Slate Roofing for Consultants: What You Need to Know

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ABSTRACT

In 2015, RCI members were surveyed regarding slate roofing. RCI, in conjunction with the National Slate Association, conducted the poll. The tabulated results showed a strong interest in specific areas of slate roof design and form the basis for the content of this presentation. This program will feature three topic areas. Slate Sources includes information on domestic, international, and reclaimed slate. The Slate Roof Assessment segment focuses on the slate shingles themselves, slating nails, flashings, repair vs. replacement decision-making, and expected remaining service life. Fasteners, underlayments, and flashings will be addressed in the Detailing segment.

SPEAKERS

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ROBERT FULMER is principal of a firm that provides inspection, design, specification, and project management for building envelope projects involving institutional, academic, and ecclesiastical structures. He learned the trade of slate roofing while working for his family’s roofing business. Prior to becoming a building envelope consultant, he operated his own slate roofing and restoration business. Fulmer currently serves on the board of directors of the National Slate Association and is chairman of the group’s Education Committee.

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DOUGLAS FISHBURN is president of his firm. He is a past president of the RCI Ontario Chapter and has held the position of RCI Regional Director. He is an active member of the Canadian Standards Association (CSA), has written numerous technical articles for professional trade journals, and has lectured at universities.

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JEFFREY LEVINE is president of his company. His expertise in the field of slate roofing is nationally recognized. He has served as project manager for over 270 restoration and rehabilitation projects and has written numerous articles on slate roofing, including Preservation Briefs No. 29, published by the National Park Service. Levine edited and cowrote the National Slate Association’s Slate Roofs: Design and Installation Manual and its Mobile Field Guide.
SLATE SOURCES

Currently there are over 20 countries producing slate throughout the world. Even within a single continent, however, the performance and characteristics of roofing slate vary widely. All slate reflect the mineralogy of the various regions they are quarried within (Figure 1).

The basic petrography of roofing slate is defined as a fine-grained, foliated, metamorphic rock, containing the principal minerals of mica, quartz, and chlorites. However, it is the regional proportions and interactions of these and other “local” minerals, in addition to the ancient metamorphic formation conditions, that create the numerous variations in appearance and service life of the principal slate materials.

HISTORICAL NORTH AMERICAN SLATE SOURCES

Slate quarrying in the United States predates the Revolutionary War. During the mid- to late eighteenth century, the vast majority of roofing slate in the U.S. was imported from North Wales to the east coast port cities of Boston, New York, and Philadelphia. By the early to mid-1800s, roofing slate were being produced throughout North America.

Pennsylvania

In 1734, slate was discovered in the U.S. by William and James Resse, Welsh immigrant brothers who had settled in the Peach Bottom district of Pennsylvania, near the Susquehanna River. Pennsylvania began producing a range of black slate in two designated “districts.” The abutting counties of Lehigh and Northampton formed the Lehigh-Northampton district, which was the larger and more productive

Figure 1 – Roofing slates of the world.
of the two districts. This district contained two roughly parallel slate beds. The northerly bed, located in Lehigh County, was known as the “soft vein” and contained principally softer “black slate.” The southerly vein of Northampton County produced both soft- and hard-vein slate. The hard gray “Chapman” and “Belfast” slate were produced from the hard-vein southern section that continued on, extending beneath the Delaware River, into Sussex County, New Jersey.

The second Pennsylvania slate district was much smaller and was known as the “Peach Bottom” district. This district straddles the Pennsylvania/Maryland border in York County, PA, and Cardif, MD. Quarries were located in Delta, PA; Peach Bottom, PA; and Cardif, MD. Although production volume was significantly less than the Lehigh-Northampton district, the slate quality was excellent.

As the nation’s largest slate source, Pennsylvania produced approximately 60% of the roofing slate in the United States from the 1880s to 1914. By 2010, three quarrying operations remained, located in Pennsylvania produced approximately 60% of the roofing slate in the United States from the 1880s to 1914. By 2010, three quarrying operations remained, located in Pennsylvania. The region of the Arvonia Slate belt in Buckingham County, central Virginia, contains deposits of hard and fine-grained black slates. Although roofing slate was first produced there in small quantities in 1787, between 1835 and 1841, W.B. Rogers convinced the Virginia legislature to investigate black slate deposits discovered “east of the Blue Ridge Mountains,” in the region of Buckingham County. The effort revealed three distinct slate veins, and quarrying continues there today.

Maine
In 1870, a deposit of high-quality “black” slate was discovered by Welshman William Griffith Jones in Monson, Maine. Two large slate belts occurred in an area approximately 15 miles wide by 20 miles long. Monson slate were extracted utilizing “shafts”—several of which were over 1,000 ft. deep, with tunnels almost a mile long (Figure 2). By 1882, five quarries were operating, with more to follow. Today, however, only one quarry remains open and produces architectural slate but not roofing slate.

Other States
During the late nineteenth to the early twentieth centuries, small-scale roofing slate production occurred in other states as well. These quarries produced when demand was high but rapidly failed when demand fell. Those states included Colorado, Arizona, Utah, California, Michigan, Minnesota, New Jersey, Massachusetts, West Virginia, Tennessee, Georgia, and Arkansas.

