CHAPTER TWO | Roofing

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ASPHALT SHINGLES

Asphalt shingles, which cover 80 to 90% of residential roofs, have undergone much change in the last 20 to 30 years. Until the late 1970s, all asphalt shingles were manufactured from a heavy organic felt mat that had established a reputation for both strength and flexibility and generally outlasted their 15- to 20-year life expectancy. Since their introduction in the late 1970s, fiberglass shingles have come to dominate the market, accounting for over 90% of shingles sold today. However, premature failure of some fiberglass shingles in the 1980s and 1990s tarnished the product's reputation and spawned a number of lawsuits and resulted in a toughening of standards and a general improvement in fiberglass shingle quality.

Shingle styles have changed as well. The common three-tab shingles of the 1950s and 1960s are now joined by no-cutout shingles, multitab shingles, and laminated "architectural" shingles (Table 2-1). Laminated shingles provide deep shadow lines and a heavily textured appearance, some simulating wood or slate. These now account for over half the shingles sold.

Shingle Quality

Shingle quality is often difficult to determine visually since it is based largely on hidden factors such as the strength of the reinforcing mat (organic felt or fiberglass), the strength and flexibility of the asphalt, and the amount and type of fillers used. In most cases, however, the guidelines outlined below can help to select shingles that perform as promised.

Organic Felt vs. Fiberglass. Organic shingles are built around a thick inner mat made from wood fibers or recycled paper saturated with soft asphalt. Fiberglass shingles, on the other hand, use a lightweight nonwoven fiberglass held together with phenolic resin. Both shingles are then coated on top with a layer of harder asphalt and fillers and topped with colored stone to create a decorative surface and protect against ultraviolet light. A thin layer of asphalt on the bottom is coated with a nonsticking dusting that keeps the shingles from sticking in the bundle. Each type has its pros and cons (Table 2-2).

Organic. In general, organic shingles have better tear resistance and resistance to nail pull-through than fiberglass shingles, making them less likely to blow away during a cold weather installation when they have not yet had a chance to seal. Also, some roofers find that organic shingles are more pliable and easier to work with in cold weather. On the downside, the organic mat is neither fireproof nor waterproof. Organic shingles therefore typically carry only a Class C fire rating.

Although uncommon, manufacturing defects that allow water penetration into the mat can lead to premature curling and cupping of organic shingles. Blistering and curling in warm climates has also been occasionally reported. Organic shingles cost more than comparable fiberglass shingles, but remain popular in colder regions and

TABLE 2-1 Asphalt Shingle Types

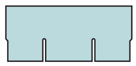
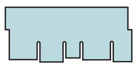
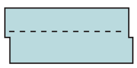
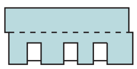
	Weight per square	Length	Width	Exposure	ASTM Fire Ratings	ASTM Wind Ratings
Three-tab 	200–300 lb.	36–40 in.	12–13 1/4 in.	5–5 5/8 in.	A or C	Wind resistant
Multi-tab 	240–300 lb.	36–40 in.	12–17 in.	4–7 1/4 in.	A or C	Many wind resistant
No-cutout 	240–360 lb.	36–40 in.	11 1/2–14 1/4 in.	4–6 1/8 in.	A or C	Many wind resistant
Laminated 	200–300 lb.	36–40 in.	12–13 1/4 in.	5–5 5/8 in.	A or C	Wind resistant

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TABLE 2-2 Organic vs. Fiberglass Shingles

	Pros	Cons	Recommendations
Organic Shingles	Better resistance to tearing and nail pull-through. Easier to install in cold weather with fewer blow-offs.	More expensive. Occasional blistering or curling from moisture penetration or excessive heat. Only Class C–fire rating.	Good for cold climates or cold-weather installations. Look for ASTM D255 certification.
Fiberglass Shingles	Less expensive. Less prone to cupping or curling from heat or moisture. Class A–fire rating. Lighter weight.	Less tear-resistant. More prone to blow-offs in cold weather. Some premature failures reported, primarily with lightweight, low-end products.	Best in moderate and warm climates. Look for ASTM D3462 certification from an independent lab such as UL.

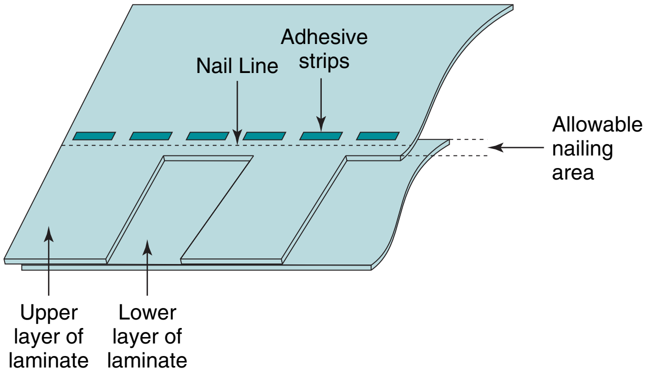
throughout Canada. With organic shingles, shingle weight tends to be a good predictor of performance and longevity since the added weight usually indicates a thicker mat saturated with more soft asphalt.

Fiberglass. Fiberglass shingles, built on a thin nonwoven fiberglass core, were first introduced in the late 1970s and now account for over 90% of the shingles sold. Because they use less asphalt, they are lighter and generally less expensive than organic shingles. Because fiberglass mats are more fire-resistant and moisture-resistant than felt, most fiberglass shingles carry a Class A (severe exposure) fire rating and are less prone to cupping and curling from moisture damage. On the downside, fiberglass shingles are generally not as tear-resistant as organic shingles, making them more prone to blow-offs in cold weather when the shingles have not properly sealed. After they have sealed, they can still tear from movement in the sheathing, since fiberglass shingles have little give, unlike organic shingles. In this situation, if the bond strength of the adhesive strip exceeds the tear strength on a lightweight shingle, the shingles can crack.

Premature failure of some fiberglass shingles due to splitting or cracking led to a number of class-action lawsuits in the 1980s and 1990s. The problems were primarily with lower-end shingles with lightweight mats, types that have been largely eliminated from the market. But it still pays to buy ASTM-rated products from a reputable company that provides a good warranty.

Laminated Shingles. Also called "architectural" or "dimensional" shingles, these have two layers laminated together at the lower half of the shingle, giving the roof a thicker textured appearance with deeper shadow lines. Depending on the shape and size of the cutouts, half or more of the exposed shingle area is triple thickness and the rest double. With the added thickness and without the tabs, which typically wear out first in three-tab shingles,

FIGURE 2-1 Laminated Asphalt Shingles.



In general, laminated or "architectural" shingles perform well due to their heavy profile and lack of cutouts. Nails placed too high, however, may miss the lower layer of laminate, allowing it to come loose over time.

most laminated shingles carry longer warranties as well as higher wind ratings, some as high as 120 mph.

While not immune to the problems of other shingles, such as premature cracking, it is reasonable to expect good performance from a reputable brand. One problem unique to laminated shingles is the loosening of the bottommost piece of the shingle caused, in part, by nailing above the line where the double thickness ends (Figure 2-1).

On many laminated shingles, nails must be precisely placed so they are high enough to stay hidden while still penetrating both layers.

Wind Resistance. Most shingles carry a wind-resistance rating of 60 miles per hour as tested under ASTM 3161 or UL 997, while specialty shingles may be rated to as much as 130 miles per hour. While laboratory tests may not predict actual performance in a storm, a higher rated shingle will likely perform better than a lower rated one. Shingles rated at over 100 mph are often special-order items and typically require six rather than the usual four nails per shingle. Adding two extra nails and extra dabs of plastic roofing cement to a regular shingle can also increase its performance in high-wind conditions (see "Fastening," page 58, and "Manual Sealing," page 57).

A wind-resistance rating is not the same as a warranty. Shingles that carry a wind-resistance warranty generally require that the shingle tabs have been adequately sealed to the adhesive strip and most limit wind coverage to five or ten years from installation. In cold, cloudy weather or on a steep north-facing slope, manual sealing with roofing cement may be necessary.

Algae Resistance. Black streaks on shingles caused by algae or fungal growth used to be limited to warm, humid climates, but now this can be seen on houses as far north as Canada. Some experts attribute the spread to the increased use of crushed limestone as a filler material in asphalt shingles. Limestone is economical and makes a durable shingle, but the calcium carbonate in the limestone supports algae growth. In algae-resistant (AR) shingles, zinc or copper granules are mixed in with the colored stone topping. When the shingles get wet, the zinc or copper is released, inhibiting algae growth. Warranties for algae resistance are usually for less than 10 years since the protection ends when the mineral washes away. Some shingles have longer lasting protection than others due to a higher percentage of AR granules.

Manufacturing Standards. Fiberglass shingles are covered by ASTM D3462, which includes a tear test as well as a new nail-pull-through test added after fiberglass shingle failures started occurring in the late 1980s. A new pliability test was also added in recent years. Organic asphalt shingles are covered under their own standard, ASTM D255. In the past, most companies did their own testing, but under pressure from contractors' associations and others, most now use independent certifiers such as UL. With fiberglass shingles, look for the UL label next to the ASTM D3462 certification. This is not the same as a UL listing for a fire rating, which is printed on most fiberglass shingle packages. More and more jurisdictions are requiring compliance with ASTM standards, but discount shingles are still available with no certification.

As with many consensus standards, the ASTM D3462 requirement for tear strength of fiberglass shingles is considered by many experts to be a bare minimum rather than a guarantee of high quality. Also, once installed the shingles' strength will likely diminish. So finding products that exceed the minimum is recommended for demanding applications.

Warranties. Shingle warranties run from 20 to over 50 years. Although products with longer warranties are usually of higher quality, in some cases, the longer warranties are more of a marketing strategy than an accurate predictor of shingle life. While the specific terms of the warranty are important, more important is the manufacturer's reputation for warranty service in the local area. All manufacturers retain the right to void the warranty if installation instructions are not closely followed, and they can often find a way to avoid honoring a claim if so inclined. Key issues to consider in a warranty are as follows:

- Is the warranty prorated from the date of installation, or is there an introductory term of 5 to 10 years when the full value can be recovered?
- How long are warranties valid against wind damage, algae growth, or other types of damage?
- Does the warranty cover a portion of the labor costs of tear-off, disposal, and installation, or does it cover materials only?
- Is the warranty transferable?

- Perhaps most importantly, does the manufacturer have a strong reputation for warranty service in the local area?

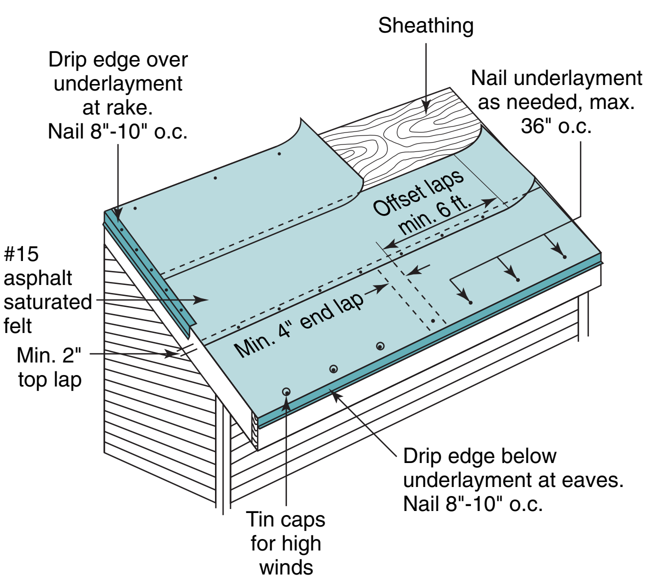
Underlayment

The roof deck should be sound and level before laying the underlayment. Fifteen-pound or heavier felt underlayment is required by code in some areas. Whether or not it is required, underlayment is cheap insurance against problems. There are several good reasons to install underlayment:

- It protects the roof deck from rain before the roofing is installed.
- It provides an extra weather barrier in case of blow-offs or water penetration through the roofing or flashings.
- It protects the roofing from any resins that bleed out of the sheathing.
- It helps prevent unevenness in the roof sheathing from telegraphing through the shingles.
- It is usually required for the UL fire rating to apply (since shingles are usually tested with underlayment).

Standard Slopes. On roofs with a slope of 4:12 or greater, use a single layer of 15 lb. asphalt-saturated felt, starting at the eaves and lapping upper courses over lower by a minimum of 2 inches. Vertical joints should lap a minimum of 4 inches and be offset by at least 6 feet in successive rows (see Figure 2-2).

FIGURE 2-2 Underlayment for Asphalt Shingles.



On roofs with a slope of 4:12 or greater, use a single layer of minimum No. 15 asphalt-saturated felt, starting at the eaves and lapping upper courses over lower. Run the felt 6 inches over ridges and hips from each direction, and 6 inches up any adjoining walls.

Secure each course along seams and edges with enough corrosion-resistant nails to hold it in place until the roofing is installed. In high-wind areas, apply fasteners a maximum of 36 inches on-center along overlaps.

For best protection against leaks, run felt 6 inches over ridges and hips, from each direction, and 6 inches up any adjoining walls. Valleys should be lined with a full width of roofing felt (or bituminous membrane) pushed tight into the valley so there is no slack. Side courses of underlayment should run over the valley lining and extend 6 inches past its edge. (See "Valley Flashing" page 59.)

Low Slopes. Asphalt shingles can be used on roofs with a slope of 2:12 to 4:12 if double-coverage underlayment is used. Start with a 19-inch strip of 15 lb. asphalt-saturated felt along the eaves, and lap succeeding courses by 19 inches as shown in Figure 2-3.

Wherever there is a possibility of ice or snow buildup or the backup of water from leaves or pine needles, install a self-adhering bituminous membrane along the eaves that extends up the roof to a point at least 36 inches inside the interior wall line. An alternative approach, not widely used anymore, is to seal all laps in the lower courses of roofing felt with lap cement or asphalt plastic cement.

