid in mortar, providing extra protection against wind driven rain.

"Not all that glitters is gold. Not all that looks like slate is good slate." claims the Bangor Slate Co. of Easton, Pennsylvania. They issued this certificate in 1906 emphasizing the source of slate as an indication of quality. [click image for larger view]

Today slate continues to be quarried domestically as well as being imported from Europe, China and South America.

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ROOFING FOR HISTORIC BUILDINGS

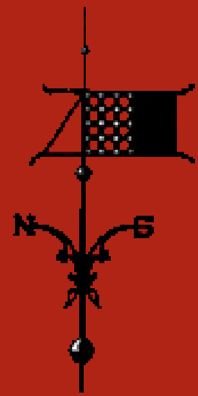
Wood Shingles

Wood roofing shingles were commonplace in early America not only because of the abundance of timber, but also because of the relative ease with which they could be fabricated and installed. Made from the heartwood of a variety of locally available trees, early shingles were hand split with a mallet and froe and then dressed or smoothed with a draw knife to ensure they would lay flat on the roof. The introduction of water and, then, steam powered saws in the early 19th century revolutionized the shingle industry by making possible the mass production of uniformly cut and smoothly finished shingles that required no hand dressing. As early as 1802, for example, N. Combes of Lamberton, New Jersey, informed the public that he now had a shingle dressing machine that had been newly invented by 'D[avid] French of Connecticut. This machine at one stroke shaves the Shingle complete; at the second stroke it joints the same, and this done much more complete than it is possible to have it done by hand, in the usual way (**The True American**, Trenton, December 6, 1802). The number of inventions for new types of shingle machines, as well as refinements to existing ones, quickly multiplied as the century advanced; at least nineteen patents were issued in 1857 alone for shingle making machines.

"The drawing was taken in a swamp which has been worked, for its buried logs, for the fifty years past; and the scattering trees which are seen are only such as have escaped the workman's axe. The levers, spade, and other tools of the shingler are seen, and he is in the act of cutting up the floated log. Several bolts, or blocks in form for splitting into shingles, are lying on the ground in front of him. In the background, a man is seen shaving the shingles. The workmen go over the same ground again and again, and find new logs each time." (From George H. Cook, **Geology of the County of Cape May**, State of New Jersey [Trenton: Printed at the Office of the True American, 1857], 78). [click image for larger view]

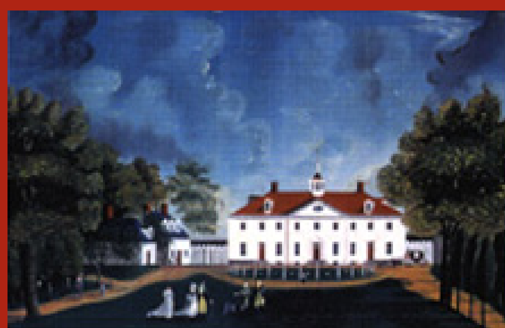
Despite such technological advances, hand split shingles never entirely disappeared. In fact, during most of the 19th century a thriving split shingle industry existed in southern New Jersey. Interestingly, much of the wood used in these shingles came from white cedar logs that had been buried in swamps and then "mined" or raised by shinglers who probed the area for suitable logs. Reportedly a good shingler could tell merely by smell whether a log had been blown down or broken off, the former being the more desirable since it was less likely to be decayed. Once loosened from the peat, the log floated in the water, where it was sawn into blocks and then split into shingles. An expert worker could mine and shave up to 1,000 shingles a week. Besides supplying local markets, South Jersey's mined shingles were shipped to cities and towns up and down the Delaware River, including Philadelphia.

Although wood shingles received strong competition from other roofing materials in the 19th century, they enjoyed renewed popularity in the late 19th and early 20th centuries with the introduction of the various revival styles of architecture. Wooden shingles were steamed and bent to resemble thatched roofs on Tudor Revival homes, laid in evenly spaced overlapping