Canada
Approximately 200 miles further north from Monson, Maine, a black slate deposit of exceptional quality was discovered just over the U.S. border, in Saint-Marc-du-Lac-Long, Quebec. This deposit was uncovered during construction of the Canadian Transcontinental Railroad in the early 1900s. Quarrying efforts began but were halted a short time later in order to support the Canadian government’s effort in World War I (Figure 3).

From 1860 to the early 1900s, the principal slate production region in Canada was within the St. Francis valley, located in southern Quebec, south of the St. Lawrence River and approximately 50 miles north of the Vermont border. Known as the Melbourne slate band, this region included the eastern townships located in Richmond County and extended from Melbourne Township across the St. Francis River, to include the townships of Cleveland and Shipton.

Small amounts of Canada’s roofing slate were also produced in British Columbia, Nova Scotia, and Newfoundland. Successful from 1902 to 1905, the “Maritime Slate” were principally exported to England. However, production from this region has been intermittent since the early 1900s. After remaining closed for many years, the Newfoundland quarry at Trinity Bay...
reopened in the mid 1980s but closed again in 2010. There were several factors that negatively impacted both the U.S. and Canadian roofing slate markets, but they were remarkably similar. The effects of WWI on the global economy and skilled labor markets, changing architectural design tastes, a growing interest in synthetic roofing materials such as asphalt and asbestos shingles, as well as metal products—all conspired to cause the decline in the use of slate roofing in both countries.

SLATE COLORATION AND WEATHERING

Prior to discussing the current geographic sources of slate, it is important to understand two principal slate designations unique to North America.

Traditionally, slate in North America are commercially grouped into two lithotypes regarding both color and weathering characteristics. Historically, the term “fading” is used to describe slate that, upon exposure to the elements, have a discernable, marked, and generally uniform lightening in color due to their mineral makeup. In some cases, the color change and mineral makeup have no impact on the longevity of the slate on the roof, while in other cases, if the color change is due to the accelerated deterioration of deleterious minerals, the service life of the slate can be shortened.

When slate are known to have no “fading” characteristics, “unfading” is the most common reference for this color stability. These slate will more or less maintain their original color on the roof. Even for unfading slate, color change on a roof can take place as a result of environmental pollutants, most commonly in the form of high-sulfur-content acid rain.

Also, the terms “weathering” or “semi-weathering” are used to describe slate that show various percentages of color change—usually to tones of buff, tan, and brown and occurring slowly over varying periods of time as the slate are exposed to the elements.

This color weathering is generally due to the presence of calcite and iron compounds, primarily fine-grained iron pyrite in the form of limonite. In most cases, these minerals are not deleterious and do not affect the life expectancy of the material. The common reference for this color characteristic is “semi-weathering.”

CURRENT NORTH AMERICAN ROOFING SLATE SOURCES

The dynamics of the U.S. and Canadian slate roofing industries in the early part of the twentieth century served to define the slate producers, markets, and slate types that are also our extant resources. Within the United States, natural roofing slate is currently being produced in Vermont, New York, Pennsylvania, and Virginia. In Canada, natural roofing slate is being produced in Quebec.

In the following sections, slate sources and types will be discussed, along with anticipated service life for each slate type.

In order to determine service life, each slate type must be tested and graded for durability and quality. In the U.S., the American Society for Testing and Materials International (ASTM) develops and publishes standards for the grading of roofing slate. Under the ASTM C406 standard, three tests have evolved from their 1930s origins: the ASTM C217 “Weather Resistance” test, the ASTM C121 “Water Absorption” test, and the ASTM C120 “Breaking Load” test.

After each slate type is tested, it receives one of three “grade” designations of S1, S2, or S3, with S1 being the most durable. Each slate manufacturer can provide all testing results and samples of their materials upon request.

Vermont and New York

Within this region, known as the “Slate Valley,” a number of active quarries currently produce all of the colored slate available in North America. The full range of slate types within the Slate Valley is as follows:

1. **Semi-Weathering Gray/Green, also known as Sea Green:** “Bright” green or gray/green when first extracted from the quarry, a percentage of these slate will weather to tones of buff and brown upon exposure to the elements. Anticipated service life: 90-125 years.

2. **Semi-Weathering Gray, also known as Vermont Gray:** Clear gray or gray with small black markings when first extracted from the quarry, a percentage of these slate will weather to tones of buff and brown upon exposure to the elements. Anticipated service life: 90-125 years.

3. **Semi-Weathering Strata Gray, also known as Mottled Gray/Black:** This is a medium gray slate with black (or dark gray) stripes. A percentage of these slate will weather to tones of buff and brown upon exposure to the elements. Anticipated service life: 110-135 years.

4. **Semi-Weathering Variegated Purple:** A blend of clear purple and purple with green markings.
when first extracted from the quarry. Anticipated service life: 120-130 years.

5. **Semi-Weathering Gray/Black, also known as Vermont Black:** Depending on the source, these slate include a variety of blends of medium and dark gray shades with or without black and darker gray linear markings. A percentage of these slate can weather to tones of buff and brown upon exposure to the elements. Anticipated service life: 110-130 years.