In areas with extensive snowfall or windblown rain, the best protection against leakage is to cover the entire low-slope roof area with a bituminous membrane, as shown in Figure 2-4.

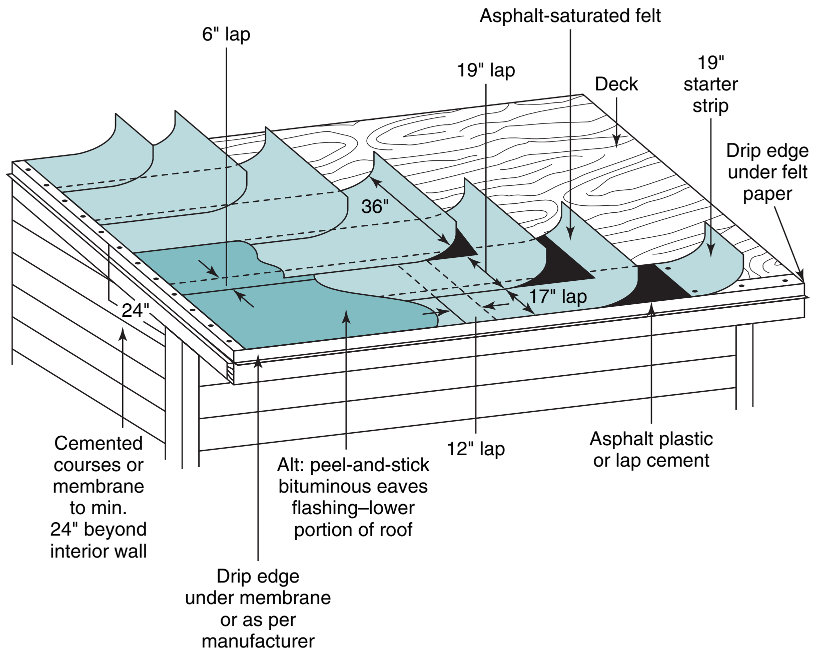
Vertical end laps should be at least 3 inches and horizontal laps 6 inches. If the roof changes to a steeper slope, for example, where a shed dormer joins the main roof, extend the membrane 12 to 18 inches up the main roof slope. Bituminous membranes are self-healing around nail holes, and because they bond fully to the sheathing, any leaks that occur cannot spread. As a safeguard against expensive callbacks, many roofers now apply membrane to the entire surface of any roof with a slope of 4:12 or less.

Eaves Flashing. The best defense against ice dams in cold climates is a so-called "cold roof," consisting of high levels of ceiling insulation separated from the roof surface by a free-flowing vent space (see "Preventing Ice Dams," page 97). Where a cold roof cannot be achieved due to complex roof shapes, unvented roofs, or retrofit constraints, ice dams may form during severe winters, in some cases, causing pooled water to wet wall cavities and interior finishes.

Where adequate insulation and ventilation cannot be assured, self-adhering bituminous eaves flashing should be installed. The membrane should go from the lower edge of the roof to a point at least 24 inches inside the interior wall line (Figure 2-5).

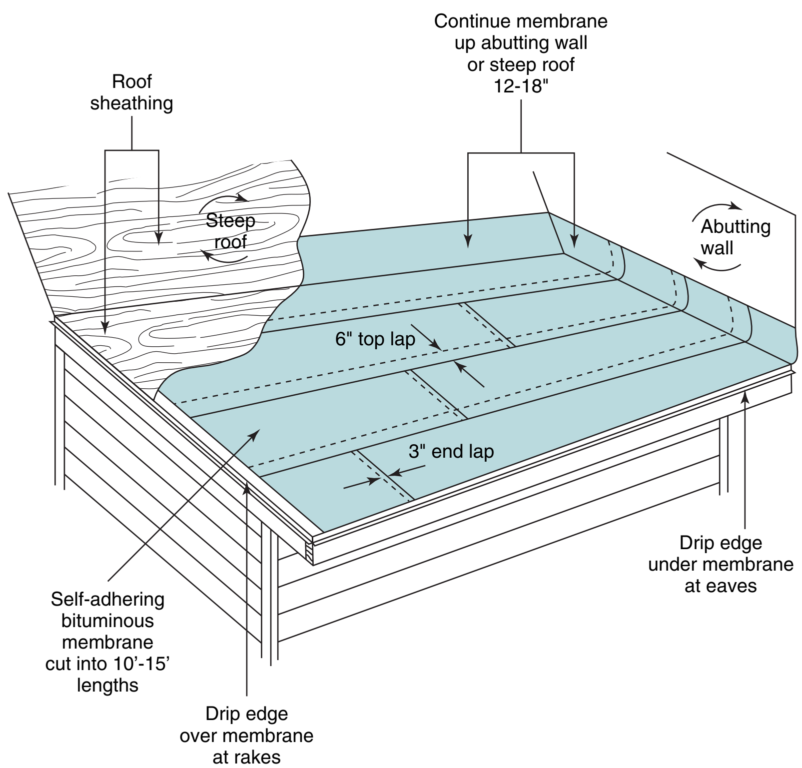
Where two lengths of eaves flashing meet at a valley, run each across the valley, starting with the length from the roof with the lower slope or lesser height. The valley flashing should later lap over the eaves flashing.

FIGURE 2-3 **Low-Slope Underlayment.**



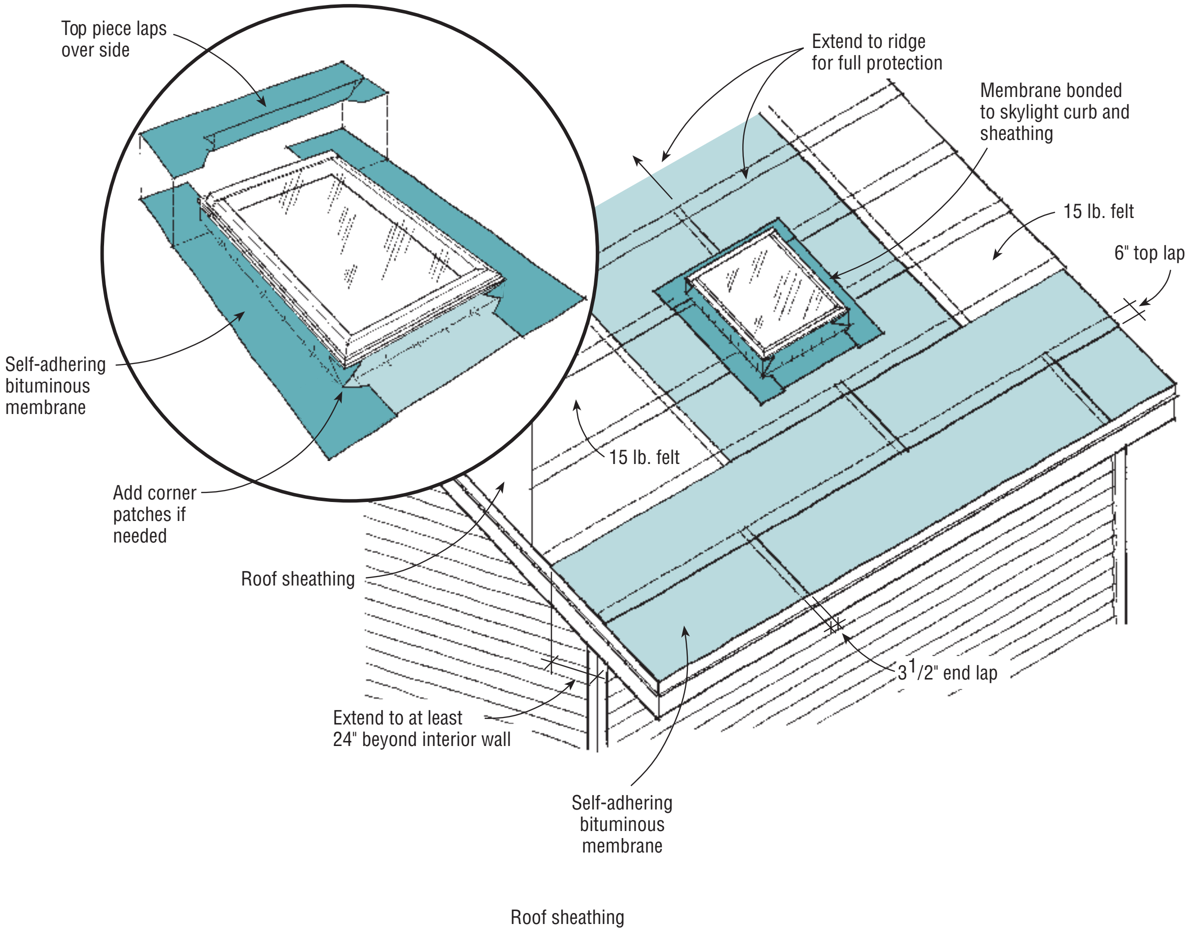
With slopes from 2:12 to 4:12, use a double layer of No. 15 underlayment as shown. Where water may back up from ice or debris from trees, protect the lower portion of the roof with a bituminous eaves flashing or fully cemented felt, as shown.

FIGURE 2-4 **Low-Slope Underlayment in Cold Climates.**



In areas with extensive snowfall or windblown rain, the best protection against leakage is to cover the entire low-slope roof area with a bituminous membrane. Extend the membrane to the top of skylight wells and up any adjacent walls or roof slopes by 12 to 18 inches.

FIGURE 2-5 Eaves Flashing.



Where adequate roof insulation and ventilation cannot be assured, install a bituminous eaves flashing to a point at least 24 inches beyond the inside surface of the wall. Also, continue the membrane up to and around skylights where heat leaks can melt snow and contribute to ice dams.

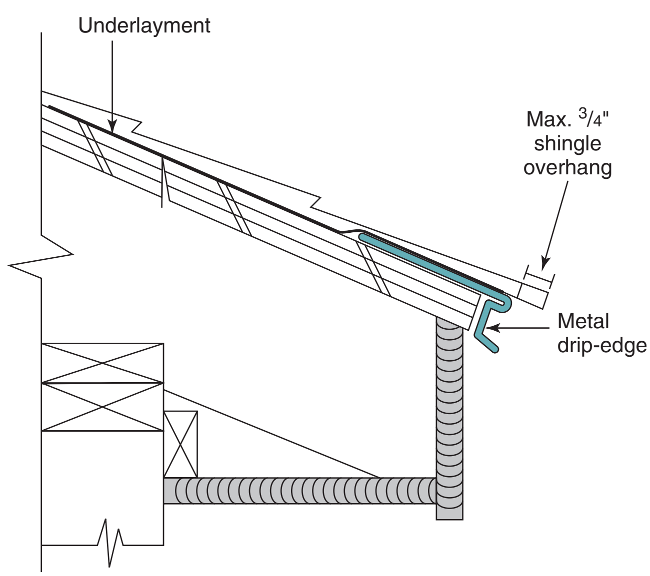
Skylights. With deep snow, melting water from above and around the skylight can lead to ice dams below. For full protection, some contractors extend the eaves membrane up to the bottom of any skylights and continue it around the sides and top of the skylight. By wrapping the skylight curb with membrane as well, any potential flashing leaks are also eliminated as shown in Figure 2-5 (see also "Skylight Flashing," page 127.)

If it is impractical to install membrane all the way from eaves to skylight, install a 3-foot-wide band of membrane below the skylight, lapping the bottom edge of the membrane over the row of shingles where the membrane terminates.

Drip Edge. Drip edge should always be used along the eaves to kick water away from the fascia, and it is a good idea along rakes as well. Drip edge should lap over the underlayment at the rakes and under it at the eaves (as shown in Figure 2-6). Overlap joints in the drip edge by 2 inches. Shingles can be set even the with the drip edge or overlap by up to $\frac{3}{4}$ inch.

Some manufacturers of eaves membranes specify that the drip edge be installed on top of the membrane along the eaves, violating the principle that upper layers of flashing

FIGURE 2-6 Drip Edge.



Install the drip edge over the underlayment at the rakes and under it at the eaves. Shingles may lie flush with the metal edge or overhang by up to $\frac{3}{4}$ inch.

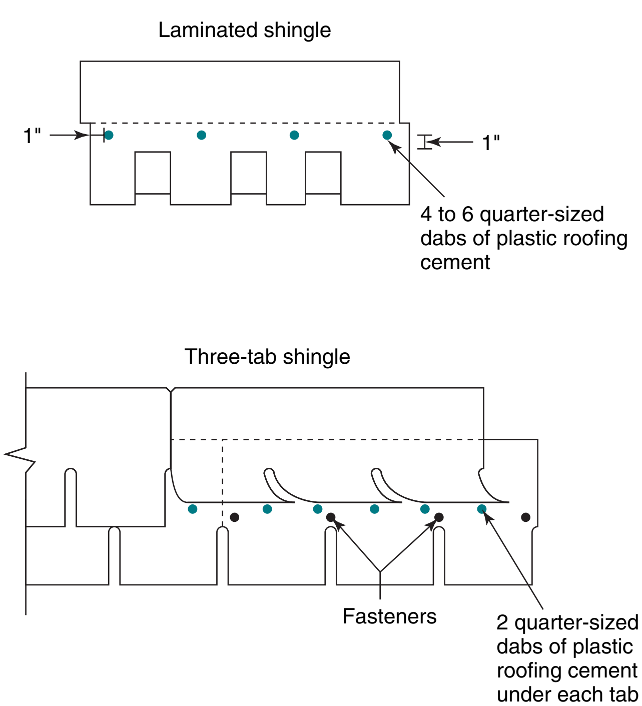
should overlap lower layers. To remedy the problem, the manufacturers suggest using a second strip of membrane to seal the top of the drip edge to the eaves membrane. In practice, however, most installers place the drip edge first and lap the eaves membrane over it, consistent with good building practice.

Installation

Installation Temperature. Ideally, shingles should be installed at temperatures ranging from 40°F to 85°F. Below 40°F, shingles are brittle and crack easily when hammered or bent. Above 85°F, it is easy to tear the shingles or mar the granular coating. In hot temperatures, roofers often start very early in the morning and break at midday. In cold temperatures, it is best to store the shingles in a heated enclosure until they are installed.

