InterNACHI
Student Course Book
"Inspecting Tile Roofs" Online Video Course
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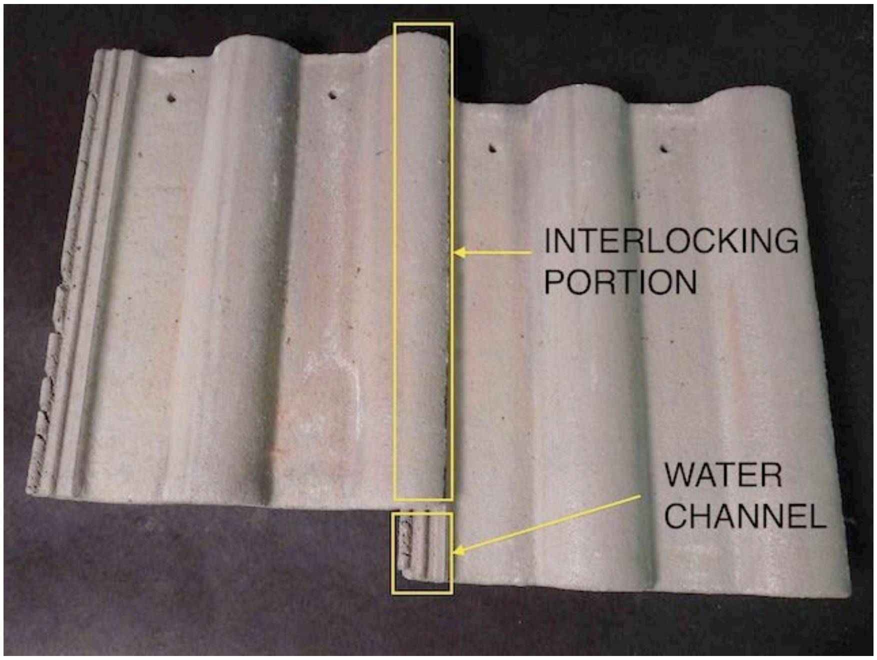


Welcome to the InterNACHI video course on inspecting tile roofs.

This course is designed to help you recognize and identify defects and damage, to determine the sources of those problems as often as possible and to make good recommendations.

Roof tiles come in a huge variety of sizes, styles, materials and weights. Covering all facets of all tile types and styles lies beyond the scope of this course. We'll be concentrating on the basics of installation, defect recognition, and general performance performance characteristics. Along with roof tiles, we'll cover related components like underlayment, flashing and fasteners. We'll cover the general, industry-accepted methods for installation, where to look for defects, how to recognize them, how to determine how serious they are, and how to tell when tile roofs are at or near the end of their useful lives. The sections on inspecting for damage from wind and hail were developed with the cooperation of members of the insurance and roofing industries.

Although we'll use common terminology throughout this course, you should keep in mind that different names for the same things are sometimes used in different parts of North America. The exact terms you choose are not as important as making sure that you explain conditions clearly and in a way that they will be understood.

Tile roof installation methods can vary with the particular type and profile of tile, with the manufacturer's requirements, with roof height and pitch, with the wind and climate zones in which the structure is located, and sometimes with jurisdictional regulations like those of provincial, state, county or city governments. Now, I know that sounds pretty complicated, but I do have a little ray of sunshine for you, and that is that most tile manufacturers and jurisdictions accept the installation recommendations of the Tile Roof Institute, and their installation manuals for moderate and cold weather climates are available for free on their website.

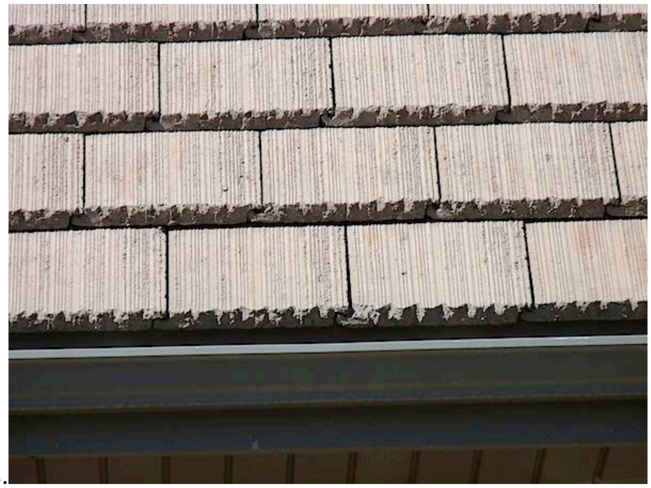
Because of the many variables, this course will be limited to examining the properties of, and installation methods for… a wide variety of the most common types of tile. In general, you'll be looking to see that the installation method used appears to be adequately protecting the home from moisture intrusion and holding tiles in place.