6. **Unfading Mottled Green and Purple:** These purple slate exhibit frequent inclusions of green in almost every piece, in varying amounts. They will hold their original color when exposed to the elements. Anticipated service life: 110-130 years.

7. **Unfading Gray/Green:** A light green slate of a consistently uniform shade. They will hold their original color when exposed to the elements. Anticipated service life: 110-130 years.

8. **Unfading Green:** A blend of green slate ranging from bright green to gray/green tones. These slate will hold their original color when exposed to the elements. Anticipated service life: 120-130 years.

9. **Unfading Gray:** Medium gray slate with small black or darker gray markings. These slate will hold their original color when exposed to the elements. Anticipated service life: 110-130 years.

10. **Unfading Red:** Quarried in Granville, NY, and representing one of the few deposits of red slate in the world. A very hard, bright red slate that will hold its original color when exposed to the elements. Anticipated service life: 120+ years.

**Quebec**

The Glendyne Quarry, located in Saint-Marc-du-Lac-Long, Quebec, produces dark gray slate with a slight blue tone. Known as “North Country Black,” these unfading slate display regular fissility with very fine mineralogy. The blue/black slate also have a consistent uniform shade with subtle darker vertical markings. Reopening in 1995, the Glendyne Quarry is currently the largest slate quarry operating in North America and the last quarry producing roofing slate in Canada. Anticipated service life: 130+ years.

All of the above-mentioned slate sources are currently active and quarrying roofing slate.

**SOURCES FOR SLATE THAT ARE NO LONGER PRODUCED**

Throughout the prominent slate regions of North America, high-quality, durable slate were produced during the late nineteenth and twentieth centuries. While some of these good quarries are no longer in production, their exceptional slate are extant today, many with significant portions of their service lives remaining. Consequently, there is a demand for slate that match those that are no longer produced.

The following section provides two options for matching slate that are no longer produced.

**Current Matching Producers**

With the proper identification of existing slate and careful evaluation, it may be pos-
It is possible to locate slate from a current producer that resembles slate from a former producer. There are potential considerations, such as the age and coloration of a “fading” or semi-weathering slate, environmental pollution, etc., which may prevent an exact match. Good-quality “former” quarries and their potential currently produced matches are listed below:

**Peach Bottom Slate:** The quality of Peach Bottom slate was excellent, with an anticipated service life of 150+ years. A good current production match for Peach Bottom Slate is Buckingham slate from Arvonia, Virginia.

**Monson Slate:** The Monson quarries produced an exceptional slate with an anticipated service life of 150+ years. A good current production match for Monson slate is “North Country Black” slate, produced by the Glendyne quarry in Quebec, Canada (Figure 4).

**Chapman (Pennsylvania Hard-Vein) Slate:** Chapman slate exhibited diagonal ribbons across the full width of the slate. Their anticipated service life is 100+ years. A current production match for Chapman slate is Vermont Strata Grey.

**Newfoundland Purple Trinity Slate:** Newfoundland Purple has not been produced since 2011. A current production match for Newfoundland Purple is “Penrhyn Unfading Purple” from Penrhyn, Wales.

**Unfading Purple (a.k.a. Royal Purple):** A Vermont slate that has not been produced since 2012. A current production match for Unfading Purple is “Penrhyn Unfading Purple” from Penrhyn, Wales.

**Salvaged or Reclaimed Slate**

There is an active reclaimed (or salvaged) slate market in North America. The term “reclaimed” indicates the slate were formerly in service on an existing building but have been removed, inspected, and sorted to be sold and reinstalled. A significant advantage of utilizing reclaimed slate is that they can be a source of slate that are no longer available. This can be an important consideration for roof maintenance or replacement on a historic structure. Reclaimed slate can also provide a good option for matching an existing “fading” or semi-weathering slate roof if both the existing and reclaimed slate are the same type and approximately the same age.

Reclaimed slate can also be a cost-effective option for installing a natural slate roof. While the cost of reclaimed slate may vary due to age (an indication of remaining service life), condition, rarity of the slate, etc., the price of reclaimed slate is generally 40% to 60% of the cost of new slate.

**INTERNATIONAL SLATE SOURCES**

A rich global history of slate production exists in Europe. However, over the centuries, the global sources and production of slate have changed significantly. Since the 1980s, the Truchas Syncline on northwest Spain’s Iberian Peninsula has been the world’s largest producer of roofing slate, accounting for 90% of European production (Figure 5).

The region of Galicia is the principal (but not the only) quarrying area and includes four production districts. The slate produced in this region include a range of durable, fine-grained, black, dark gray, and gray slate with low absorption index (less than 0.4%) and smooth texture.

Current global export statistics show Spain as the largest exporter of roofing slates, followed by China and Brazil, sequentially. China remains close to Spain’s production in export tonnage but lags significantly in export dollars. The principal consumers of Spanish slate (in order) are France, Germany, the UK, and the U.S. Other global exporters of roofing slate include India, the UK, Italy, Norway, Greece, Africa, and Russia.