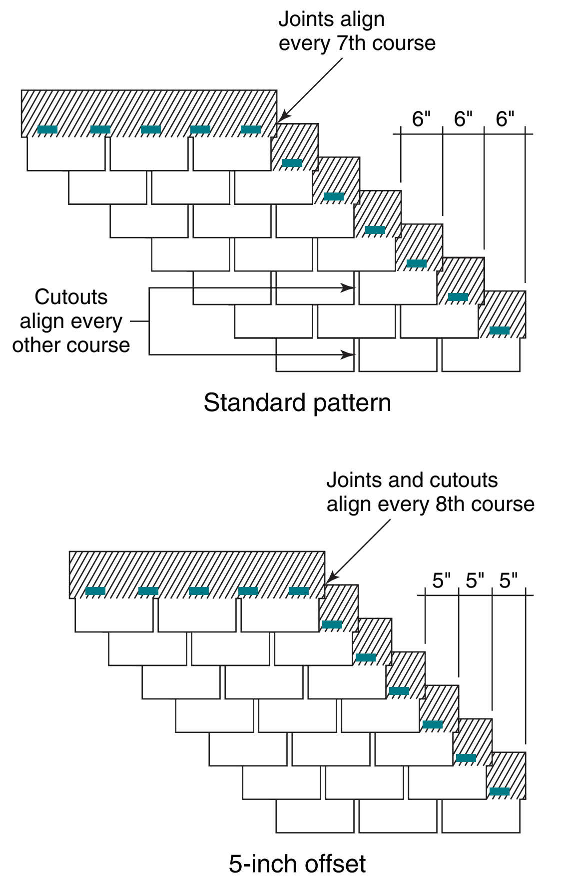
Manual Sealing. In cold climates, the sealant strip may not set up properly and may require manual sealing. For three-tab shingles, place two quarter-size spots of plastic roof cement under the lower corners of each tab (as shown in Figure 2-7). With laminated shingles, place four to six quarter-sized dots, spaced evenly, about one inch above the bottom of the overlapping shingle.

FIGURE 2-7 Manual Sealing of Asphalt Shingles.



Manual sealing of shingles may be required in cold weather or on slopes over 21:12. Three-tab shingles (bottom) require two spots of plastic roof cement under the lower corners of each tab. Laminated shingles (top) require four to six spots spaced evenly about one inch above the lap line.

FIGURE 2-8 Asphalt-Shingle Offsets.



In the standard installation pattern (top), cutouts line up every other course and generally wear out first from channeled water. A 5-inch offset (bottom) creates a more attractive random appearance with less wear in the cutouts.

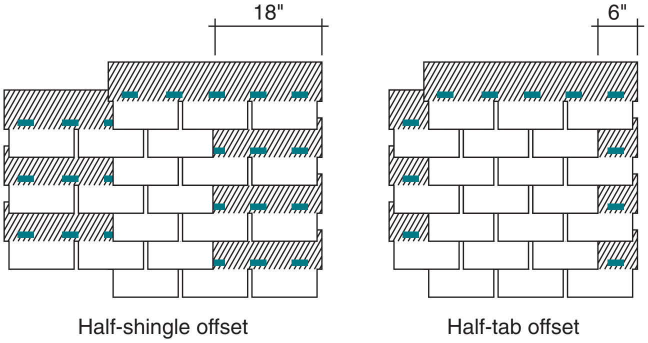
Starter Course. After the underlayment and drip edge are installed, a starter course of asphalt shingles, with the tabs removed, is nailed along the eaves so its sealant strip seals down the first course.

Offsets. Successive courses are typically offset 6 inches (half a tab) on a 36-inch shingle in a stepped fashion, making cutouts align every other course and butt joints align every seventh course (Figure 2-8). For a more random pattern where cutouts align only every eighth course, offset shingles only five inches. Both of these patterns effectively resist leakage, but the 5-inch offset may provide longer wear since water will not be channeled down the cutouts thereby eroding the stone topping.

For ease of installation some roofers install shingles straight up the roof, staggering shingles 6 inches or 18 inches back and forth (Figure 2-9). Since this lines up butt joints every other course, this is considered a less watertight roof and may leak under extreme situations, such as windblown rain on a low pitch. It is not recommended by any roofing manufacturers. Manufacturers also claim that shingle color patterns may create splotches or stripes if laid this way.

Fastening. The preferred fastener is galvanized roofing nails with a minimum 12-gauge shank and head diameter of at least $\frac{3}{8}$ inch. Although staples are allowed in some jurisdictions, they do not provide the same holding power. Both nails and staples should be long enough to penetrate the roof sheathing by $\frac{3}{4}$ inch or penetrate $\frac{1}{4}$ inch through the sheathing if it is less than $\frac{3}{4}$ inch thick. Fasteners should be driven straight and flush with the shingle surface (Figure 2-10). Overdriven nails or staples can cut into the shingle or crack it in cold weather.

FIGURE 2-9 Straight-Up Installation of Asphalt Shingles.



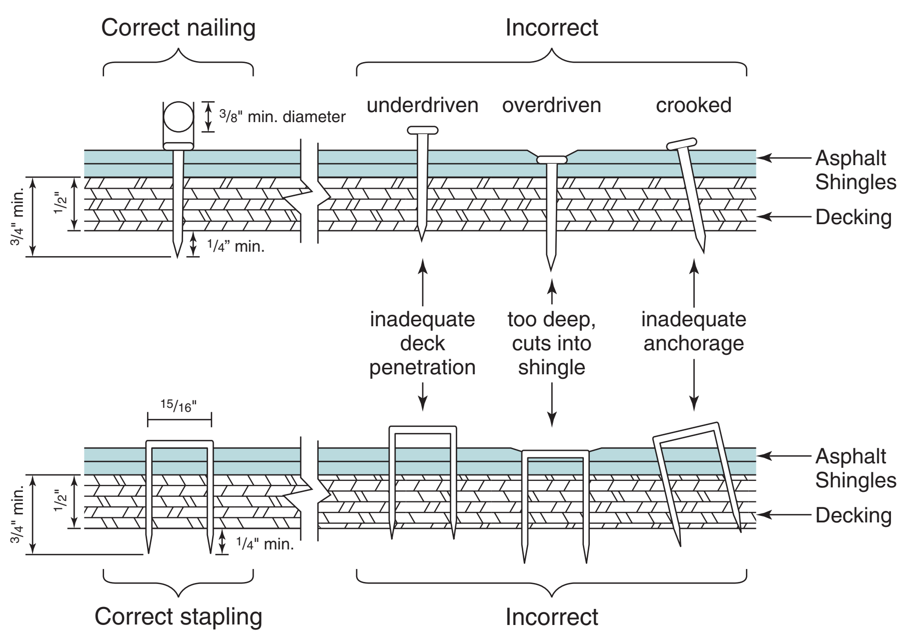
While some roofers install shingles straight up the roof, staggered by either a half tab or half shingle as shown, manufacturers recommend against this approach. With butt joints lined up every other course, leaks could occur on shallow slopes or with windblown rain.

Fastener Location. Standard nailing for three-tab shingles is four nails per shingle, about 1 inch in from either end and one over each slot. Placement should follow manufacturers specs, which typically require nailing and stapling just below the sealant strip (Figure 2-11).

Nailing too high can allow wind to get under the shingles. Nailing too low will expose nails to the weather and to view from below. Nailing through the sealant strip can interfere with sealing.

- ***High winds.*** For areas subjected to high winds, use six nails as shown in Figure 2-11 or add two dabs of sealant at the bottom of each tab (as shown in Figure 2-7). Also special wind-rated shingles with heavier sealing strips are available by special order and may be required in some jurisdictions.
- ***Laminated shingles.*** With laminated shingles, standard nailing is four fasteners spaced equidistant as shown in Figure 2-12, or six fasteners equidistant for heavy-duty installations. It is important that fasteners go in the designated nail area where they will penetrate both laminations. Nailing too high will leave the bottom lamination loose and subject to slipping out of place.

FIGURE 2-10 Asphalt-Shingle Fasteners.



Nails provide better holding power than staples. Either type of fastener should be driven straight and flush with the surface. Overdriving or under-driving weakens the fastener's holding power.

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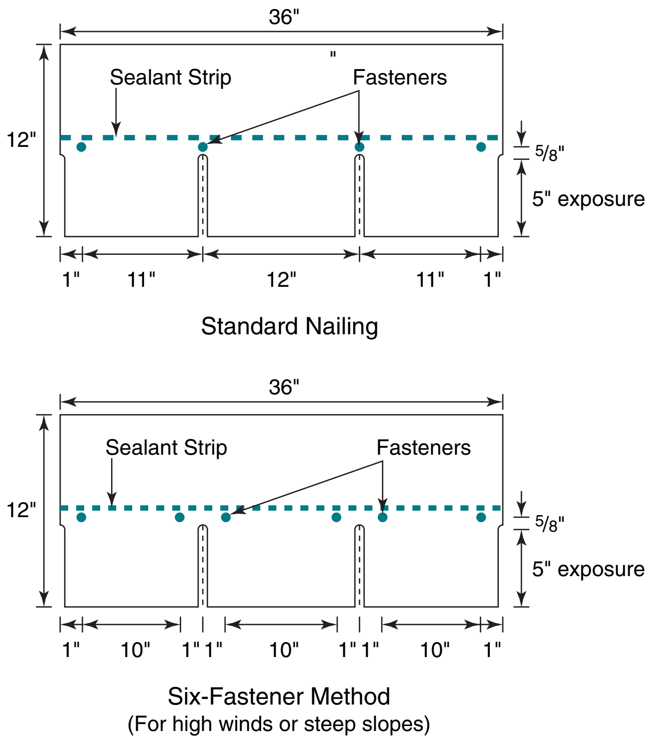
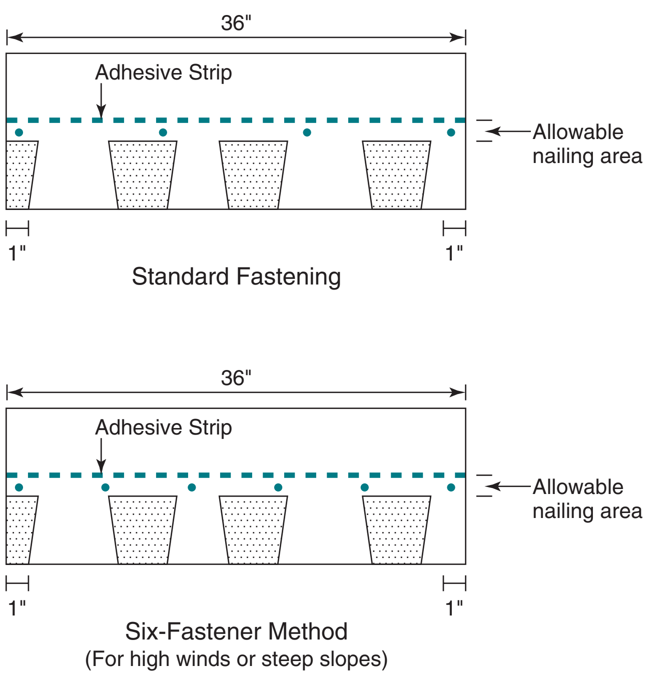
FIGURE 2-11 **Fastening Three-Tab Shingles.**



Standard nailing for three-tab shingles is four nails per shingle just below the sealant strip. For more demanding conditions, such as high winds or steep pitches over 21:12, use six fasteners, as shown.

FIGURE 2-12 **Fastening Laminated Shingles.**



Standard nailing for laminated shingles is four nails per shingle; six per shingle for high-wind conditions or slopes over 21:12. Nails must penetrate both laminations or the bottom layer may come loose.

Low Slopes

Asphalt shingles can be installed on roof slopes of 2:12 to 4:12 if special procedures are followed for underlayment (see "Low Slopes," page 54). Eaves flashing to a point at least 24 inches inside the interior wall is recommended if there is any possibility of ice dams or water backup from leaves or pine needles. A conservative approach is to run self-adhering bituminous membrane over the entire low-slope area. Once the underlayment is complete, shingles are installed in the standard fashion. In cold weather, manual sealing may be required as wind uplift will be greater on shallow roofs (see "Manual Sealing," page 57).

Steep Slopes

Asphalt shingles should not be installed on vertical walls, but they can be used on steep slopes, such as mansard-style roofs. For slopes greater than 21:12, apply underlayment in the normal fashion. However, shingle sealing may be a problem, particularly on shaded portions of the roof. For best performance, use the six-fasteners-per-shingle method (Figure 2-11) and manually seal the shingles with plastic roofing cement (see "Manual Sealing," page 57).

Flashings

Flashings for asphalt shingles should be corrosion-resistant metal with a minimum thickness of 0.019 inch. A cricket or saddle should be installed on any chimney greater than 30 inches wide and can be covered with flashing or the same materials used as a roof covering.

Valley Flashing

Because valleys catch water rushing down two roof planes, they are likely places for roof leaks. Leaks can be caused by water rushing up the opposite side of the valley or from wear and tear caused by the channeled water, snow and ice buildup, or traffic on the roof. For that reason all valleys should start with a leakproof underlayment system to back up the shingle or metal valley detail.