TYPES of TILE

The materials most commonly used for roofing tiles are clay and concrete. In the past, tiles made from fiber cement were common, but are no longer manufactured in the US due to legislation enacted to limit the use of asbestos in products. Tiles made from a variety of other materials are also available.

The Tile Roof Institute divides roof tiles into four profile classifications:

1. Flat profile tiles like flat tiles have a surface rise of ½-inch or



less.

2. Low profile tiles have a rise to width ratio equal to or less than 1 in 5, meaning the tile is a maximum of 1-inch high for every 5 inches in width.

3. High profile tiles have a rise to width ratio greater than 1 in 5, meaning tiles are at least 1-inch high for every 5 inches in width

4. Accessory tiles are tiles used in conjunction with low, medium or high profile field tiles. Accessory tiles are used at areas like ridges, rakes, hips, valleys and in starter courses.

SIDE PROFILES

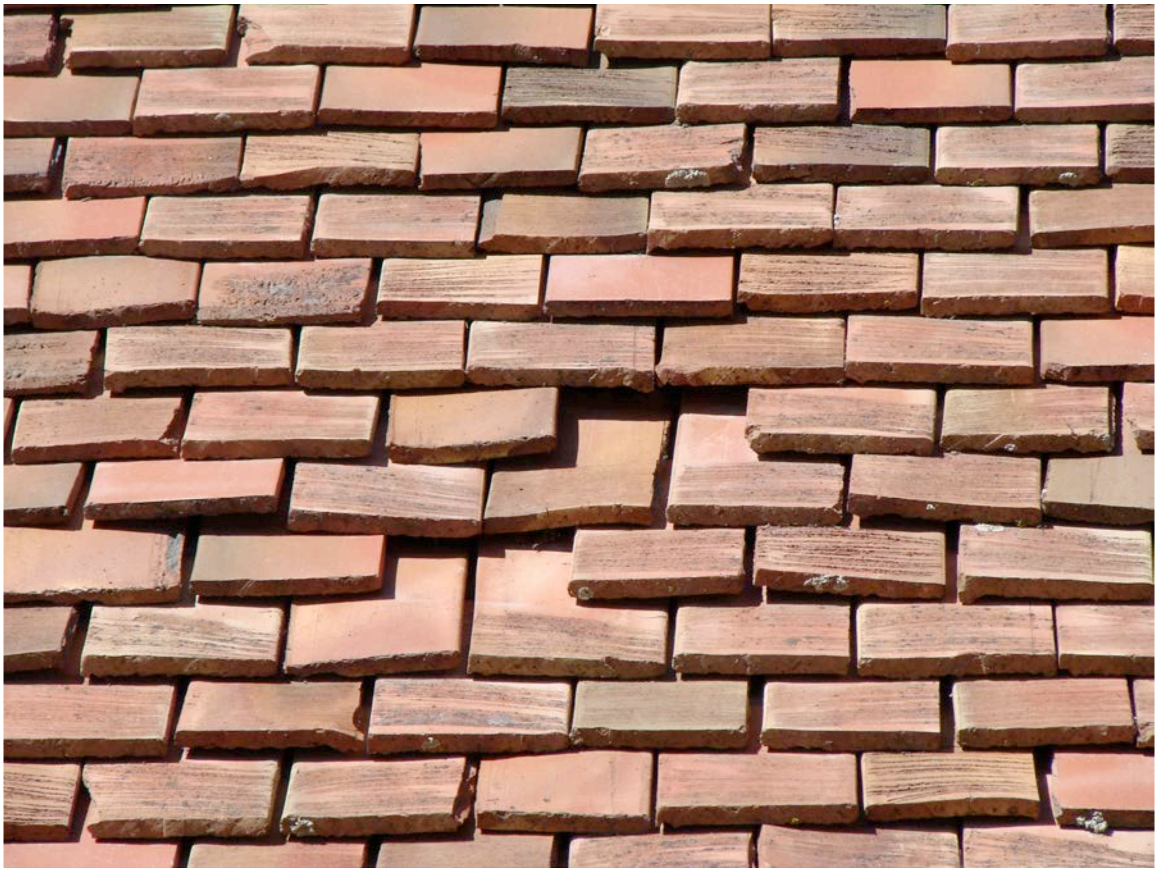
Tiles are installed shingle fashion, with each course overlapping tiles in the course below. Tiles in the same course may interlock, may overlap, or may butt.