Traditionally, the quality of roofing slate entering the global markets has varied widely. As a result, the major European slate exporters developed their own standards.

In December of 1999, European Norm (EN) 12326-2:2000 was released, followed by EN 12326-1:2004. Part two contained prescriptive test methods and requirements that are more comprehensive than those set forth in the current U.S. ASTM C406.

In May of 2006, the Conformity European (CE) mark became mandatory for slate purchased or sold in the EU. The CE marking must be attached to the slate pallets as a placard that lists the specific slate.
Figure 6 – Roof plan showing low-sloped and slate roofs.

characteristics, based on the test requirements of EN 12326-2. Currently, there is no such labeling requirement in the U.S.

COMPLETING AN ASSESSMENT

Before commencing an assessment, obtain information about the project from the client, including past reports and drawings, or review past work with contractors. Establishing the historical significance and determining whether the building has been classified as a historic landmark is important.

Information obtained will assist in developing terms of reference for the project, the time required, and the method of documenting results. The technical approach may depend on whether the consultant was requested to solve a roof leak, complete a full assessment, or appear as an expert in a litigation case.

Working safely is paramount, and some means to gain safe access is required to comply with regulatory safety requirements. Improperly secured, broken, or defective slate present a safety hazard—particularly on steep-pitch roofs. The method used to gain access will impact safety, time, and cost of the assessment.

A review of photographs obtained from Google Maps or other aerial photography will prove useful in helping to determine the size, height, and shape of the roof, as well as the color of the existing slate. Taking overall photographs from the ground or from a drone can be used to develop a photo roof plan of the various elevations of the roof to be examined. These photographs can be used to generate a rough roof plan that can be used during the investigation and in writing the report.

Color makes documentation easily readable. Show all openings and projections, such as chimneys, vent stacks, snow guards, snow rails, gutters, and adjacent roofs in the roof plan. Provide a slope arrow and percentage of slope on each elevation (Figure 6).

Interior Inspection

Inspect the building interior to determine interior finishes and the location and extent of water leakage.

Inspect the attic to assess the size and spacing of roof rafters and their condition. Figure 7 shows a cracked roof rafter.

Determine the construction and condition of the framing and roof deck. Verify the type (smooth or ring-shanked) and length of nails.

Surfaces

Determine whether the roof space has been constructed with a vapor barrier and insulation. Record the type and thickness of insulation and its condition. If the roof
attic is insulated, determine the type, location, and quantity of ventilation provided to ensure it meets building code requirements. Look for black staining that may indicate mold.

**Exterior Inspection**
Inspect and record the type of roof underlayment.

**Exterior and Interior Inspection**
Review the type, thickness, color, and condition of the roof slates as well as method of installation. Sound slates typically have a smooth finishing and can provide a longer service life than slates that have a rough or flaking surface. Sound slates ring when sounded, while deteriorated/delaminating slates have a dull sound. Breaking off a section of slate on-site can provide an indication of its hardiness and show the original color.

A visual survey of the roof from the ground or adjacent roofs can provide useful information on its aesthetics, slate color, areas of repair, and the location of missing slates (Figure 8). Observe and record the exposure, head laps, gaps, and plumb of slates (Figure 9). Failure to provide a proper head lap can result in leakage. Lower-sloped roofs require greater head laps than steep-sloped roofs—particularly in ice damming areas. A standard head lap is 3 in. On slopes 4:12 to 8:12, a 4-in. head lap is required; on slopes 8:12 to 20:12, it is 3 in.; and 20:12 and above, 2 in.

On a roof installed with graduated slates, the slates are typically thicker and have greater exposure at the bottom than at the top of the slope. Record the size and length of nails in more than one location.

Remove or complete inspection openings in the slate assembly to look at: 1) the back side of the slate, 2) nails, 3) concealed flashings, 4) underlayment, and 5) the roof deck. Have a quantity of matching new or used slates on hand if the original slates are to be retained and not reset.

**Valleys**
Examine and record the width and size of slate at valleys and whether open or closed valleys are installed. Confirm the thickness of the metal, type of underlayment, and whether the valleys have been installed with clips and hemmed. Record whether a V- or W-style valley was installed. Inspect the valleys for damage.

**Ridge Caps and Hips**
Determine and record type of material and method of installation of the ridge caps and hips. The slates in mitered hip need to be underlaid with softer metal—typically copper. Verify the size and head laps at hips and ridges. Measure the length of nails since longer nails are typically used at hips and ridges.

**Eave and Rake Edges**
Inspect and verify the overhang of slates at the eave of the roof. Approximately 1½ in. is recommended, or 1 in. if a gutter is installed. Verify whether or not a cant has been installed at the drip edge.

Inspect the eaves for eave protection and the installation of metal flashings. Verify that a starter course has been installed and that minimum offset has been provided between the upper and lower courses. Verify that brackets for gutters are not secured through the slates.

**Flashings**
Based on the authors’ experience, flashings represent 70% of problems with roofing systems, and slate roofs are no exception. The flashings of roof projections at chimneys, skylights, openings, and vent stacks need to be properly flashed if long-term service is to be provided. Lightning protection should be inspected for proper installation.