Valley Underlayment. Start by cleaning any loose nails or other debris and nailing down any sheathing nails that are sticking up. If eaves flashing is used, it should cross the valley centerline each way and be installed before the valley underlayment (see "Eaves Flashing," page 54). Next install a 36-inch-wide strip of self-adhering bituminous membrane in 10- to 15-foot lengths up the valley. Keep the membrane tight to the sheathing at the valley center, since any hollow sections could be easily punctured. Next install the 15-pound felt underlayment across the roof, lapping over the valley flashing by at least 6 inches. Roll roofing is also an acceptable underlayment for asphalt shingle valleys, although it is more prone

TABLE 2-3 Asphalt Shingle Valley Types

	Pros	Cons	Recommendations
Woven	Minimal cutting and no sealing required. Very weather resistant due to double coverage across valley.	Both sides must be shingled together. Hollows left under weave may be torn or punctured. Heavy laminated shingles create uneven appearance.	Make sure shingles are pushed tight to sheathing. Use extra nail in top corner of end shingles.
Closed Cut	Each side can be shingled separately. Provides clean appearance with any shingle type.	Single coverage at valley center. Shingles on overlapping side must be clipped at corners and sealed with roofing cement.	Push lower shingles tight to sheathing and use extra nail in top corner of end shingle. Seal shingles carefully. Use bituminous underlayment as backup.
Open Metal	Most durable if appropriate metal is used. Attractive appearance with heavy laminated shingles.	Most costly. Metal lining requires prefabrication. Shingles on both sides must be clipped at corners and sealed with roofing cement.	Use with heavy laminated shingles where decorative appearance is desired. Avoid uncoated aluminum. Best with copper, lead-coated copper, or steel (enameled, galvanized, or stainless)

to crack and is not self-healing around nails. After the underlayment is complete, the valley can be completed in any of the following ways (Table 2-3).

Woven Valley. On the first course across the valley, the shingle from the larger or steeper roof plane overlaps the shingle from the smaller or shallower plane. Extend the end of each shingle at least 12 inches beyond the valley centerline and avoid placing any butt joints near the valley center. Press the shingles tight into the valley when nailing and place no fasteners within 6 inches of the valley center. Add an extra nail at the end of each shingle that crosses the valley (see Figure 2-13).

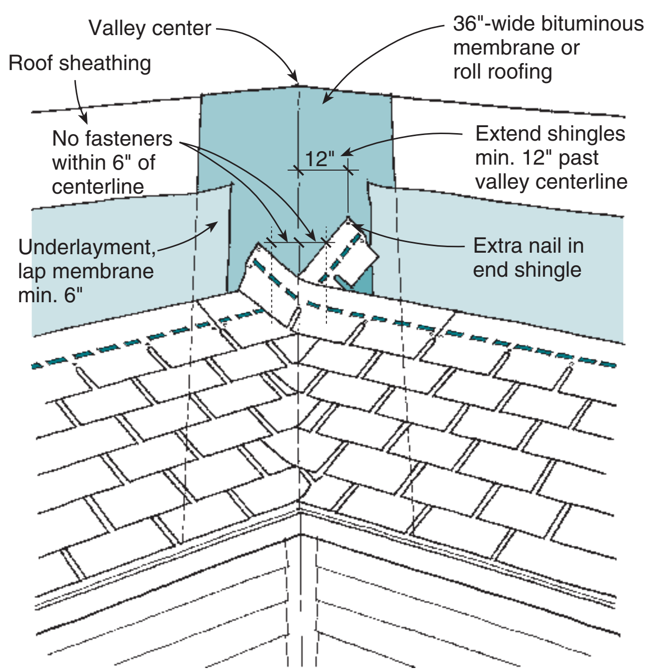
Continue to the top of the valley. Done correctly, woven valleys are very weather-resistant and best for high wind regions, but they are somewhat slow to install. They work better with three-tab shingles than with heavy laminated shingles, which do not conform well to a crisp valley line.

Closed-Cut Valley. This starts the same way as a woven valley, with the first course of shingles run across the valley from both roof planes, lapping the shingle from the larger or steeper roof plane over the shingle from the smaller/shallower plane. Then continue roofing the smaller or lower-slope roof plane, running each course at least 12 inches past the valley centerline. Press the shingles tight into the valley and nail in place, locating no fasteners within 6 inches of the valley center and adding an extra nail at the end of each shingle that crosses the valley (see Figure 2-14). Do not allow any butt joints to fall in the valley.

Next, snap a chalk line 2 inches out from the valley centerline on the opposite slope and shingle up the other side of the valley, holding nails back 6 inches from the valley center. Trim each shingle to the guide line as you go, or run them long and trim them later. In either case, clip about 1 inch off the uphill corner of each shingle to help direct rushing water into the valley. Finally seal each shingle to the valley and to the overlapping shingle with a 3-inch-wide bead of plastic roofing cement.

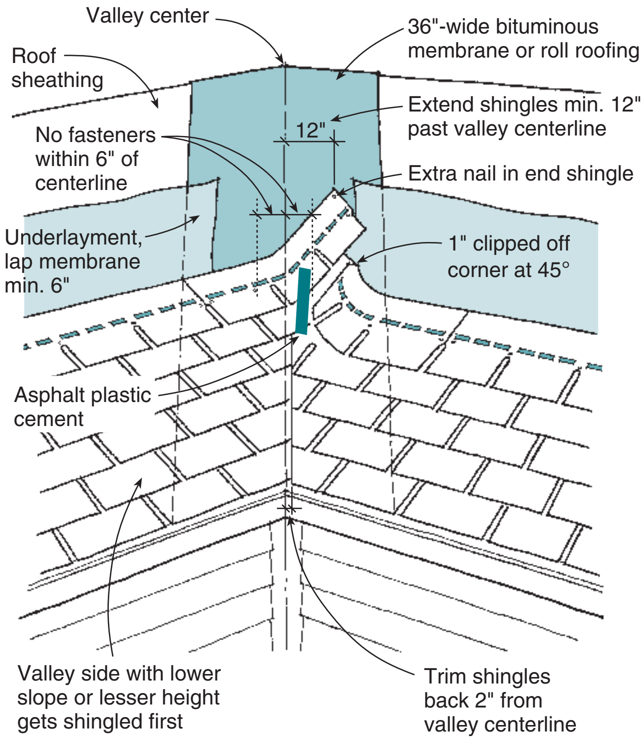
Closed valleys go up quickly and provide a clean appearance with either standard or laminated shingles. If sealed well, they provide adequate protection.

FIGURE 2-13 Woven Valleys.



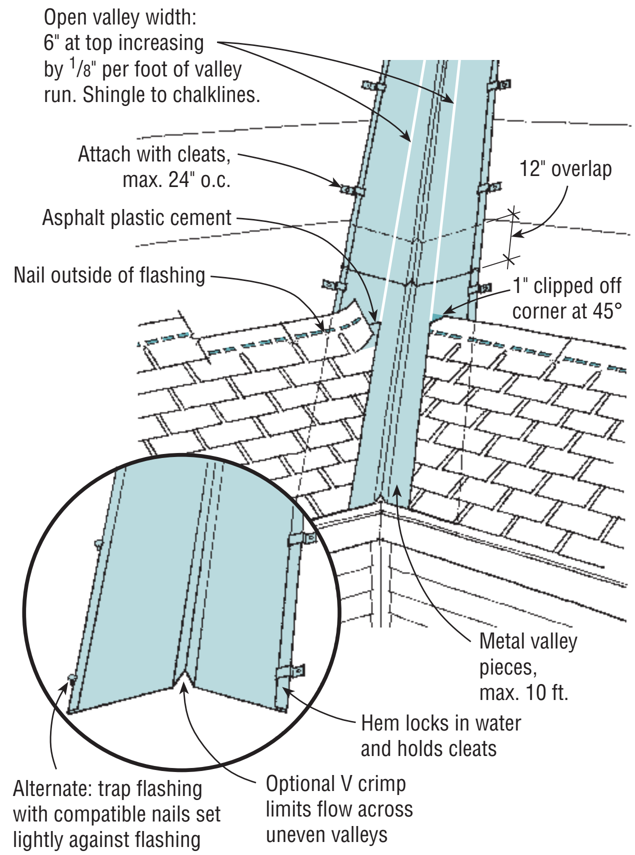
Woven valleys do not rely on roofing cement for a water seal and are very weather-resistant. However, thick laminated shingles may not conform well to a crisp valley line.

FIGURE 2-14 Closed-Cut Valleys.



Closed valleys are popular since they go up fast and allow one roof plane to be shingled at a time. However, they only provide single coverage at the valley center and rely on a good sealant job for weatherproofing.

FIGURE 2-15 Open Valleys.



Open valleys should be wider at the bottom to handle the increased water flow along the valley. To avoid wrinkling in metal valleys, limit sections to 10 feet in length, and fasten with cleats that allow movement. A V crimp in the valley center keeps water from flowing across the valley where the two roof slopes are uneven in size or slope.

Open Valleys. With a heavy-gauge, noncorrosive metal lining, open valleys are the most durable valley and the most costly (see "Flashing Materials," page 6). An economical version uses two layers of roll roofing for the lining, which should last as long as an asphalt roof. The bottom layer of roll roofing goes on with the gravel facing downward; the top layer with the gravel facing upward. Nail along the edges every 12 to 18 inches, keeping the material tight against the roof sheathing.

The valley lining, whether asphalt or metal, should have 6 inches open at the top (3 inches on either side of the valley centerline) and increase by $\frac{1}{8}$ inch for each foot of valley length to accommodate the greater flow further down the valley. So a 16-foot valley would have 6 inches open at the top and 8 inches at the bottom (see Figure 2-15).

Metal valley linings should be 2 to 3 feet wide and no more than 8 or 10 feet in length to prevent wrinkling from lengthwise expansion. Overlap valley sections by 12 inches, and seal the lap with a flexible sealant, such as polyurethane or butyl, on roofs shallower than 5:12. Where two valleys meet, for example above a gable dormer, a soldered joint is likely to break from the movement. A lead cap overlaid 6 inches onto each valley is an effective way to seal the top.

Where the roof slopes are uneven or one roof is larger than the other, a 1- to $1\frac{1}{2}$-inch-high V crimp in the middle of the metal valley will prevent the uneven flow from running up one side of the valley. The crimp also stiffens the valley. A hem is also desirable, both to stop any overflow water and to provide a place to attach nailing clips, which hold the flashing securely while allowing movement. Nails wedged against the edge of the flashing and driven lightly against the flashing may also be used. Clips and nails should be the same metal as the valley or a compatible metal that will not cause galvanic corrosion (see "Galvanic Corrosion," page 83).

Shingles should overlap the valley lining by at least 6 inches. With a roll roofing valley, keep the nails at least 6 inches from the valley centerline. With a metal liner, nail $\frac{1}{2}$ inch outside the liner. Seal each shingle to the liner and overlapping shingle with a 3-inch-wide bead of plastic roofing cement.

Reroofing

Reroofing saves the cost, trouble, and risks (water damage while the roof is exposed) associated with a tear-off. If the roof is structurally sound, most building codes allow for two layers of asphalt shingles and some allow for a third on roofs with a 5:12 or steeper pitch. If the original shingles are not badly curled and the sheathing is sound (check for bouncy areas), then a reroof is a good alternative.

Shingle Type. The heavier the shingle on the new layer, the less likely it is that irregularities in the surface below will telegraph through. Laminated or other heavy-textured shingles work well, as they do not need to be carefully fitted to the existing shingles, and the irregular texture will conceal any small bumps or dips from the original roof.

Prep Work. Clip any curled shingle corners and remove any curled tabs, replacing them with new shingle scraps as shims. Install new drip edge on rakes and eaves. Specialty drip edge profiles designed for retrofitting wrap around the exposed roof edge, leaving a neat protected edge. If the roof had no eaves flashing and one is needed, use a retrofit membrane such as AC Evenseal (NEI, Brentwood, New Hampshire).

Starter Course. If laying three-tab shingles over three-tab shingles, it is important to nest the new shingles against the old to create a flat surface. This process starts with a 5-inch starter strip fit along the eaves and set against the second course of existing shingles (see Figure 2-16).

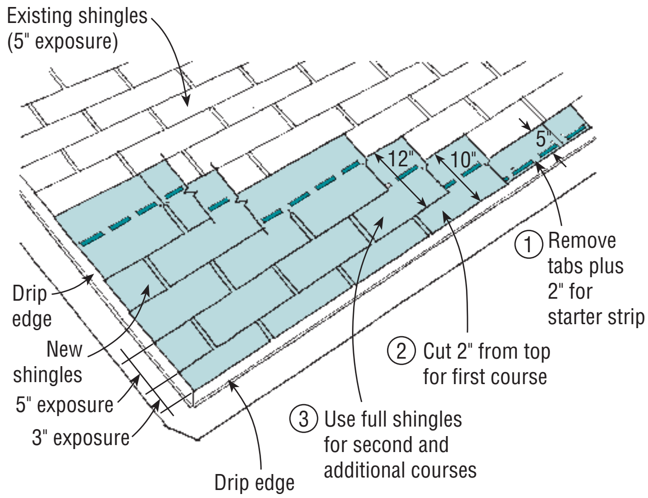
Next install a course of shingles cut down to 10 inches wide, so they fit against the bottom edge of the existing third course (this creates a new 3-inch first course). After that, shingling should proceed normally, fitting each course up against the bottom of an existing course.

Fastening. Use galvanized roofing nails long enough to fully penetrate the sheathing, typically $1\frac{1}{2}$ inches for a second roof and $1\frac{3}{4}$ inches for a third. Nesting each new row below an existing one keeps the new nails 2 inches below the existing, which will help minimize any splitting of the sheathing.

Flashings. Depending on their condition and accessibility, some flashings can be reused. New shingles may be able to tuck under existing step flashing, chimney flashings, and front-wall flashings. If they are deteriorated, they must be replaced along with vent boots.

Valleys. Any type of valley flashing will work and simply lays over the existing flashing (except in a tear-off, where all flashings should be replaced). Unless a metal valley flashing is used, the first step is to line the existing valley with a new underlayment consisting of either 90-pound roll roofing or a more durable modified bitumen membrane. Then install either a closed or woven valley as described above.

FIGURE 2-16 Reroofing with Asphalt Shingles.



When laying new three-tap shingles over existing ones, it is important to nest the new shingles against the old to create a flat surface. Begin with a 5-inch starter course, followed by a 10-inch first course—each set against the bottom edge of the existing shingles. Proceed with full-size shingles, each nested under the existing course above.