Coatings

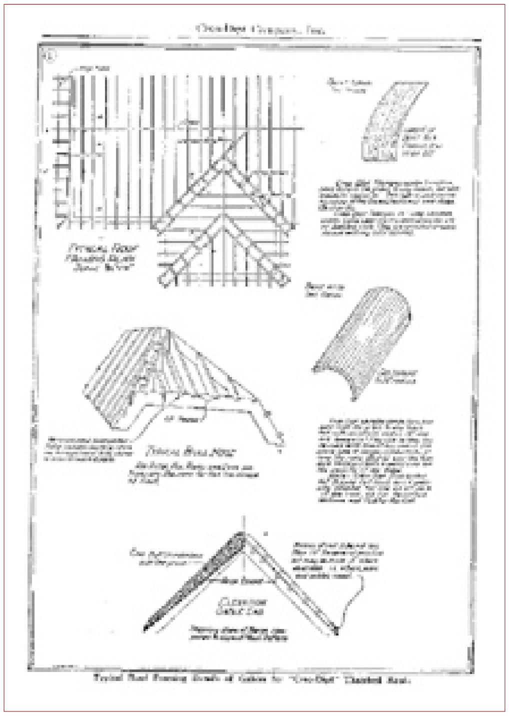
To enhance their durability, wood roofing shingles were sometimes given a protective coating. Pine tar, boiled linseed oil, and boiled fish oil (probably whale oil) were all used, often in combination with various pigments for color. The roofs of many famous buildings, including Mount Vernon,the Governor's Palace in Williamsburg, and Independence Hall, Congress Hall, and Carpenters' Hall in Philadelphia were all painted historically. Red and the red-brown shade known as "Spanish brown" were especially popular colors in the 18th and early 19th century. During the Victorian period,



A view of Mount Vernon, c.1792; oil on canvas. Courtesy of the National Gallery of Art, Washington, DC; Gift of Edgar William and Bernice Chrysler Garbish. [click image for larger view]

many painting manuals recommended painting or staining roofs in dark colors. Sherwin Williams, for example, in its 1885 book House Painting commented that a roof should not be painted a light color, but some dark color that will strongly contrast with the paint on the main part of the building." In the early 20th century, many manufacturers began coating their shingles with creosote oil, tinted in shades of brown, green, red, and gray. Shingles of one color could be laid on a roof to produce a uniform appearance or, horizontal rows on Colonial Revival houses, and used with abandon on the roofs and sides of Shingle Style buildings. Today, although wood shingles represent a relatively small percentage of the roofing market, they remain a fashionable material for custom houses as well as restoration projects.

The wood shingles on the roof of this Tudor Revival house (left) were steamed and bent to resemble thatching. To aid architects and contractors to lay such special effects shingles properly, manufacturers like the Creo-Dipt Company, Inc. of North Tonawanda, New York, published roof details, like those in the 1923 **Sweet's Architectural Catalogue** (below). (Photograph courtesy of NPS; "Country Cottage Roof".) [click image for larger view]



for a variegated effect, two or more shades could be combined. Of course, wood shingles could be, and often were, left uncoated. In such instances they would gradually assume what Calvert Vaux described in his 1857 publication Villas and Cottages as "a soft, pleasant, neutral tint that harmonizes with any color that may be used in the building."

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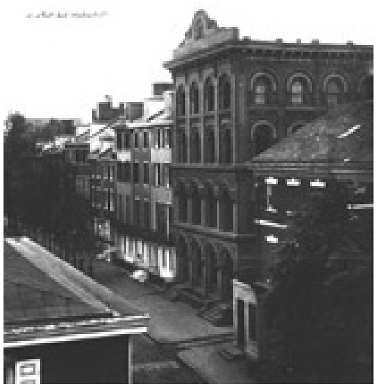
ROOFING FOR HISTORIC BUILDINGS

Gutters and Downspouts

Gutters and downspouts are the principal means by which water is conveyed off a roof and away from a building. There is little evidence that they were employed at first in the Colonies but by the early 18th century their use had become an accepted practice on finer buildings.

An early wooden gutter with brackets is illustrated in Francis William Edmonds' painting, *The Thirsty Drover*,1856. Rain barrels or cisterns were common repositories for rain water and were ubiquitous elements in the colonial landscape. (Image courtesy of the Nelson-Atkens Museum of Art, Kansas City, Missouri. Purchase: Nelson Trust). [click image for larger view]

Simple styles of wooden gutter from the 18th century include the V-shaped gutter, formed by fastening the long sides of two boards together or the rectilinear shaped gutter formed by hollowing out a hewn log. Wooden pins or wrought iron brackets were used to fasten the gutter to the eave or side of the building. "Drop gutters" or downspouts were wooden and were formed by fastening four boards together or by hollowing out a hewn block of wood or log. Improvements were made to wooden gutters over time and they became not only practical drainage components but aesthetically pleasing architectural details with classical profiles.

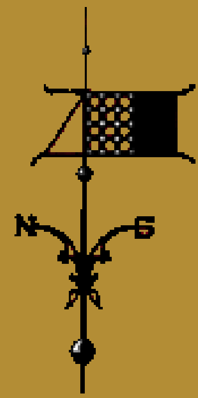


An 1871 photograph of the corner of 3rd Street, south of Walnut in Philadelphia shows a number of rain water conductor systems. In the lower left corner is a metal roof with a built-in gutter lined with metal; on the far right is a building with a wood shingle roof and a built-in gutter with exposed downspout; and in the center is a four story brick building with built-in gutters and internal downspouts. (Print & Picture Collection, The Free Library of Philadelphia) [click image for larger view]

They remained popular in the New England area until World War II. Wooden downspouts however were found to leak and were eventually replaced by metal ones.