The installation of saddles is required at any curb or chimney in excess of 24 in. The size of step flashing (typically 4 x 4 in.), needs to be verified, as failure to provide proper step flashing can lead to roof leaks. The heights of flashings at curbs, vents, and walls are based on local conditions and are usually constructed 6 to 8 in. high, depending on slope. Verify whether the underlayment or eave protection has been turned up the dormers and walls behind the cladding.

Inspect flashings at masonry chimneys and walls to determine if proper step flashings have been installed and the counter-
flashings have been properly secured into masonry joints. Verify that counterflashings are stepped with the slope and properly overlapped, and note if any galvanic reactions are discernible indicating the use of ferrous fasteners or flashings. Identify the number and location of cracks or dislodged slates. Determining whether a slate with a chipped corner is acceptable often depends on personal experience (the author is not aware of any standards in this regard). While a chip of 1 in. or less may be acceptable, a 2- to 3-in. missing slate at the corner is unacceptable and needs to be replaced. Inspect for exposed nails and holes.

Evaluate the adequacy of past repairs. Using slates that do not match, using mastic on the slates to repair holes, and caulking over previously soldered joints that have broken may be expeditious but does not necessarily provide long-term service. Use a checklist to record as-built conditions and determine the location, type, frequency, and severity of defects.

Snow Guards
Evaluate the effectiveness and installation of snow fences. Snow guards should not be secured through the surface of the slate.

Bells
Slates improperly installed over a bell can often be a source of roof leaks and result in broken slates. The head laps may have to be increased to 4 in. or more (Figure 10).

REPAIR VS. REPLACE
The decision to repair or replace can be impacted by a number of factors, including the extent of roof leaks, type and condition of the deck and structure, age and overall condition of the slates and fasteners, number of slates requiring replacement, condition of the flashings, cost of repairs vs. replacement, type of slates, historical performance of the slates, scheduling, and client’s preference and budget.

Salvaging and reusing the slates will depend in part on the quality and possible color of the slates and anticipated service life once reinstated. Salvage is expensive and can double the labor cost for the project in comparison to disposal and providing new slates.

Generally, if 20% of slates are broken, missing, cracked, or delaminated, then it may be more practical to replace rather than repair. There are always exceptions.

In the end, it will depend upon your experience and the client’s requirements as to whether you recommend repair or replacement of a roof.

DETAILING
As with any roofing project, the success of slate roofing projects hinges largely on the details. And there are plenty of details to worry about: headlap, exposure, offset, layout, roof slope, moisture migration, approach slates, blending, sorting, culling, etc. This section will focus on the detailing topics of concern to those who participated in the RCI slate roofing survey in advance of this conference: slating nails, slate nailing, underlayments, and flashings.

Slating Nails
Large-head, solid-copper slating nails are most frequently specified and used to secure slate shingles to the roof deck. Copper nails are very durable and should remain serviceable for as long as the slate itself. They are also readily cut by a slate ripper, making slate repair easy, with little or no disruption to adjacent slates.

When repairing an older slate roof with, say, 20 or 30 years of remaining service life, copper nails can certainly be used for securing individual replacement slates. If the goal, however, is to match the service life of the repairs to the service life of the existing roof and to make the repairs in as economical a manner as possible, then hot-dipped or double hot-dipped galvanized roofing nails will perform just as well. Electroplated nails (labeled EG on the box, for electro-galvanized) have too thin a coating of zinc to protect the underlying steel from corrosion and should not be used on a slate roof, even for repair purposes.

While solid copper nails can be readily driven into a wide variety of roof deck materials, certain decks are dense or hard enough to cause copper nails to bend when being driven. Such substrates include old concrete decks, some old wood decks that have become harder with time, and new or existing hardwood decks, such as red or white oak, whose interior faces might be exposed to view. Jumping up from an 11-gauge (0.120 in. shank diameter) to a 10-gauge (0.134 in.) copper nail is an option that sometimes does the trick. Predrilling an undersized hole for each nail is also an option, albeit an expensive one. Stainless steel nails, being less malleable than copper, are less likely to bend when driven, and are, therefore, a better option than predrilling. The downside of using stainless steel slating nails arises when slate repair is needed. The extra effort required to cut or remove the stainless steel nails securing a broken slate can sometimes cause adjacent slates to break or become dislodged.

When specifying slating nails, nail length, gauge, and shank type must be defined. For nail length, the basic rule is to double the slate thickness and add an inch. Thus, for a ⅜-in.-thick slate, a 1½-in.-long nail should be specified. Be aware that many slates are marketed and sold today as ⅝- to ⅞-inch in thickness. If this is what is being specified, then double the thicker dimension and add an inch to derive the required nail length; 1¾ in. long in this case. Lastly, longer nails–2½ to 3 in. long–are usually specified for hip and ridge slates, due to the multiple thicknesses of slate that can be present.

The most common gauges of copper and stainless steel slating nails are 10-gauge and 11-gauge. Eleven-gauge copper nails...
are fine for most wood and plywood decks. Ten-gauge copper slating nails might be appropriate when heavier (thicker and larger) slates are specified. So, 11-gauge nails might be fine for ¼-in.-thick, 20x10 slates, but 10-gauge nails should be specified for ¾-in.-thick 20x12 slates.