Interlocking tiles

Interlocking tiles are manufactured with edge profiles that fit together to keep tiles aligned and help seal against moisture intrusion. Interlocking tiles consist of a coverlock that overlaps an underlock that also serves as a water channel. Different tiles will have different interlock profiles

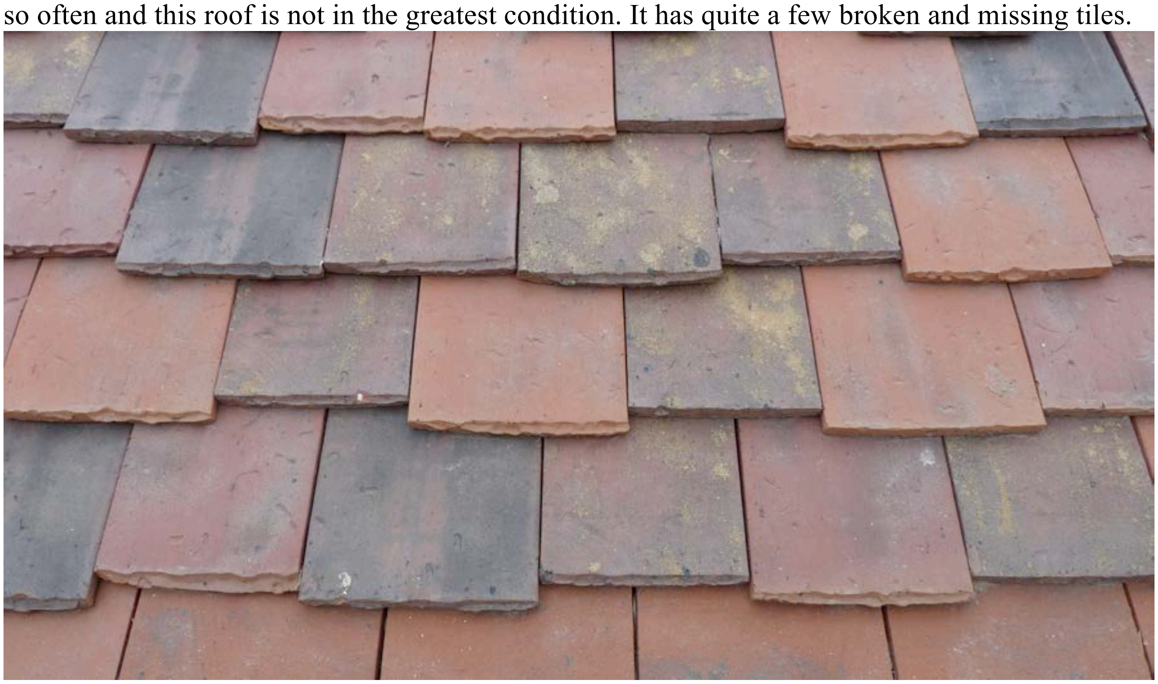
Overlapping tiles

Overlapping tiles may be a two-piece pan and cover, or may be “S-tiles”. Pan tiles are installed in courses oriented vertically up and down the roof, with upper tiles overlapping lower tiles.



Butting tiles

Flat tiles sometimes simply butt adjacent tiles in the same course. You don't see butting tile quite so often and this roof is not in the greatest condition. It has quite a few broken and missing tiles.



These are higher quality tiles in good condition.

Quantities per Square

Roof tiles come in a wide variety of sizes. Thicknesses for different models ranges from about 3/8- of an inch to an inch and a half. The size of each tile and the exposure determine how many tiles are needed to cover a square, which is an area 10 feet by 10 feet. At maximum exposure, the number of tiles per square may be anywhere between 75 and 400.

Quantities per Square

Weight can also vary, with Standard clay tiles weighing from 600 to 650 pounds per square, while concrete ties weigh from 800 to 1100 pounds per square. Lightweight concrete tiles may weigh from 500 pounds to about 800 pounds per square. Some types of plastic comp0osite ties may weight less than 250 pounds per square.

PERFORMANCE STANDARDS

For strength and resistance to damage from the freeze/thaw cycle, roof tiles should meet ASTM standards. For concrete tiles, this will be ASTM C1492. For clay tiles it will be ASTM C1167. An important part of the standards are resistance to moisture absorption and damage from the freeze/thaw cycle. Underwriter's Laboratory Standard UL2218 is for impact rating. The Cool Roof Rating Council maintains a third-party rating system for radiative properties of roof-covering materials, including tile. Radiative properties are those properties that relate to absorbing and emitting heat, and reflecting sunlight.