Lead was another material used during colonial times for making gutters and downspouts. The half-round was the earliest form of hanging metal gutter and was made from sheets of hammered lead formed around wooden poles into a U-shape shaped trough. When hung, the gutter was loosely suspended from the roof eaves by straps. Early metal downspouts were typically cylindrical in shape and made of lead. Some downspouts ran only partially down the sides of buildings while others dropped to just above grade and onto splash stones, into cisterns, or into underground drainage systems. With the advent of the Revolutionary War, the military need for lead for the Colonies encouraged the use of other metals like copper, tinplate, and terneplate.

Built-in gutters were introduced into the



Snow Guards

Snow guards or snow brakes, as they are sometimes called, began appearing on slate and metal roofs of New England in the late 1800s. The tremendous quantities of snow and ice that accumulated on these roofs made the wood or metal diverter, typically attached above the front entry, an ineffective tool in preventing the snow from sliding down the roof. With snow guards in place, the snow would eventually blow away or remain until it melted. Not only was the risk of damage to objects and persons below avoided, but the banking of snow and ice at the eaves was prevented, thus eliminating the chances of backwater and consequent leaks, as well as a straining of the gutter structure. (Sweet's Architectural Catalogue, 1906. Courtesy of the Sweets Group, the McGraw-Hill Companies, Inc.)

Folsom Snow Guard Company of Boston, Massachusetts advertised three models of snow guards in the 1906 **Sweet's Indexed Catalogue of Building Construction**. [click image for larger view]

American vocabulary with high-style 18th century buildings. Characterized by its integration with a cornice (either open or closed), built-in gutters preserved the architectural detail of the cornice while providing a practical solution to storm water drainage.

Historically these were boxes made of wood, the bottom of which was sloped, and, where possible, lined with metal, usually lead. As buildings grew in height and complexity in the 19th century, cast iron or tile internal downspouts or leaders were introduced to invisibly move water away from the roof and into subterranean drainage systems.

The pole gutters on the roof at 757 Swanson Street, Philadelphia in 1868 divert rainwater to a short cylindrical downspout. Moisture damage is evident on the wall of the building below the end of the pipe where there is no downspout extension. (Print & Picture Collection, The Free Library of Philadelphia) [click image for larger view]

Another type of metal gutter seen on early high style buildings of the 18th century was the pole or stop gutter. In its simplest form, a pole gutter was made by folding up one edge of the metal sheet until the upright edge was perpendicular when placed upon the roof. It was fastened near the eaves to channel water directly off the roof or to a downspout. Wooden boards were often secured just below the metal gutter to keep it from flattening out. Pole gutters were popular until the early 20th century.

During the Industrial Revolution hanging metal gutters became very popular. Supplier's catalogues offered seven different styles, custom and stock, imitating classical moulding profiles in eight-foot lengths. By the 20th century these were available in terne, copper, galvanized iron, galvanized steel, monel, aluminum, and even vinyl. The "K-style" gutter trough, easily identified by its ogee profile, became a standard in the 1940s.

ROOFING FOR HISTORIC BUILDINGS

Roofing Today

The manufacturing of roofing materials and installation practices today draw upon the experience of the past 300 years. While this is particularly true with restoration work on historic buildings, it is also evident with new construction work. The strong market today for "substitute" materials that convey some of the same visual qualities of traditional roofing reflects our society's appreciation of historic architecture.

The first ply of hot applied, built-up roofing is installed over perlite insulation board. The system is carefully installed to accommodate locations of roof penetrations and rooftop mechanical equipment. (Photograph courtesy of Wiss, Janney Elstner and Associates)

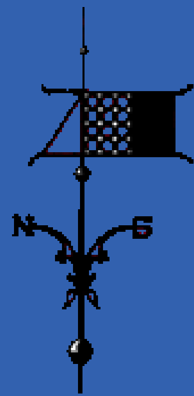
Building code changes, performance requirements, code constraints, new technologies, and modern building practices are just a few of the factors that have contributed to an ever evolving roofing industry. For historic buildings, the greatest opportunity to take advantage of these changes is with low slope roofing. Because of the low slope design, these areas are often not visible from grade and thus there is less concern with matching the appearance of the original roofing than with more visible steep sloped roofing. Some of the materials and systems originally used on historic low slope roofs (such as canvas) are not necessarily watertight or durable, and therefore are not appropriate choices for reroofing. The four main types of low slope roofing systems today are fully adhered, mechanically fastened, loose laid and ballasted, and protected membrane. Each of these systems has certain advantages and disadvantages with respect to wind, fire, resistance to mechanical damage, ease of installation, thermal value, resistance to ponded water, and compatibility with existing roof deck and structural components. Some systems strongly reflect traditional roofing practices while others are very contemporary approaches.