With regard to shank type, smooth-shank slating nails are most commonly used in wood roof decks, and ring-shank nails, in plywood decks. In wood decks, ring-shank nails will generally offer greater pullout values and should, therefore, offer greater wind-uplift resistance. Ring-shank nails are probably a good idea in high-wind zones.

It is not a good idea to use ring-shank nails in gypsum and concrete roof decks. The rings tend to crush the substrate within the hole, actually reducing the pull-out values. Use only smooth-shank slating nails in these types of roof decks.

**Slate Nailing**

Nailing the slate shingles to the roof deck is something the contractor just has to get right. But it is also something that can be specified and checked in the field.

Each slate shingle should be secured with two nails. The exception is large slates—those measuring ¾ in. or more in thickness and 20 in. or more in length—that are secured with four nails each. The two additional nails are set about 2 in. above the standard locations.

The important thing in nailing is that the slates hang from the nails with the nail heads set flush with the face of the slate shingle (see correct nailing in Figure 11). When the slating nails are set just right, one should be able to lift the butt ends of the shingles slightly by using one’s fingertips. Proper nailing is not a difficult skill to acquire, but like anything else, takes awareness, a little practice, and focus.

Both over-nailing (driving the nails too far) and under-nailing (not driving the nails far enough) can cause problems. Over-driven nails can cause cracking of the slate or excessive blowout on the underside of the slate (which can weaken the slate around the nail hole) as shown in the upper right of Figure 11.

Under-nailing leaves the head of the nail sticking up (bottom sketch in Figure 11). This causes the butt end of the overlying slate to stick up. Under-nailing can also lead to the nails working their way through the overlying slate over time. This can be seen in Figure 12, where there is now a leak.

**Underlayments**

While it will not be possible to cover everything—or even most things—related to the topic of underlayments here, what this paper can do is give the design professional some things to think about, starting with their purpose and what the codes require. Underlayments are installed on the roof deck prior to the slate and serve three primary purposes: 1) they protect the roof until all of the slate can be installed, 2) they help control moisture migration below the slate shingles, should it occur, and 3) they contribute to the fire classification of the roof assembly.

The 2012 International Building Code (IBC) states in Section 1507.7.3, that “Underlayment shall comply with ASTM D226, Type 1 or ASTM D4869.” ASTM D226, Standard...
Figure 13 – Underlayment permeances and maximum exposures, per Holladay.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product</th>
<th>Permeance*</th>
<th>Maximum exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nemco Industries</td>
<td>RoofAquaGuard UDLX</td>
<td>0.035 perm</td>
<td>6 months</td>
</tr>
<tr>
<td>W.R. Grace</td>
<td>Tri-Flex Xtreme</td>
<td>0.04 perm</td>
<td>4 months</td>
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<td>Pactiv</td>
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<td>Berger Building Products</td>
<td>REX SynFelt</td>
<td>0.05 perm</td>
<td>6 months</td>
</tr>
<tr>
<td>InterWrap</td>
<td>Pro-Master Roof Shield UDL &amp; UDL Plus</td>
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<td>12 months</td>
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<td>Helotex</td>
<td>Tech Wrap 300</td>
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<tr>
<td>Helotex</td>
<td>Tech Wrap UL</td>
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<td>12 months</td>
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<td>Sharkskin Ultra</td>
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<td>Intertape Polymer</td>
<td>NovaSeal</td>
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<tr>
<td>Propex Operating Company</td>
<td>Tech Wrap 150</td>
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<td>SDP Advanced Polymer Products</td>
<td>Opus Roof Blanket</td>
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<td>30 months</td>
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<tr>
<td>System Components</td>
<td>Palisade</td>
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<td>IKO</td>
<td>Feltex</td>
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<td>CertainTeed</td>
<td>RoofGard-SB</td>
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<td>DiamondDeck</td>
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<td>Deck Defense</td>
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<td>Summit</td>
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<tr>
<td>DuPont</td>
<td>RoofLiner</td>
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<td>6 months</td>
</tr>
<tr>
<td>GAF Materials</td>
<td>TigerPaw</td>
<td>&lt; 1 perm</td>
<td>6 months</td>
</tr>
<tr>
<td>Rosenlew RKW</td>
<td>RoofTopGuard II</td>
<td>&lt; T perm</td>
<td>6 months</td>
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<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product</th>
<th>Permeance</th>
<th>Maximum exposure</th>
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<tr>
<td>Perma R Products</td>
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<td>Delta-Maxx Titan</td>
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<td>SlopeShield</td>
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<td>Nemco Industries</td>
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<td>Barricade Dry Step</td>
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<td>Grip-Rite ShingleLayment</td>
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<td>Tam-Shield</td>
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<td>Tri-Built High Performance</td>
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Specification for Asphalt-Saturated Organic Felt Used in Steep-Slope Roofing. Type I is commonly called No. 15 felt. Keep in mind that the actual weight of No. 15 felt is around 11.5 lbs./square. It is interesting that the code does not specify a type for felt that complies with ASTM D4869, Standard Specification for Asphalt-Saturated Organic Felt Underlayment Used in Steep Slope Roofing.