ROOF DECK

Tile may be installed on a variety of roof deck materials, including metal, concrete and either solid wood panels or spaced wood boards. When tile is installed over concrete or metal, it will be hung on battens that should be fastened to the deck with a fastener type that effectively anchors the batten to the roof deck. Whatever the type of roof deck material, it should be structurally adequate to support the anticipated roof loads, including snow. Confirming the structural adequacy of the roof deck requires engineering calculations, and lies beyond the scope of a typical roof inspection. Those inspecting roofs should be looking for signs of failure, like sagging rafters or roof deck.

UNDERLAYMENT

Since tile is not waterproof, proper underlayment is important to good installation. A minimum of 30-pound felt underlayment is recommended for installation beneath both clay and concrete tiles. Felt or synthetic underlayment should be fastened with gasketed nails like plastic caps to help seal nail holes.

Underlayment requirements can vary with jurisdiction and will vary with roof pitch. Generally, roofs from 4&12 and greater should have at least one layer of 30-pound asphalt-saturated felt, with a 6-inch endlap and a 2-inch headlap.

Slopes between 3&12 and 4&12 should have 90-pound roll roofing, two layers of 30- pound asphalt-saturated felt, or a single-ply membrane like Ice and Water Shield installed. 30-pound felt installed with a 19-inch overlap will result in the underlayment being two layers thick.

Here you can see the difference between felt underlayment installed with a 19-inch overlap, at the right, and felt installed with a 2-inch overlap, at the left.

Tile on roof slopes of less than 2 ½ &12 are considered to be decorative and should have a built-up roof or waterproof membrane installed beneath the tile.

Synthetic underlayment may void the warranty with some tiles, but without documentation, or familiarity with the particular brand and model of the tiles on the roof, you will not be able to confirm the presence of synthetic underlayment as improper.

TRI/WSRCA

TABLE 1A

ROOFING TILE APPLICATION[1] FOR ALL TILES		
	ROOF SLOPE 2 ½ UNITS VERTICAL IN 12 UNITS HORIZONTAL (21% Slope) TO LESS THAN 3 UNITS VERTICAL IN 12 UNITS	**ROOF SLOPE 3 UNITS VERTICAL IN 12 UNITS HORIZONTAL (25% Slope) AND OVER**
Deck Requirements	Sheathing must be adequate to support the loads involved, but not less than nominal 1-inch thick lumber or 15/32 inch thick plywood or other decking material recognized in a code evaluation report or by the local building official. The use of sheathing less than 15/32-inch will require supporting data.	
Underlayment In climate areas subject to wind driven snow, roof ice damming or special wind regions as shown in UBC Chapter 16, Figure 16-1 as defined by local building official.	Built-up membrane, multiple plies, three plies minimum, applied per building code requirements or code approved alternate.	Same as for other climate areas, except that extending from the eaves up the roof to a line 24" inside the exterior wall line of the building, two layers of underlayment shall be applied shingle fashion and solidly cemented together with an approved cementing material per UBC. As an option code approved self adhering membrane will be allowed.
Other Climates		Minimum one layer ASTM D226 Type II (No.30 Felt) (ASTM D4869 Type IV) head lapped 2 inches and end lapped 6 inches, or approved equal per UBC. For roof slopes of 3:12 to <4:12, two (2) layers of felt are required per IBC and IRC.
Attachment [2] Type of Fasteners	Fasteners shall comply with IRC section R905.3.6 and IBC section 1507.3.6 and UBC Section 1507.3. Corrosion resistant meeting ASTM A641Class I or approved equal, number 11 gauge diameter and of sufficient length to properly penetrate ¾" into or through the thickness of the deck or batten [2], whichever is less. The head of the nail used for tile fastening shall not be less than 5/16 inches and shall comply with ASTM F1667 for dimensional tolerances. Other fastening systems such as screws, wire, or adhesive based systems as approved by code, or local building officials will be allowed.	
Number of fasteners [1,2]	One fastener per tile. Flat Tile without vertical laps, two fasteners per tile. Tiles installed with projecting anchor lugs will be installed on counter battens, or other code approved methods.	Two fasteners per tile. Only one fastener on slopes of 7 units vertical in 12 units horizontal (58.3% slope) and less for tiles with installed weight exceeding 7.5 pounds per square foot, having a width no greater than 16 inches. [3]
Field Tile Head Lap	3 inches minimum, unless precluded by tile design	
Flashing	Flashing shall be (No. 26 galvanized sheet gage) not less than 0.019 inch corrosion-resistant metal with a minimum of 0.90 ounce zinc/sq. ft. (total for both sides) G90 sheet metal or equal.	