CLAY, CONCRETE, AND COMPOSITE TILE

Tile roofing accounts for about 8% of new residential roofs in the United States, primarily in the Southeast, Southwest, and on the West Coast. In addition to its durability and natural beauty, tile is impervious to fire, insects, and rot, and it can be formulated to withstand freeze-thaw cycles. When colored white, tile roofing has been shown to reduce cooling costs by up to 22% for barrel or flat tile (compared to black asphalt shingles in tests conducted by the Florida Solar Energy Center). Since most tile roofs carry a 50-year warranty and a Class A fire rating, they are a popular choice for high-end projects, particularly in warm climates.

Nearly all roofing tiles in the United States were traditional clay until the 1960s when concrete tile first gained acceptance. Concrete tile now dominates most tile roofing markets, primarily due to its lower cost (see Table 2-4). Where weight is a concern, options include lightweight concrete tiles or fiber-cement shingles, which typically weigh even less. Fiber-cement roofing typically simulates

TABLE 2-4 Roof Tile Materials

	Material Costs (typical)	Advantages	Disadvantages	Recommendations
Clay Tile	$400–600 per square	Traditional material. Colorfast, lasts 50+ years, and is virtually maintenance-free. Impervious to fire, insects, and decay. Resists high winds. Can be formulated to resist freeze-thaw cycles. Class A fire rating.	More expensive than concrete tiles. Typically weighs 800–1,200 lb per square. Roof structure may need extra support. High shipping costs unless manufacturer nearby. Very susceptible to breakage from foot traffic.	Confirm structural support is adequate. In cold climates, use vitrified tile with low water absorption. Choose larger tiles for best prices.
Concrete tile	$100–$300 per square	Less expensive than clay tile. Lasts 40–50 years in Southwest; 20–30 years in Southeast. Impervious to fire, insects, and decay. Resists high winds. Can be formulated to resist freeze-thaw cycles. Can simulate shakes or slates. Lightweight version available (550–800 lb per square). Class A fire rating.	Installed costs about three times asphalt shingles. Typically weighs 900–1,200 lb per square. Roof structure may need extra support. High shipping costs unless manufacturer nearby. Colors tend to fade. Lightweight type are very susceptible to breakage from foot traffic.	Confirm structural support is adequate. In cold climates, check warranty for freeze-thaw resistance. Use through-color tiles in cold climates.

slate or wood shakes and provides a Class A fire rating at a cost comparable to wood shakes.

Tile Shapes

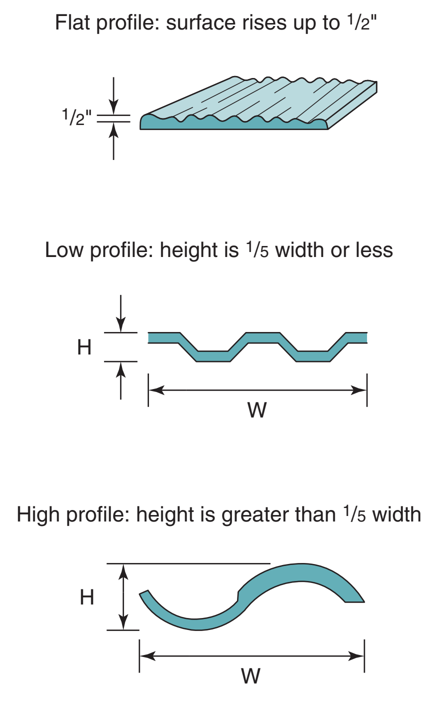
All tiles can be classified as high-profile, low-profile, or flat (see Figure 2-17). Common high-profile tiles include two-piece pan-and-cover Mission tile and one-piece Spanish S-tiles. Low profile styles include a wide variety, many with a double-S shape that creates multiple water courses. Many flat tiles are shaped and colored to simulate slate or wood shakes. In general, patterns using smaller tiles cost more per square for both materials and labor than patterns using larger tiles.

Clay Tile

To make tiles, moist clay is extruded through a die or cast in a mold and then fired in a kiln until the clay "vitrifies," fusing the particles together. Complete vitrification will create a strong tile with very low water absorption, which protects tile from freeze-thaw damage in cold climates or damage from salt air in coastal areas. Where regular freeze-thaw cycling is expected, roof tiles should comply with ASTM C1167 Grade 1, which allows minimal water absorption. Grade II tile provides moderate resistance to frost action, and Grade III tile is porous and should not be used in freeze-thaw areas.

When buying clay tile, look for at least a 50-year warranty on both durability and fading. Costs vary widely, depending on quality, style, and the shipping distance required. In general, patterns using smaller tiles will cost more for both materials and labor.

FIGURE 2-17 Tile Shapes.



The industry generally classifies tiles as high-, low-, or flat-profile depending on the ratio of width to height. Flat tiles often mimic slates or wood shakes.

Color. Clay tiles come in a wide range of colors. Color-through tile takes the natural color of the clay, ranging from light tan to pink and red. Other colors can be added to the tile surface as a clay slurry before firing, but slurry coatings are only suitable for warm climates, as they cannot withstand freeze-thaw cycles. Clay tile can also be colored with ceramic glazes to create a durable, glass-like surface in just about any color. In general, clay tiles do not fade in the sun.

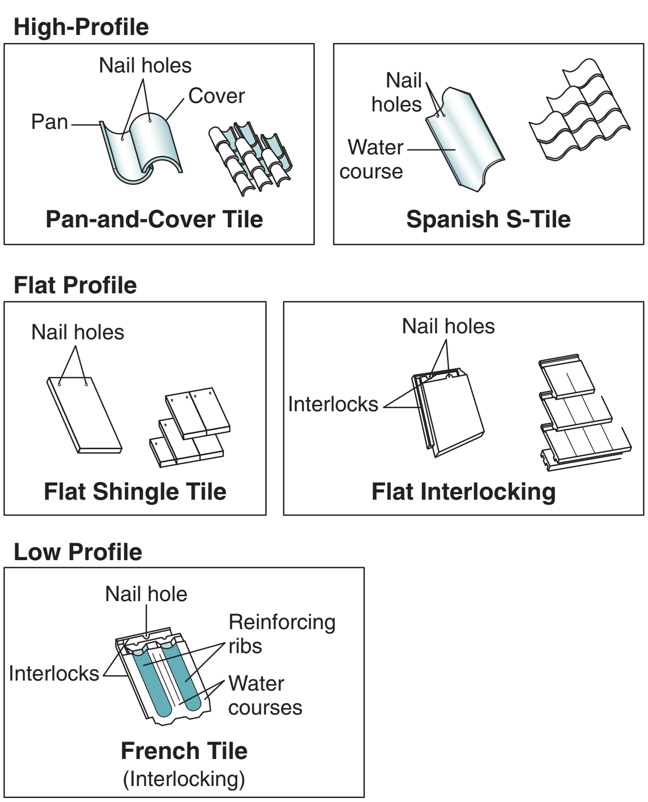
Blended Patterns. Some jobs require the installer to mix two or three different colors in a random pattern. The best way to achieve this is to premix bundles on the ground with the correct proportion of each color, then send them up to the roof for installation. Periodically inspect the roof from the ground for hot spots or streaking.

Clay Tile Styles. Clay roof tiles are available in traditional two-piece styles, one-piece profiles, and flat profiles (Figure 2-18).

Designs are either overlapping or interlocking, with protruding lips that lock the tiles together and form a weather seal. Many flat clay tiles interlock. Interlocking designs are recommended for regions with heavy rain or snow. Manufacturers provide special trim tiles to seal the voids formed at ridges, rakes, and hips.

- ***Pan and cover.*** This traditional two-piece style, also called barrel- or Mission-style, is installed in pairs with the cover tile overlapping the pan tile. It provides an attractive high-profile look but is labor-intensive and expensive to install. Variations include Roman and Greek profiles, which have flat, rather than curved, pan tiles. Tiles typically range from 8 to 12 inches in width and from 16 to 19 inches long.
- ***Spanish S-tile.*** These one-piece tiles provide the high-profile look of traditional pan-and-cover tile but with simpler installation. The most popular S-tiles measure about 13 inches wide by $16\frac{1}{2}$ inches long. Other common sizes are $8\frac{3}{4}$x11 and 9x14 inches.
- ***Flat shingle tile.*** These are laid in a double thickness, like slate. Widths range from 6 to 8 inches, lengths from 12 to 18 inches.
- ***Interlocking tile.*** These are either flat or low profile and are laid in a single thickness with a 3-inch overlap. They have interlocks on the sides with channels or ribs, and butts may also lock into the tops of the underlying shingles. Contours and ribs add strength to the tiles. Widths typically range from 9 to 13 inches and lengths from 11 to 16 inches.

FIGURE 2-18 Typical Clay-Tile Profiles.



Concrete Tile

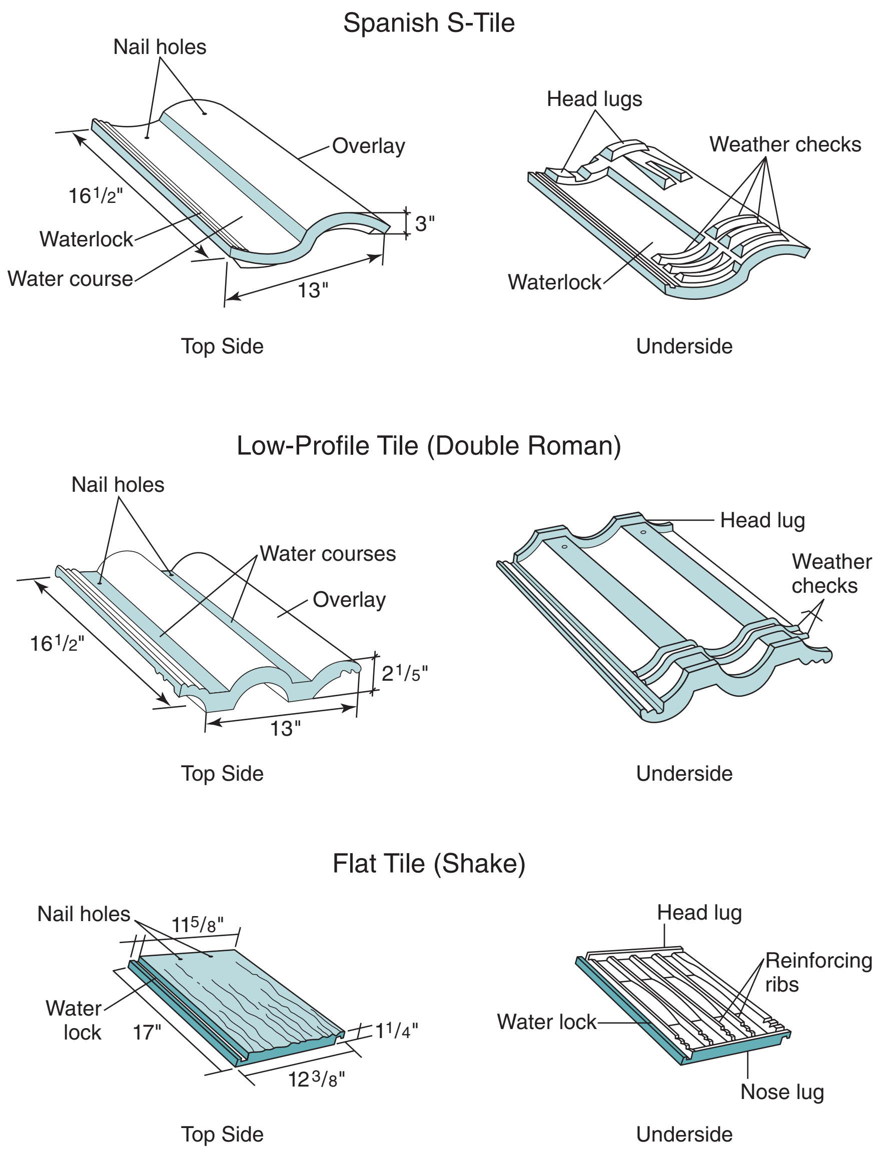
Concrete tiles were introduced to the United States in the early 1900s, but they did not catch on until the 1960s. They now account for more than half the tiles sold in the United States. In Europe, over 90% of new houses have concrete tile roofs. Concrete tiles cost as little as half as much as clay and offer both traditional and flat styles that simulate slate roofing and wood shakes.

High-quality concrete tiles should last up to 50 years in arid climates and up to 30 years in hot, humid climates. While some early products faced problems with freeze-thaw cycling, most newer formulations are made to withstand winter weather. In cold climates, make sure the product is warranted for freeze-thaw durability.

Special lightweight concrete tiles weighing under 600 lb per square are gaining in popularity. Although they cost more than standard concrete tiles and are more prone to breakage, they are easier to handle and suitable for applications where the roof structure cannot support the weight of standard tiles. Lightweight tiles cannot support foot traffic without adding walking pads to distribute weight or filling the space under the tiles with polyurethane foam. They are also not recommended for high-snow regions.

Color. Concrete tiles can be surface colored with a slurry of iron-oxide pigments applied to the surface or have the color added to the concrete mix for a more durable, and expensive, through-color. Through-color choices are more limited, and the colors are more subdued. Either type of tile is also sealed with a clear acrylic spray to help with curing and efflorescence. While the color-through tile will hold its color better than the slurry type, particularly under freeze-thaw cycling, all concrete tile coloring can be expected to fade and soften over time. Surface textures can also be added to flat concrete tiles to simulate wood shakes or shingles.

FIGURE 2-19 Typical Concrete-Tile Profiles.



Concrete Tile Styles. Concrete tiles are available in shapes that simulate traditional clay styles as well as flat profiles that simulate wood or slate (Figure 2-19).

Most are designed with an interlocking channel on the left edge that is lapped by the next tile. Underneath each tile is a head lug at the top and series of ridges at the bottom. The head lug fits over the top of a horizontal 1x batten, if these are used. Otherwise it sits directly on the roof deck. The ridges at the bottom (called nose lugs or weather checks) match the profile of the tile below, creating a barrier against windblown rain and snow. Manufacturers provide special trim tiles to fill in the large voids that profile tiles leave at ridges, rakes, and hips. While many sizes are available, the most common concrete tiles measure 12 to 13 inches wide by $16\frac{1}{2}$ or 17 inches long.