Unperforated, asphalt-saturated organic felt is the traditional underlayment used below slate shingles and is still commonly used today. Felt has its drawbacks and naysayers: It is not as thick or heavy as it used to be; it wrinkles; it tears. Given the actual weight of the material, it is a good idea to specify a double layer of ASTM D226 Type II, No. 30 felt (26 lbs./square) or ASTM D4869 Type 4 felt, laid shingle style, 17 in. to the weather. These are classified under ASTM D6757, Standard Specification for Underlayment Felt Containing Inorganic Fibers Used in Steep-Slope Roofing. Many also comply with ASTM D226 and ASTM D4869. ASTM D6757-compliant fiberglass reinforced felts lay flatter and don’t wrinkle as much as organic felts. Some contractors familiar with the product say, however, that the D6757 felts tear easily, making them more difficult to install. Another, similar option is SBS-modified, asphalt-saturated, glass-fiber mat roof underlayment. These are heavier (37 to 70 lbs./square) than felt, lay flatter, don’t wrinkle as much, and don’t deteriorate or “rot,” according to their manufacturers. They have an important drawback, however, having to do with their permeance (see below).

Synthetic underlayments are numerous in today’s marketplace. They are manufactured from different materials, including polypropylene, polyester, polyethylene, polyolefin, and, according to one manufacturer, “advanced polymer resins.” Manufacturers market their products as having numerous advantages over traditional felt: more durable in high winds, more tear-resistant, install quicker because they are lighter and come in wider rolls, can be left exposed longer, and provide better traction or slip resistance.

Some synthetic underlayments come with their own set of disadvantages. One disadvantage of the laminated polypropylenes, for example, is that they cannot tolerate being scuffed (as by foot traffic); if so, they tend to delaminate and lose their water resistance. This is less of a concern on a 12:12 roof than a 6:12 roof. At least one manufacturer of a laminated polypropylene states that their “synthetic roof deck protection should not be utilized as a temporary roof to protect property or possessions.” This restriction defeats one of the purposes of a roof underlayment—that of temporary protection. One way around this restriction is to specify that the material be installed as the contractor works his way up the roof slope, removing previously installed means...
of temporary weather protection as each course of laminated polypropylene synthetic underlayment is installed.

Another disadvantage of synthetic underlayments is that many manufacturers require that their product be secured with cap nails to help prevent leakage around the nails. With felt, large-head roofing nails are all that is typically required. Some plastic cap nails are thick enough to cause the slate shingles to wobble or become elevated off the roof deck when the head of the slate happens to fall on the cap nail(s).

The primary concern, and the thing that design professionals must be aware of, is that many of the synthetic underlayment vapor barriers with perm ratings well below 1.² On new construction, where everything is engineered (at least in theory) in advance, this may not be an issue. On existing or historical structures, however, a vapor barrier placed on the roof deck over an unventilated or poorly ventilated attic can lead to condensation on the underside of the roof deck and consequent deterioration, especially if the attic floor is insulated and/or the attic floor lacks an air/vapor retarder. In such cases, warm, moist air entering the attic from habitable spaces can be trapped by the roof underlayment vapor barrier. When this warm, moist air contacts surfaces at or below the dew point temperature (such as the underside of the roof deck or the tips of slating nails penetrating through the roof deck), the result is condensation or frost formation on these surfaces. In many projects involving existing/historical buildings, balanced 1:150 or 1:300 attic ventilation can be difficult, if not impossible/impractical, given the detailing at the wall/roof interface and often complicated roof geometries. If a roof underlayment vapor barrier is to be added to the roof deck of an existing building, it should be modeled to be suitable in order to avoid unintended consequences.

Even on new construction, it is probably best to avoid placing a vapor barrier on a roof deck where spray polyurethane foam has been installed between the rafters. Any moisture that finds its way into such a roof assembly (can anybody really guarantee that no air infiltration will occur and no water will get past one of the thousands of nails that penetrate the underlayment?) will be trapped and could potentially lead to, at minimum, reduced R-value and, worse, deterioration of decking/framing members.

Be aware that it can be difficult to determine the permeance of a synthetic underlayment. Many manufacturers do not publish the information and, when asked, either will not tell you or state they have not tested the product.

It is generally accepted that No. 15 felt has a perm rating of 6 to 7 perms and No. 30 felt, 5 to 6 perms. What is less well known is that these perm ratings skyrocket when the felt gets wet—up to around 60 perms. One manufacturer of fiberglass-reinforced felt reports that it has a perm rating of 6 perms—about the same as organic felt. In 2011, Holladay published a list of synthetic underlayments and their associated perm ratings in Fine Homebuilding (Figure 13). Many of the vapor-impermeable synthetic underlayments were reported to have perm ratings in the 0.04 to 0.1 range, making them vapor barriers. The high-permeance synthetics listed in the chart are likely laminated products. Although SBS-modified products are not specifically called out in the chart, the manufacturer of one such product contacted by the authors reported their product had a perm rating of <1 perm.