[1] For jurisdictions enforcing the:

IBC: In snow areas, a minimum of two fasteners per tile are required or battens and one fastener.

IRC: In snow areas, a minimum of two fasteners per tile are required.

UBC: In snow areas, a minimum of two fasteners per tile are required, or interlocking tiles with anchor lugs engaged on battens with one fastener.

[2] In areas designated by the local building official as being subject to wind velocities not in excess of 80 miles per hour "basic (fastest mile) wind speed" per the UBC; 100 miles per hour "basic (3 second gust) wind speed" per the IBC and the IRC or where mean roof height exceeds 40 feet, but not more 60 feet above grade, all tiles shall be attached as follows;

[2.1] The head of all tiles shall be fastened.

[2.2] The noses of all eave course tiles shall be fastened with clips, or other methods of attachment as approved by building code officials.

[2.3] All rake tiles shall be secured with two fasteners when required by IBC table 1507.3.7 and IRC section R905.3.7.

[2.4] The noses of all ridge, hip and rake tiles will be set in a bead of approved roofers mastic.

[2.5] Other methods of tile fastening will be allowed based upon submission of testing and approval of building code officials.

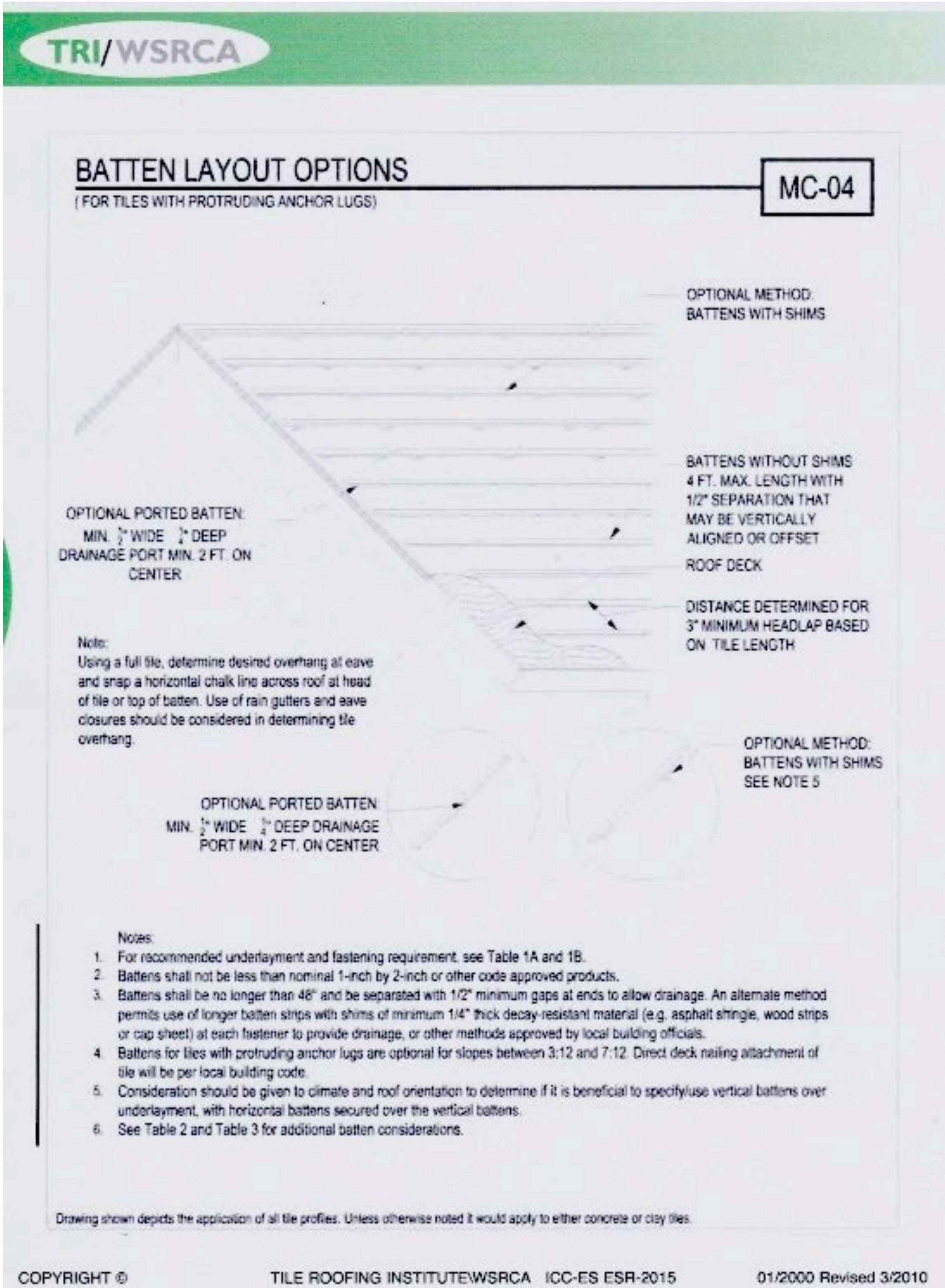
[2.6] For jurisdiction enforcing IBC and IRC, see appendix B for design considerations for high wind applications.