- ***Spanish S-tile.*** These provide the look of traditional two-piece Mission tiles but with simpler installation. Nearly all have interlocking side channels.
- ***Interlocking low-profile tile.*** These have a less pronounced double-S shape and interlocking joints and side channels. Heads and butts may also interlock or simply overlap.
- ***Interlocking flat tile.*** These simulate clay roof tiles, wood shakes, and slate. Ridges, hips, and rakes are easier to seal than with curved tiles.

Fiber-Cement Tile

Early generations of fiber-cement roofing products using asbestos fibers were used successfully in the United States for over 50 years. Newer formulations introduced in the 1980s and 1990s used wood fibers instead of asbestos and were marketed widely in the western United States as a fire-resistant alternative to wood shakes. Made from a mixture of Portland cement and wood fibers, they weighed 400 to 600 pounds per square and were designed to imitate slates or wood shakes. They promised excellent resistance to insects, fungus, fire, and weathering and carried warranties ranging from 25 to 50 years.

Performance Problems. Within five years of installation, however, many of the fiber-cement shakes began to deteriorate. Problems included surface crazing, cracking, delamination, and softening and resulted in a number of lawsuits against key manufacturers and several companies abandoning the product. The problems were generally linked to high water absorption, which created an alkaline solution that was corrosive to the wood fibers.

Some products have fared better than others. In general, products that are steam-cured in an autoclave will have lower water absorption, but they tend to be more brittle. Many products are represented as complying with ASTM C1225, a standard for nonasbestos fiber-cement roofing shingles; but in its current form, this standard does not guarantee long-term durability. Only a product with a proven long-term track record in a specific climate zone should be considered.

Roof Slope

Most manufacturers recommend minimum slope requirements for their tiles as well as special underlayment and fastening techniques for low-slope installations. Typical minimums are shown in Table 2-5. Some manufacturers allow specific tile types to be installed on roofs as shallow as $2\frac{1}{2}$:12 if a full waterproofing layer, such as a built-up roof or single-ply membrane, is installed. Reduced exposure and special fastening techniques may also be required for low slopes. On slopes less than $3\frac{1}{2}$:12, roofing tile is considered decorative only. The underlying roof provides all the necessary waterproofing.

In general, there is no maximum slope for tile roofs. However, on extremely steep roofs above 19:12 or on vertical applications, wind currents may cause tiles to rattle. To avoid this, use wind clips on each tile along with a construction grade silicone sealant or other approved sealant.

TABLE 2-5 Minimum Slope Recommendations (Typical)

	Type	Minimum Slope
Clay	Flat shingle tile	5:12*
	Interlocking flat tile	3:12
	Interlocking low-profile (French) tile	3:12
	Pan-and-cover tile	4:12–5:12*
	S-tile	4:12*
Concrete	Interlocking flat tile	4:12
	Interlocking low-profile tile	4:12
	Interlocking S-tile	4:12

*May be reduced to $2\frac{1}{2}$:12 or 3:12 by using full waterproofing underlayment as per manufacturer and code.

Roof Sheathing

While spaced sheathing is allowed under the codes, most installations today are done on solid wood sheathing with or without battens. The sheathing must be strong enough to support the required loads between rafters. Minimum requirements are nominal 1 inch for board sheathing or $\frac{15}{32}$ for plywood and other approved panel products.

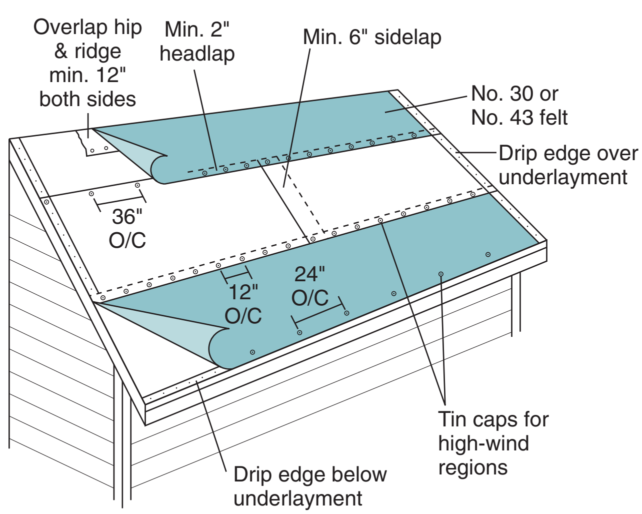
Underlayment

Because of the long service life of tile, a long-lasting underlayment should be used as well. Underlayments play a key role in tile roofing, since most tile roofs are not completely waterproof. At a minimum, use a Type II No. 30 or No. 43 felt, lapped 2 inches on horizontal joints and 6 inches at end laps. The underlayment should lap over hips and ridges 12 inches in each direction and turn up vertical surfaces a minimum of 4 inches (Figure 2-20).

At tricky areas, such as around roof vents, chimneys, and skylights, self-adhesive bituminous membrane can help achieve a watertight seal. In windy areas, use tin caps or round cap nails to hold the underlayment securely. The fastening schedule for the underlayment will depend on local wind conditions.

For harsher conditions or shallower slopes, use mineral-surface roll roofing, self-adhering bituminous membrane, or other durable waterproofing systems. For slopes below $3\frac{1}{2}$:12, the underlayment must provide complete weather protection, and the tiles are considered merely decorative. Underlayment recommendations for different types of tiles and climate conditions are shown in Tables 2-6 to 2-8.

FIGURE 2-20 Underlayment for Roofing Tile.



Use minimum No. 30-felt underlayment for moderate climates and No. 43-felt or mineral-surface roll roofing for high-wind and coastal regions. Tin caps or round cap nails are recommended in windy regions.

TABLE 2-6 Underlayments for Mechanically Fastened Tile Roofing Without Head Lugs

	Roof Slopes from $2\frac{1}{2}$:12, to Less Than 3:12*	Roof Slopes from 3:12 to Less Than 4:12	Roof Slopes 4:12 and Greater
Moderate climates	• Three-ply built-up roofing membrane. • An approved single-ply membrane.	• Two layers of type II No. 30 felt, lapped 19 inches on horizontal (36-inch roll), and 6 inches on vertical. • One layer Type 90 granular surface roll roofing. • An approved single-ply membrane.	Type II No. 30 felt, lapped 2 inches on horizontal, 6 inches on vertical.
Subject to windblown snow, ice dams, or high winds	• Three-ply built-up roofing membrane. • An approved single-ply membrane.	Two layers of type II No. 30 felt, lapped 19 inches on horizontal (36-inch roll), and 6 inches on vertical. Also eaves flashing of self-adhered membrane, or two layers No. 30 felt fully cemented.	Type II No. 30 felt, lapped 2 inches on horizontal, 6 inches on vertical. Also eaves flashing of self-adhered membrane, or two layers No. 30 felt fully cemented.

*Tile considered decorative only at this slope.
SOURCE: Based on recommendations of the Tile Roofing Institute and Western States Roofing Contractors Association.
All recommendations subject to local code.

TABLE 2-7 Underlayments for Tile Roofing with Projecting Head Lugs

	Roof Slopes Less Than 4:12	Roof Slopes 4:12 and Greater
Moderate climates	Consult manufacturer and local codes.	Type II No. 30 felt, lapped 2 inches on horizontal, 6 inches on vertical.
Subject to windblown snow, ice dams, or high winds	Consult manufacturer and local codes.	Type II No. 30 felt, lapped 2 inches on horizontal, 6 inches on vertical. Also eaves flashing of self-adhered membrane or two layers No. 30 felt fully cemented.

SOURCE: Based on recommendations of the Tile Roofing Institute and Western States Roofing Contractors Association. All recommendations subject to local code.

Prep Work

Battens. Tiles with projecting head lugs can be installed either directly on the deck or with the lugs fitting over pressure-treated wooden battens nailed horizontally across the roof. Battens are typically nominal 1x2 or 1x4 lumber, but they may be larger to accommodate snow loads or unsupported spans over counterbattens. Battens should be made from pressure-treated lumber except in very dry climates. They are nailed at minimum 24 inches on-center with spaces for drainage every 48 inches. Lay out battens to provide equal courses with a minimum 3-inch head-lap, unless the tile profile is designed for a specific head-lap. Fasten with 8d galvanized nails or corrosion-resistant $1\frac{1}{2}$-inch 16-gauge staples with $\frac{7}{16}$-inch crowns.

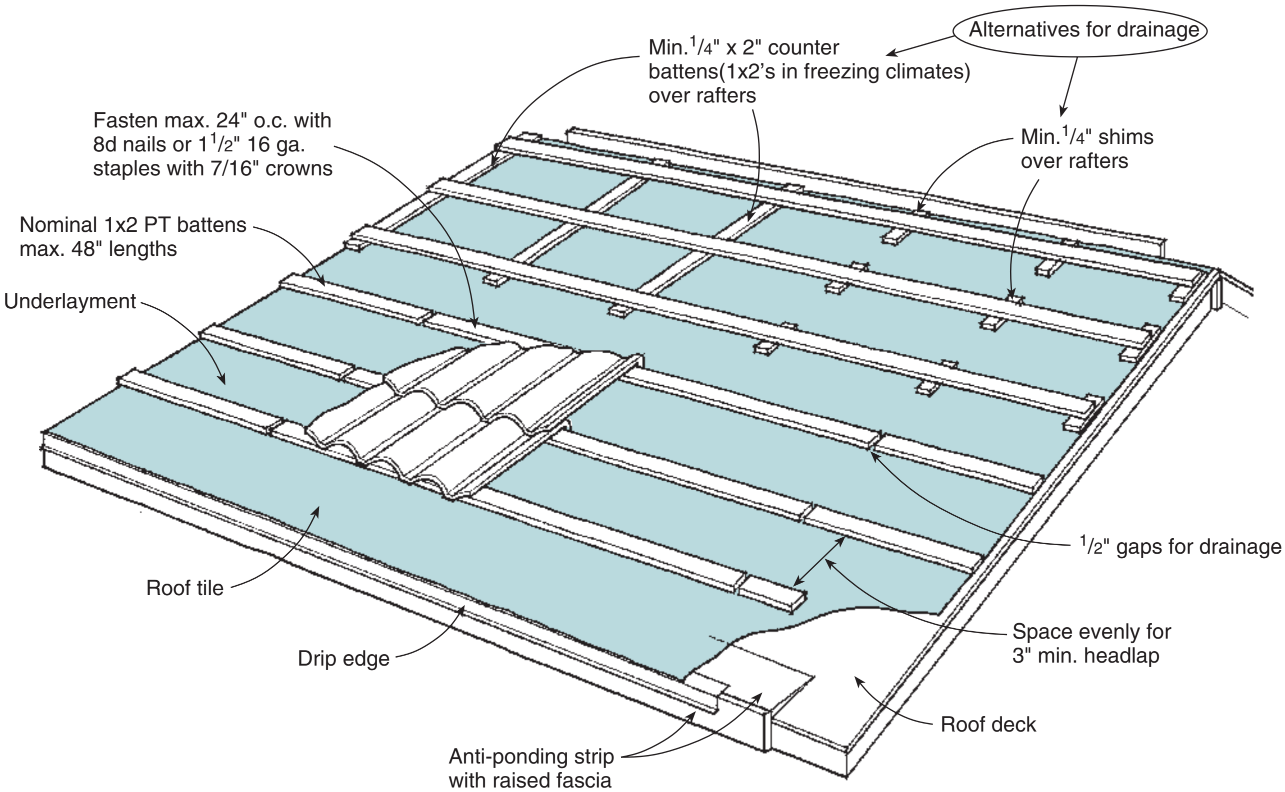
Battens are recommended on roof slopes greater than 7:12 to provide solid anchoring and on slopes below 3:12 to minimize penetration of the underlayment. On low slopes and in areas subject to ice damming, counterbattens

TABLE 2-8 Underlayments for Tiles in High Wind and Coastal Conditions

	Roof Slope 2:12 and Greater	Roof Slope 4:12 and Greater
Mechanically fastened tile (battens or direct deck)**	• Hot-mop or cold process: No. 30 or No. 43 felt base ply plus 90 lb roll roofing or modified cap sheet.* • Self-adhered underlayment applied to wood deck. • No. 30 felt plus self-adhered underlayment.	• Single-ply No. 43 or 90 lb organic or modified cap sheet.* • Two-ply No. 30 or No. 43 underlayment (battens only)
Mortar set tile (direct deck)	Hot-mop or cold process: No. 30 or No. 43 base ply sheet plus 90 lb roll roofing or modified cap sheet*	
Adhesive set tile (battens or direct deck)	• Single-ply 90 lb roll roofing or modified cap sheet. • Hot mop or cold process: No. 30 or No. 43 felt base ply plus 90 lb roll roofing or modified cap sheet. • Self-adhered underlayment to wood deck. • No. 30 felt plus self-adhered underlayment.	

*Plastic cement or approved sealant at fasteners penetrating underlayments.
** All applications below 3:12 must have both vertical and horizontal battens. Above 7:12, battens required for tiles with head lugs.
SOURCE: Based on recommendations of the Florida Roofing, Sheet Metal, and Air Conditioning Contractors, Inc. and the Tile Roofing Institute.
All recommendations subject to local code.

FIGURE 2-21 Tile Installation Over Battens.



Horizontal battens are recommended for tiles with projecting head lugs on roof slopes greater than 7:12. Battens are also used on low slopes to minimize penetration of the underlayment. Vertical counter-battens are recommended to promote drainage on low slopes and in regions with high snowfall.

nailed vertically up the roof slope are also recommended to promote drainage. Counterbattens should be minimum $\frac{1}{4}$x2 inches thick in moderate climates, $\frac{3}{4}$ inch thick in areas subject to ice damming. When battens are nailed directly to the deck, allow a $\frac{1}{2}$-inch gap every 4 feet or set the battens on minimum $\frac{1}{4}$-inch shims placed at each nail (see Figure 2-21).