The other thing the IBC says about underlayments, in Section 1507.7.4, is that ice dam protection membrane (e.g., a self-adhering, polymer-modified bitumen sheet) must be installed “in areas where the average daily temperature in January is 25°F (-4°C) or less or where there is a possibility of ice forming along the eaves causing a backup of water.” Where valleys are contiguous with the roof eave, consideration should also be given to extending the ice dam protection membrane up the valley, especially where the roof slope is relatively low (e.g., in the 4:12 to 8:12 range). In all cases, it is recommended that the roof underlayment be installed and tacked in place atop the ice dam protection membrane so that the heads of the slates do not dig into the somewhat soft ice dam protection membrane, thereby possibly negatively impacting the integrity of the membrane and making any future slate repair more difficult (the heads of the broken slates tend to stick to the membrane).

Flashings

This paper cannot inform the roof designer/specifier of all there is to know about the flashing of slate roofs. It can, however, provide guidance and point the reader to resources containing a plethora of technical information that can be integrated into design documents, with modi-

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Figure 14 – Detail of base (step) flashings at a vertical wall. Source: NSA Mobile Field Guide.
fications and adjustments to account for project-specific circumstances.

Two primary sources for slate roof design and installation detailing information are the National Slate Association’s (NSA’s) Slate Roofs: Design and Installation Manual, 2010 Edition, and NSA’s Mobile Field Guide. The NSA Manual is a detailed design and installation guide with chapters on the characteristics of slate, basic principles, installation details, roof repair, and specialty systems, and with over 100 detail drawings. It is available from both the NSA and RCI websites. The NSA Mobile Field Guide is a quick reference to information contained in the NSA Manual. It is a mobile reference tool meant for use on smartphones and tablets wherever Internet service is available. The Mobile Field Guide contains many of the key details found in the Manual, with the added feature that each detail may be constructed and deconstructed via use of a finger-controlled slide bar. The Mobile Field Guide is available free of charge at mobile.slateassociation.org.

There are hundreds of flashing details associated with slate roofs. Two of them—base (step) flashings and a mitered hip—will be explored here, just to give a flavor. For more information on these two details and scores of others, refer to the two publications mentioned above.

Base flashings (Figure 14), typically constructed of 20-oz. copper, are interwoven with each course of slate as shingling progresses up the roof. Base flashings should extend a minimum of 4 in. up the wall and 4 in. out onto the slate. With graduated roofs, the amount by which the vertical leg of the base flashing extends up the wall varies, being greater at the eave, where thicker slates are used, and less toward the ridge, where thinner slates are employed. Thus, if the slates at the roof eave of a graduated roof are 1 in. thick, the required base flashing height would be a minimum of 6 to 7 in. (a minimum 3- to 4-in. lap by the wall cladding/counterflashing, plus three thicknesses of 1-in. slate). Base flashing length is typically equal to the exposure of the slate, plus the headlap, plus 1 to 2 in. for nailing the flashing to the roof deck. The roof underlayment turns up the wall, behind the base flashings. Base flashings should lap each other a minimum of 3 in.

The base flashing sizes given above are, of course, minimum size requirements. They should be increased to help accommodate situations where the roof slope is relatively low, in severe climates, where the rafter length is particularly long, or where concentrated water flows occur in the area. The wall underlayment may be installed over the roof underlayment or, better, over the base flashings to help shed moisture that might get behind the wall cladding material. Base flashings are typically nailed in the upper-, outer-most corner of the roof flange in order to 1) eliminate the possibility of placing the nail too low on the wall and, thus, potentially in the path of water flows/ice damming; and 2) allow for their removal without having to remove the wall cladding.

Mitered hips are accomplished by cutting field slates to meet at the hip apex (Figure 15). The hip slates are laid in the same plane as, and with their butts aligned with, the field slates. The slate coursing must, therefore, line up each side of the hip apex. In finer work, the hip slates are given a reverse bevel (i.e., trimmed face up, so that the resulting beveled edge occurs on the unexposed face of the slate) to allow them to meet in a tight miter. Flashings—typically 16-oz. soft copper—are interwoven with each course of paired hip slates. Wider slates are used at the hip to provide more room for nailing. Three or four nails are used to fasten each hip slate, set in a triangle or diamond pattern. The butt ends of the hip slates may be set in dabs of adhesive to help prevent displacement.

REFERENCES


FOOTNOTES

1. Fissility or fissionability refers to the property of rocks to split along planes of weakness into thin sheets.
2. Vapor permeability is measured in accordance with ASTM E96, Standard Test Method for Water Vapor Transmission of Materials. The unit of measurement is perms. The higher the number, the more moisture vapor the material will allow to pass. Perms are the number of grains of water vapor that will pass through 1 sq. ft. of material in one hour when the vapor pressure differential between the two sides of the material is 1 in. of mercury (0.49 psi). Materials with perm ratings less than 0.1 are generally considered to be vapor barriers; those with perm ratings between 0.1 and 1, vapor retarders; and above 1.0, vapor semi-permeable or vapor-permeable.