[3] On roof slopes over 24 units vertical in 12 units horizontal (200% slope), the nose end of all tiles shall be securely fastened.

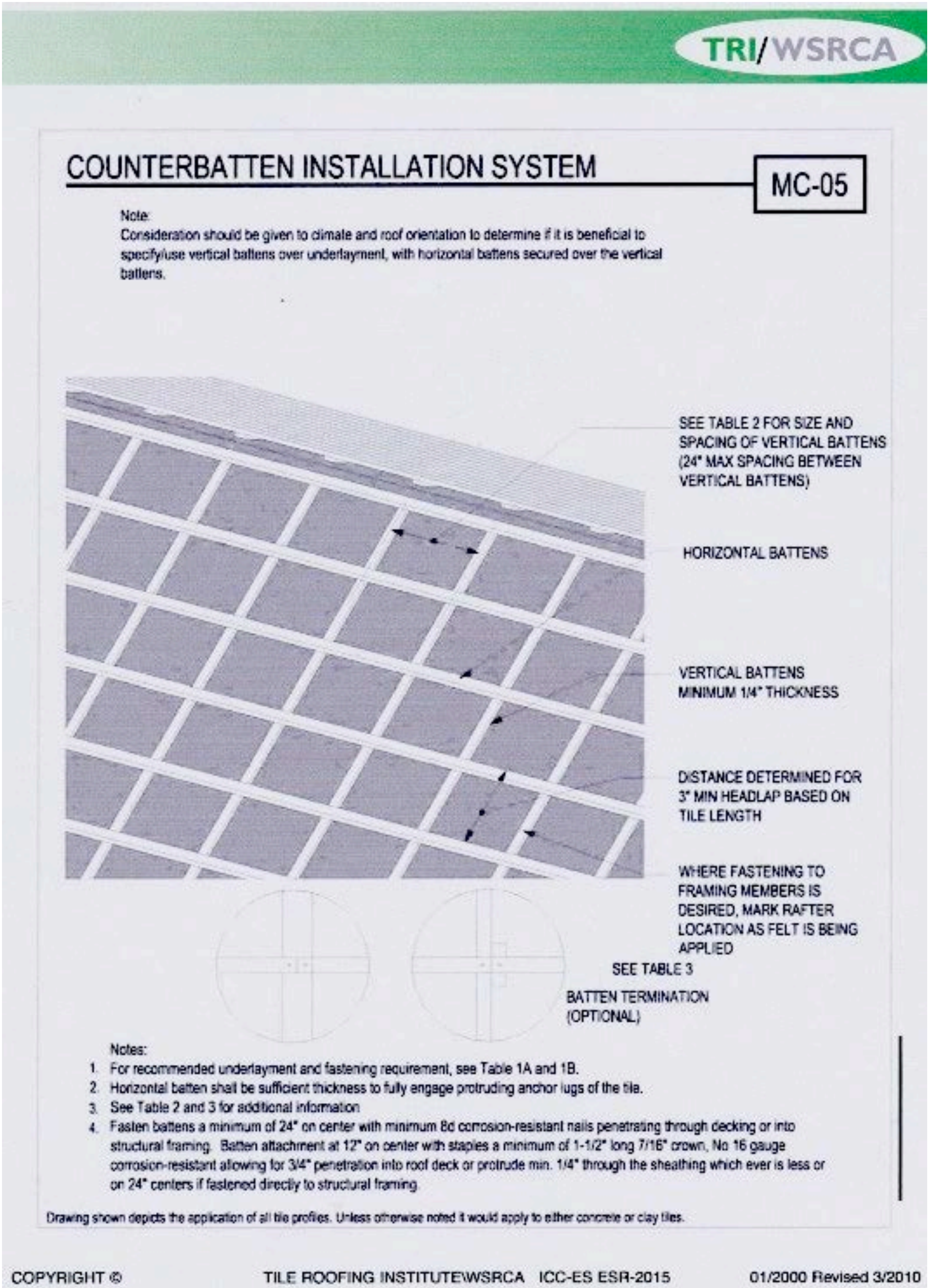
This table 1A from the tile roof institute Installation Manual for Moderate Climate Regions gives sheathing, underlayment, flashing, headlap and fastener schedules according to roof pitch.