Layout and Stacking. Lay out the courses so that tile exposures are equal with a head-lap of at least 3 inches (unless the tile specifies a different lap). Snap lines on the underlayment along the top of each course or along each batten. One or more vertical lines can also be helpful in keeping the tiles aligned. Accurate layout is critical with most tile patterns.

Next, carry tiles up to the roof and distribute the weight equally across the roof, as tiles weigh as much as 10 pounds each. Depending on the tile, stacks of about 6 to 10 tiles is workable. If mixing different colored tiles, arrange bundles with the correct proportions on the ground before stacking them on the roof.

Fastening Tile

The preferred method of attachment depends on the type of tile, climate conditions, and slope of the roof.

Loose Laid. For standard concrete tiles with lugs set on battens, building codes still allow tiles to be laid loose at slopes less than 5:12 (except for one nail per tile within 36 inches of hips, ridges, eaves, or rakes). Loose-laid tiles are not allowed, however, in snow regions, areas subject to high winds, or with tiles weighing less than 9 pounds per square foot installed.

Nail on. Nails are the least expensive and most common method for attaching concrete and clay tiles. Tiles can be nailed either directly into the roof sheathing or tiles with lugs can be nailed to battens. Corrosion-resistant nails must be minimum 11 gauge, with $\frac{5}{16}$-inch heads, and long enough to penetrate the sheathing by $\frac{3}{4}$ inch—typically 8d nails. Ring-shank nails or hot-dipped galvanized nails hold better than smooth-shank nails in areas subject to heavy winds. Whether driven by hand or pneumatic nailers, nails should be driven so heads lightly touch the tile but not so tight as to risk cracking tiles. Because of the longevity of a tile roof, some contractors use copper or stainless-steel roofing nails. No. 8 or 9 stainless-steel or brass screws also work well and are sometimes used in high-wind regions.

Most tiles have two prepunched nail holes. On curved tiles, use the hole closest to the deck surface unless a nail there would penetrate a critical flashing. The other hole is

TABLE 2-9 Minimum Nailing for Concrete and Clay Tile in Moderate Climates[1]

Roof Slope	Spaced or Solid Sheathing With Battens	Solid Sheathing Without Battens	Spaced Sheathing Without Battens	Perimeter Tile All Sheathing Types[2]
Less than 5:12	None required[3]	One per tile	As per manufacturer	One per tile
5:12 to less than 12:12	One per tile every other row	One per tile	One per tile every other row	One per tile
12:12 to 24:12[4]	One per tile	One per tile	One per tile	One per tile

[1]For roofs 40 ft high or less in areas without significant snowfall or repeated winds of over 80 mph. In snow regions, min. two nails per tile.
[2]First three tile courses, but not less than 36 in. wide, at any ridge, hip, eave, or rake. Also any roof overhang.
[3]Tiles less than 9 psf installed require one nail.
[4]On roofs over 24:12, the nose end of all tiles should also be securely fastened with wire clips or roofing cement.

also used for cut tiles or applications requiring two nails. For example, all flat, noninterlocking tiles require two nails. And in snow regions, codes require two nails per tile for all types and slopes. Otherwise follow the guidelines in Table 2-9, or the manufacturer's guidelines if they are more stringent.

High-Wind and Seismic Installations

In areas prone to high winds, such as Florida, setting the tiles in mortar was once considered the strongest system. However, newer anchoring systems using wires, special clips, and, in some cases, specialized adhesives have proven more reliable and have replaced mortar-set systems as the preferred approach. Wire and clip systems also perform better than rigid attachment systems in seismic zones, as the flexible systems tend to absorb the shockwaves of an earthquake and protect the tiles from cracking.

Codes vary in their requirements for high-wind and seismic areas but most permit one or more of the anchoring systems described below. Model specifications for high-wind installations are available in the *Concrete and Clay Roof Tile Installation Manual,* jointly published by the Florida Roofing, Sheet Metal and Air Conditioning Contractors Association and the Tile Roofing Institute. General guidelines for high-wind installations or roofs over 40 feet above grade include:

- Fasten the head of every tile.
- Fasten the nose of every tile with clips or other approved methods.
- Secure all rake tiles with two fasteners.
- Set the noses of all ridge, hip, and rake tiles in a bead of approved roofer's mastic.

Twisted Wires. This approach is used on roofs ranging from 2:12 to 24:12 in seismic zones and areas with moderate winds. Rather than nail the tiles to the roof, each tile is wired to a length of twisted 12-gauge wire (galvanized, copper, or stainless steel) running from eaves to ridge under each vertical course of tiles. The twisted wire has a loop to tie into every 6 inches and is attached every 10 feet with special anchors, making relatively few holes in the underlayment (see Figure 2-22).

Because wire systems allow some movement, seismic forces do not tend to break the tiles. Also, damaged tiles are easy to replace by snipping the tie wire and wiring in a new tile. Installation is labor-intensive, however, compared to nailing.

Hurricane Clips. A hurricane clip, also known as a storm clip or side clip, is a concealed L-shaped metal strap designed to lock down the water-channel side of a roofing tile near the nose (Figure 2-23).

Clips are well-suited to concrete tile and are used in conjunction with nails, screws, or other systems that secure the head of the tile. They are approved for use in some hurricane areas, but they should be combined with a nose clip or similar device for maximum protection. Used alone, they may deform or loosen after several storms.

Nose Clips. Also known as nose hooks, butt hooks, or wind locks, these simple metal clips hold down the bottom (nose) end of a roofing tile to prevent strong winds from lifting and breaking the tiles (Figure 2-24).

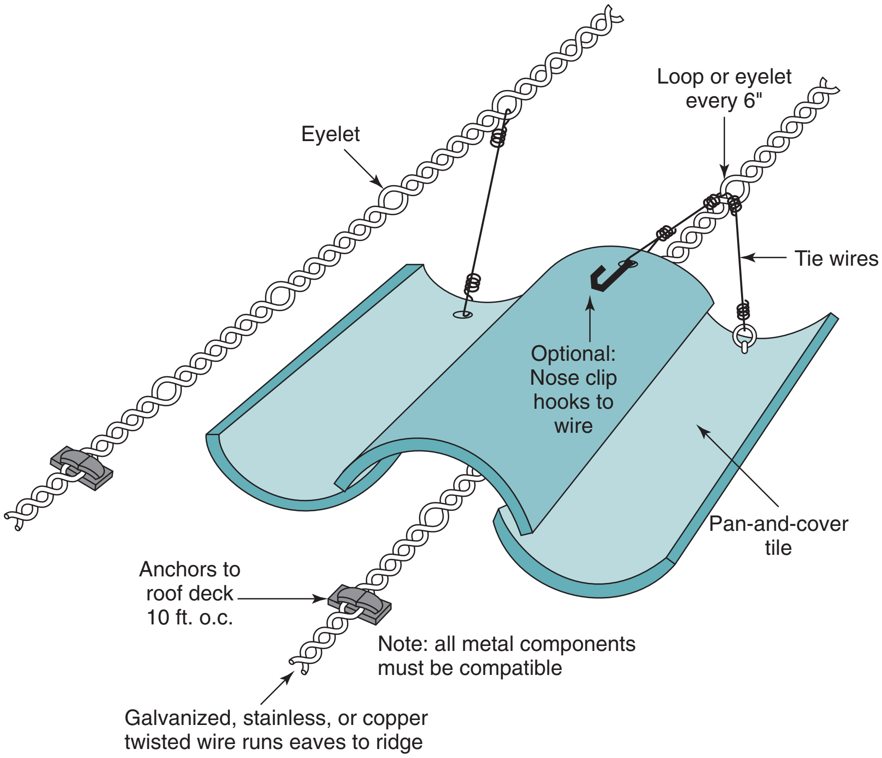
Nose clips are nailed in place through the underlying tile or attached to the tie wires in wire systems. They are compatible with all methods of tile attachment and are recommended for high-wind areas and slopes greater than 7:12. The main drawback to nose clips is that they are visible at the nose of each tile, which some homeowners find objectionable.

Tile Nails. This innovative fastener, used mostly with S-tile or two-piece Mission tile, functions as both a nail and a nose clip. Because the nail is driven about 6 inches above the tile, there is no risk of breakage and the nail hole can be easily sealed with mastic (Figure 2-25).

Tile nails are approved for all slopes and are especially useful in high-wind areas and on very steep pitches such as mansards. They are also useful for securing the first course of two-piece Mission tile. Examples include the Tyle Tye® tile nail from Newport Tool & Fastener Co. and the Hook Nail from Wire Works, Inc.

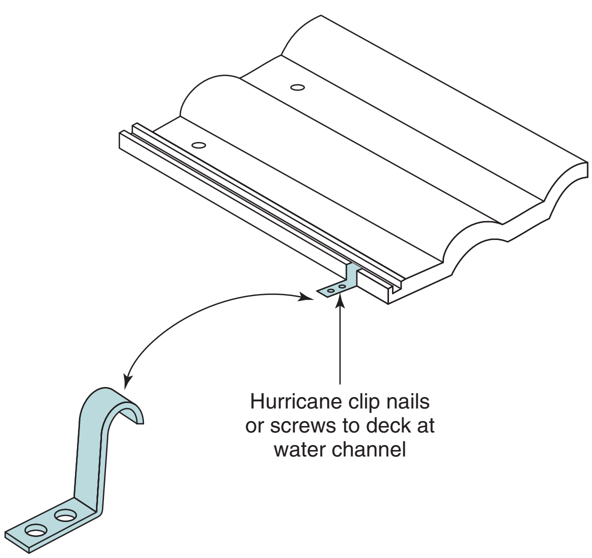
Tile Adhesives. Another way to prevent uplift in windy conditions and to keep tiles from rattling on steep slopes is

FIGURE 2-22 Twisted-Wire Systems.



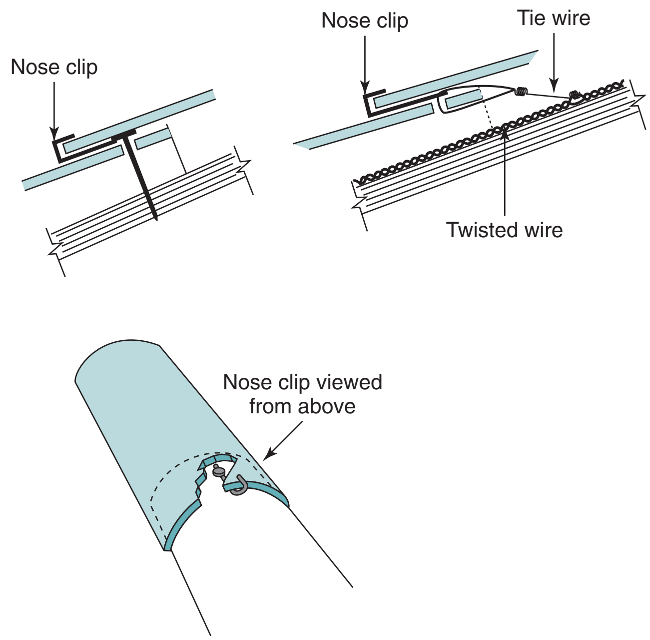
Popular in high-end construction and commercial jobs, twisted wire systems create a nonrigid attachment that performs well in seismic zones. Wires are secured from eaves to ridge with special anchors. High-wind performance can be further enhanced by adding nose hooks, hurricane clips, or adhesives. Avoid mixing components of different metals.

FIGURE 2-23 Hurricane Clips.



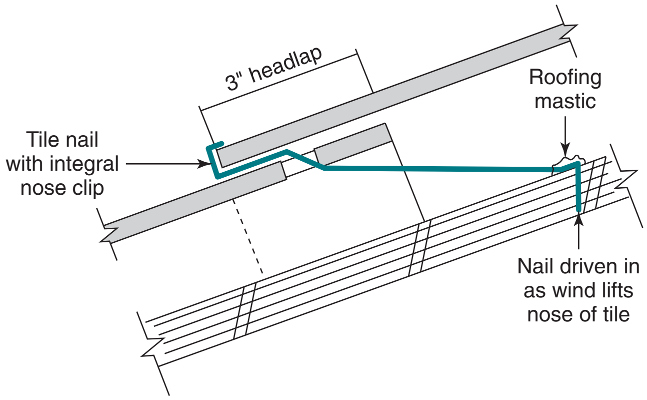
Hurricane clips clamp onto the side of one-piece roof tiles and help prevent tile rotation or movement in high winds. They install quickly and are concealed, but other devices, such as nose clips, may offer better protection. For best performance, secure with screws rather than nails.

FIGURE 2-24 Nose Clips.



Nose clips are recommended for steep slopes and high-wind regions to prevent tiles from lifting in the wind. They are nailed in place through the underlying tile (left) or attached to the tie wires in wire systems (right). Their main drawback is their visibility from the ground, particularly on low roofs.

FIGURE 2-25 Tile Nails.



This innovative fastener functions as both a nail and nose clip. Because it is driven about 6 inches above the tile, there is no risk of breakage. Also, uplift pressure on the nose of the tile tends to drive the nail deeper rather than pull it out. Tile nails are useful in high-wind areas and on very steep slopes such as mansards.

to set the butt edge of each tile in a dab of roofing cement. Over time, however, roofing cement may become brittle and fail. New proprietary tile adhesives promise to last longer and stay flexible over time. In hurricane-prone areas, some contractors are applying adhesive to every tile—in some cases combined with other fastening methods, such as twisted wires. While long-term performance has not been well-established, testing by manufacturers has demonstrated that adhesives can outperform mortar systems in hurricane-force winds.

Installation Details

A number of specialized flashings, tiles, and fittings simplify modern tile installations. Key details for interlocking flat and profile tiles are shown in Figures 2-26 and 2-27.