Built-Up Roofs

Today's built-up roofing systems incorporate traditional as well as contemporary materials, and contemporary improvements for installation techniques. Modern built-up roofs are fully adhered assemblies of multiple reinforcing plies (organic, fiberglass, or nonwoven polyester mats) that are directly embedded in layers of hot asphalt or coal tar. The finished assemblies are often covered with gravel. Asphalt roofs can be left smooth surfaced but must be coated to protect them from direct sunlight and also to provide a fire rating. Coal tar bitumen, used on many historic buildings, offers superior resistance to ponded water.

Single Plies

Single ply roofs today involve contemporary materials and installation techniques. Single ply roofs consist of a single layer of synthetic materials, 30 to 80 mils (.030 to .080 inches) thick, that can incorporate a reinforcement layer of polyester or fiberglass. Single ply roofs

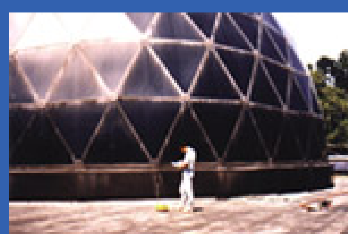


Tools and Equipment for Investigation and Installation

Many traditional tools are still used in roofing, but equipment for investigation and installation has changed. Modern techniques for investigation include nuclear moisture meters, infrared thermal imaging, capacitance meters, moisture monitoring systems, and special measuring devices.

New tools and equipment for installation include electrical lifting equipment such as cranes and small mechanized hoists, as well as special safety equipment such as special ladders and fall protection, and mechanical fasteners such as nail guns. These new tools have significantly facilitated roofing work.

The first ply of hot applied, built-up roofing is installed over perlite insulation board. The system is carefully installed to accommodate locations of roof penetrations and rooftop mechanical equipment. This single ply membrane with an isolation felt material (visible at left) is covered by concrete masonry unit pavers, in this example of a ballasted system. The pavers are interlocked with plastic tabs. Along the wall at the right is a PVC clad metal base flashing.



This investigator is using a nuclear moisture meter to identify areas of moisture in the roof system. The nuclear moisture meter is most appropriate for use with gravel

This single ply membrane with an isolation felt material (visible above) is covered by concrete masonry unit pavers, in this example of a ballasted system. The pavers are interlocked with plastic tabs. Along the wall at the right is a PVC clad metal base flashing.(Photograph courtesy of Wiss, Janney Elstner and Associates)

can be ethylene propylene diene monomer (EPDM), polyvinyl chloride (PVC), thermoplastic polyolefin (TPO), or hypalon, which begins as a weldable thermoplastic and becomes rubber-like as it cures. Single ply roofs are categorized as thermosets, thermoplastics, and plasticizers. They can be fully adhered, mechanically fastened, loose laid and ballasted, or placed under an extruded polystyrene insulation board as a protected membrane roof.

surfaced built-up, EPDM, and modified bitumen roofing systems. The system is most accurate when the rigid insulation beneath these systems is uniform in thickness. (Photograph courtesy of Wiss, Janney Elstner and Associates)

Modified Bitumen

Modified bitumen roofs involve some traditional materials, but use modern fabrication methods, and traditional or more contemporary installation techniques. Modified bitumen roofs are made from prefabricated rolls of modified asphalt (or coal tar) reinforced with a fiberglass or polyester reinforced mat. Rubber-modified asphalts, such as styrene-butadiene-styrene (SBS) materials, are granular surfaced and are normally installed in two or more plies using mopping asphalt, cold adhesives, or torch welding. Plastic-modified asphalts such as atactic polypropylene (APP) systems are smooth or granular surfaced and can be heat welded or laid in cold adhesive.

Metal Roofs

Metal roofs have a long history of use, although improvements have occurred in shop fabrication methods and new sealant materials. Metal roofs are available in a wide variety of rib configurations, colors, and slope configurations. Architectural systems use an underlying deck to provide structural support, while structural standing seam metal roofs provides an integral supporting frame. Structural systems can be used to retrofit an existing flat roof deck to provide improved drainage. Sealant is required at valleys, gutters, and drains, to ensure watertightness.

Sprayed Polyurethane Foam

Sprayed polyurethane foam is a contemporary system that is sometimes appropriate for use on historic structures. Sprayed polyurethane foam (SPF) accepts a variety of substrates and is readily adapted to recovering existing flat or low sloped roofs. This roofing can be designed to incorporate increased slope for better drainage. The foam also serves as insulation. A smooth or granular coating is usually applied to provide protection from sunlight.

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