BATTENS

Horizontal battens



You may see tiles hung from wood battens installed horizontally across the roof. Tiles used with battens have anchor lugs that protrude from the underside of the top edge of the tile, and which hook over the battens. Dirt accumulating on the uphill side of battens can retain moisture that accelerates deterioration of the underlayment at these areas. Requirements for batten installation can vary with tile manufacturer, with jurisdiction and with the degree of roof slope. In some areas, battens may need to be pressure-treated to resist decay. Battens should have spaces between ends at least a half-inch wide to encourage drainage. Other requirements may include the installation of counter-battens.



Counter-battens

With the counter-batten system, to improve drainage, battens are first installed vertically, typically every 16 or 24 inches, depending on what's specified by the manufacturer. Horizontal battens are then installed on centers that will provide the exposure recommended by the manufacturer. Typically a 3-inch headlap is the minimum.

One of the purposes of the batten system is to reduce the number of fasteners that penetrate the underlayment, so fasteners that hold tile in place should penetrate the battens at least ¾ of an inch, but should not penetrate the underlayment.

Counter-battens provide a space for airflow that helps keep the tile cool, and encourages drying of any moisture that finds its way past the tile.

As a home inspector, you won't know the manufacturer's requirements and won't be confirming proper installation unless you're familiar with the installation requirements of the particular tile installed and with any jurisdictional requirements. Instead, you'll be looking for signs of failure.

Battens should be fastened every 24 inches if they're nailed and every 12 inches if they're stapled. For fastening purposes, battens become part of the roof deck.

Over-spanned battens will allow excessive deflection when the roof is walked on or is supporting a snow load. Excessive deflection can crack tiles.

It's important to follow the manufacturer's instructions regarding batten installation. Battens should be fastened every 24 inches if they're nailed and every 12 inches if they're stapled. For fastening purposes, battens become part of the roof deck.

Over-spanned battens will allow excessive deflection when the roof is walked on or is supporting a snow load. Excessive deflection can crack tiles.

Starter course

The first course of tile called the "starter" course should have the butts raised at the eves so that the starter course will lie on the same plane… at the same angle… as the field tiles. If this is accomplished by raising the fascia or using a solid strip… then an anti-ponding device… like a beveled strip… should be installed to prevent runoff from pooling.

Here you can see weep holes designed to allow drainage built into the birdstop.

FASTENERS

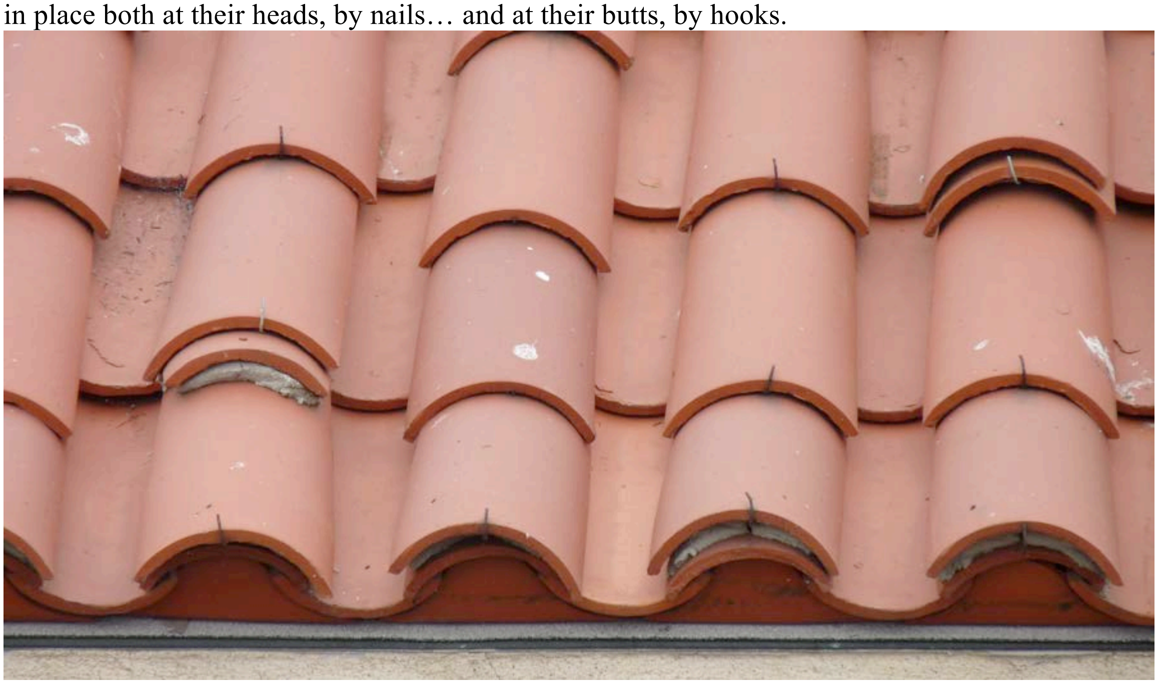
The type and spacing of the fasteners will vary with local regulations, the climate zone in which the structure is located, the roof pitch, height, and design, the roof deck material, the wind exposure and the tile manufacturer's installation requirements. System components should be of similar materials to prevent galvanic corrosion, so if tiles were held in place with galvanized steel clips, you'd want to see galvanized steel nails… and that would be hot-dipped galvanized nails, not electro-plated galvanized nails. In coastal environments, in which the salty air is hard on fasteners, copper nails last the longest, followed by stainless steel, followed by galvanized steel. The length of the fastener service life becomes more important when tiles with long service lives are used.