Eaves Closure. Both profile and flat tile need special treatment at the eaves to raise the bottom edge of the first tile to the correct height and to close off any openings to birds and insects. For profile tile, many contractors use a metal *birdstop,* a preformed L-shaped strip with the vertical leg cut to match the underside of the first tile and fit snugly between the weather checks (see Figure 2-28).

With some high-profile tiles, a special eaves-closure tile achieves the same effect as shown in Figure 2-26.

With flat tiles, the first course may be raised with a special starter tile, as shown in Figure 2-27, or by a metal eaves closure, raised fascia, or wood cant strip. With a cant strip or raised fascia, a beveled wood or foam *antiponding strip* is required to prevent ponding of water along the eaves (Figure 2-29).

Ridges and Hips. Unless hip and ridge tiles are going to be set into a continuous bed of mortar, special nailers are required to install them. The hip and ridge boards are typically 2x3s to 2x6s set on edge to hold the trim tiles in an even plane. They are toenailed in place and individually wrapped with felt (Figure 2-30).

FIGURE 2-26 Spanish S-Tile—Typical Installation.

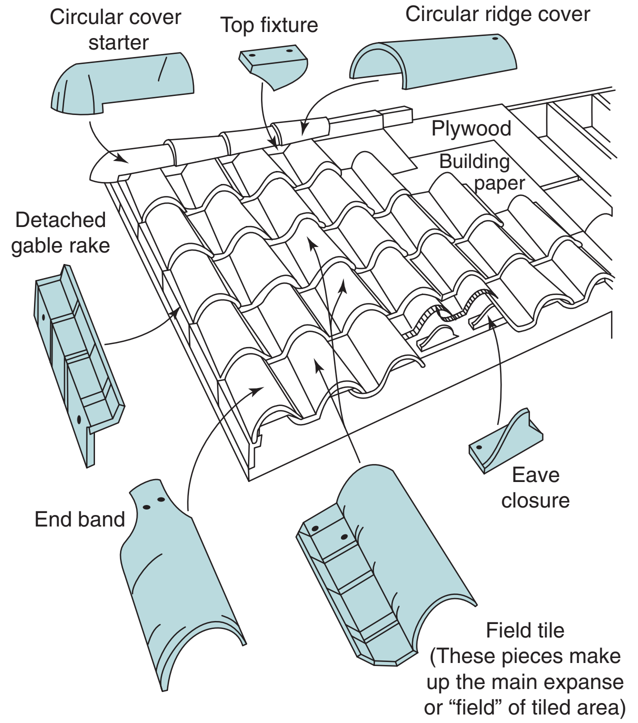


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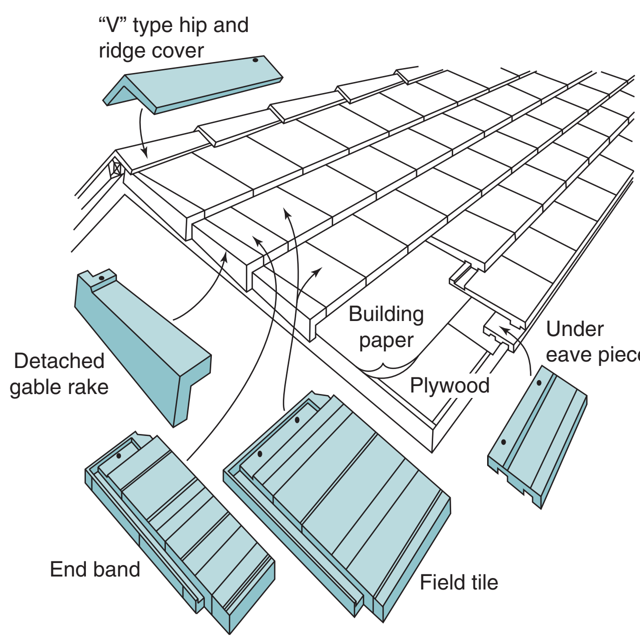
FIGURE 2-27 Flat Interlocking-Tile—Typical Installation.



SOURCE: Adapted from *Architectural Graphic Standards, Residential Construction,* with permission of John Wiley & Sons, © 2003.

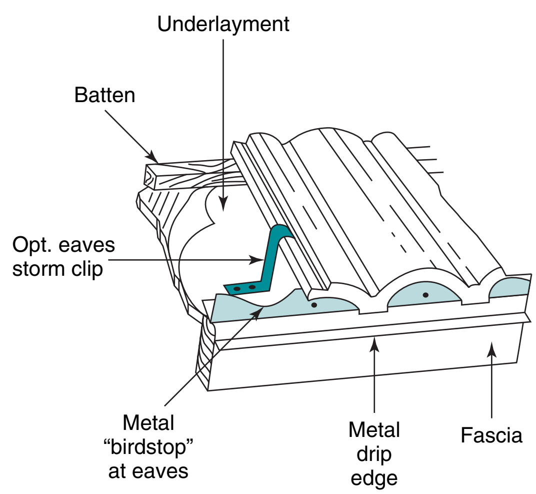
Hip and ridge tiles are later nailed on with a 2-inch head-lap, and the lower ends are sealed at the overlap with roofing cement or an approved tile adhesive. Finally, mortar, special trim tiles, or other weatherblocking is applied to fill in gaps between the ridge and hip tiles and the field tile.

Rakes. Rakes may be finished with detached gable-rake tiles (as shown in Figures 2-26 and 2-27) or with high-profile tiles, trimmed simply with half-round trim tiles as shown in Figure 2-31.

Flashings

Because of the longevity of a tile roof, high-quality flashing materials should be used. The International Residential Code calls for a minimum 26-gauge metal. Galvanized steel should have a minimum of 0.90 ounces of zinc per square foot (G90 sheet metal). More expensive options include prepainted galvanized steel or 16-ounce sheet copper.

FIGURE 2-28 Eaves Closures for Profile Tile.



With profile tile, many contractors use preformed metal birdstop, which is contoured to fit under the first course of tile and lock into the tiles' weather checks.

At Openings and Walls. At walls, dormers, chimneys, and other vertical surfaces, extend the flashing up at least 6 inches and counterflash. Extend flashing under the tile a minimum of 6 inches or as specified by the tile manufacturer. With flat shingles, use step flashing with a minimum 6-inch vertical leg and 5-inch horizontal leg with a hemmed edge. Profile tile along a wall should receive channel flashing turned up at least one inch on the lower flange (Figure 2-32).

Pipe Flashing. Pipe flashings generally get both a primary flashing when the underlayment is installed and a secondary soft-metal underlayment that conforms to the tile. For profile tile, this can be $2\frac{1}{2}$-pound lead or dead-soft aluminum with an 18-inch-wide skirt (Figure 2-33).

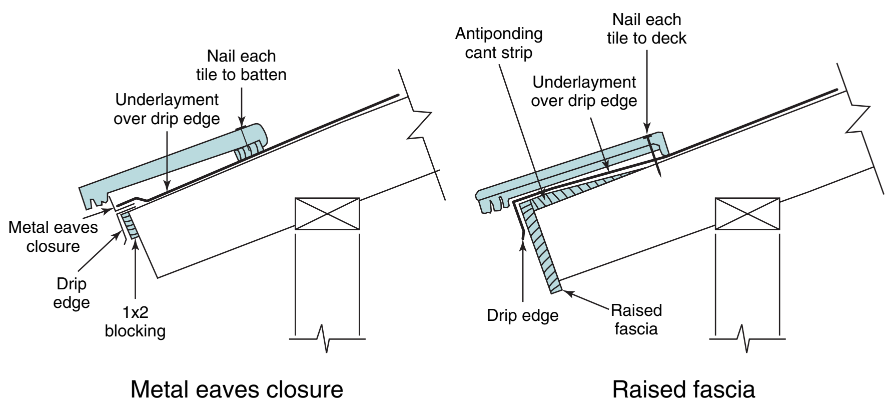
Valleys

According to the International Residential Code (IRC), valley flashing in tile roofs should extend at least 11 inches each way from the valley centerline, and the flashing should have a formed splash diverter at the center at least one inch high. The code requires a minimum underlayment at the valley of 36-inch-wide Type I No. 30 felt in addition to the underlayment for the general roof areas. In cold climates (average January temperature of 25°F or less), a self-adhering bituminous underlayment is recommended. Battens, if used, should stop short of the valley metal.

Tiles along the valley edge may be laid first and cut in place along a chalked line. Cut pieces are attached by roofing cement or a code-approved adhesive, or they may use wire ties, tile clips, or batten extenders.

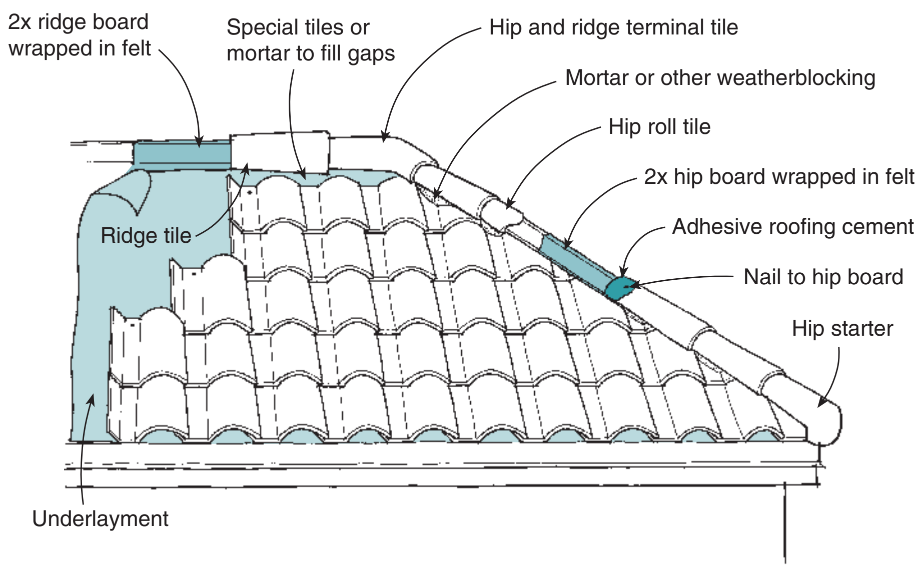
Open Valleys. Open valleys permit free drainage and are recommended in areas where leaves, pine needles, and other debris are likely to fall on the roof. They are also recommended in areas subject to snow and ice buildup.

FIGURE 2-29 Eaves Closures for Flat Tiles.



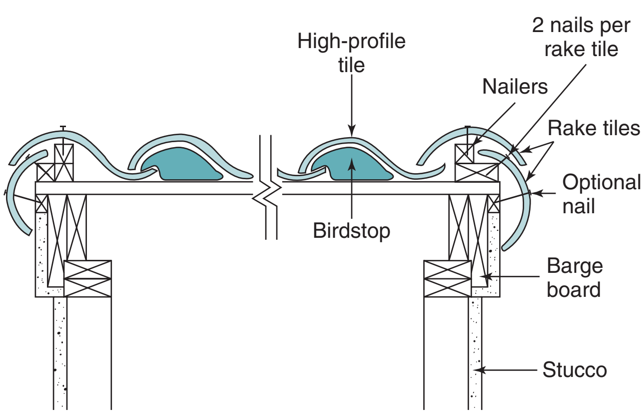
With flat tiles, use either a metal eaves closure (left) or a raised fascia with a beveled cant strip (right), to prevent ponding at the eaves. With a metal closure, no additional antiponding detail is required.

FIGURE 2-30 Tile Ridge and Hip Boards.



Unless hip and ridge tiles are set in continuous mortar, 2x nailers are required to hold them in place. Hip and ridge tiles are later nailed at their heads and cemented where they overlap. Gaps between the hip and ridge tiles and field tiles are sealed with mortar, mastic, or special trim tiles.

FIGURE 2-31 Tile Rake Trim.



With profile tiles, rakes may be trimmed with simple rolled tiles nailed into a nailer or barge board.

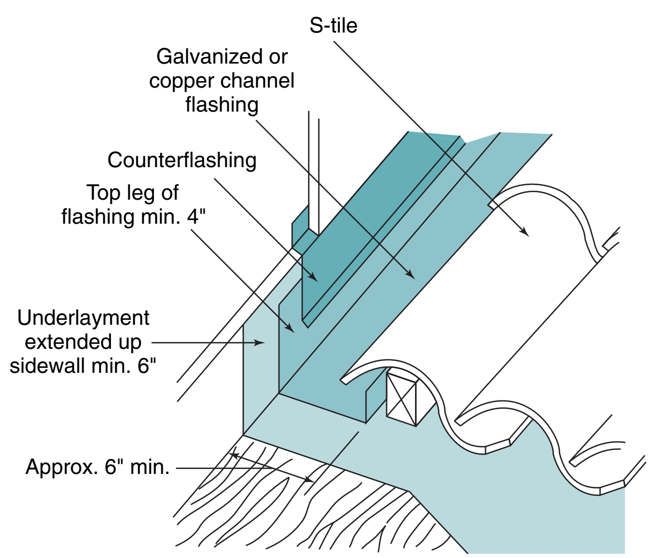
The valley flashing should have hemmed edges and be installed with cleats that allow individual sections to expand and contract (Figure 2-34).

Closed Valleys. In this type of valley, the flashing carries the runoff and the tile in the valley is only decorative. These are not recommended where debris from trees may fall on the roof or where the two roof planes joining at the valley have different pitches or length, causing uneven flows.

Foot Traffic

To prevent breakage, walk on tiles with extreme caution. Profile tile and lightweight tile are the most vulnerable, and concrete tiles are more fragile when they are freshly manufactured or "green." If possible, place antennas and other roof-mounted equipment where it is easy to access without crossing many tiles. When it is necessary to walk on tiles, step only on the head-lap (lower 3 inches) of each tile. With Mission- or S-tiles, it is best to step across two tiles at once to distribute the weight. When significant rooftop work is required, place plywood over the tile to distribute the load.

FIGURE 2-32 Channel Flashing for Tile Roofs.



Where profile tile runs along a chimney, wall, or other vertical surface, place a channel flashing of 26-gauge galvanized steel or 16-ounce copper.