These French style tiles were around 60 or 70 years old when this shot was taken and were still in good condition. Once fasteners fail over a large part of the roof, it may or may not be possible to remove and replace tiles with new fasteners. It depends on the condition of the tiles. So the lifespan of a tile roof is sometimes determined by the lifespan of the fasteners, instead of the tiles themselves.

Fasteners should be corrosion resistant and for tiles mounted directly on the roof deck, long enough to penetrate at least ¾-inch into the roof sheathing and preferably clear through it. Some tile will not require fasteners, and that usually has to do with the roof pitch, whether adhesive is used, and whether the structure is located in a high-wind area. Overdriving fasteners may crack the tile. Fasteners should be long enough to penetrate roof sheathing a minimum of ¾ inch or pass completely through it, which ever is less.

In addition to nails, tiles may be held in place with screws, hooks, straps, wire, or clips. Whatever method is used, you'll be looking to confirm that tiles are held firmly in place.

You may see nose hooks used anywhere, but they are especially helpful on very steep roofs, like those of 24 & 12 or steeper… and in areas that experience high winds. Tiles will typically be held in place both at their heads, by nails… and at their butts, by hooks.



You can see here that many of these hooks have broken off. As tile grow old and soft, if they are supported by hooks only, the hooks may cut through the tile as they have with this older slate roof tile.

ADHESIVES

Tile may be fastened to the roof with adhesives instead of nails or screws. Adhesives have to be of the proper type and applied in the proper quantity and location. Improper quantity and location may not allow for proper movement of the tiles during thermal expansion and contraction. A number of different types of adhesives may be used, including:

- mortar and synthetic mortar
- mastics
- silicones
- polymers or tripolymers
- or whatever adhesive is approved by the local building department.

Adhesives may fail for a number of reasons:

- some types of adhesive have a shelf life and may fail if they're too old when they're applied.
- some types have storage requirements like high and low temperature limitations. These temperature limitations may also apply to application conditions and can include both the temperatures of the adhesive and of the materials being adhered.
- The type of adhesive installed may incompatible with the tile or underlayment.
- Adhesive may be used in the wrong quantity. Different tiles may have different minimum and maximum amounts.
- Too much time can elapse between the time the adhesive is applied and when the tile is set in place.
- Once a tile is placed, if it is removed and repositioned, adhesive may need to be re-applied, so failure to re-apply the adhesive can result in a failed bond.
- Differential expansion and contraction rates between the adhesive and the tile over the long-term may cause the bond to fail if the adhesive is a brittle type like mortar.
- When adhesives alone are used to fasten tiles, tiles may be bonded to underlayment or battens. If tiles are adhered to underlayment only, the quality of the underlayment attachment to the roof deck will affect the wind resistance of the tile roof installation.
- Wet surfaces and even high humidity can cause adhesives to fail.

Foam adhesives generally have a good reputation. Mortar does not have such a good reputation. When you see tiles installed with mortar, look for failed bonds, especially on older roofs and at hip and ridge cap tiles.

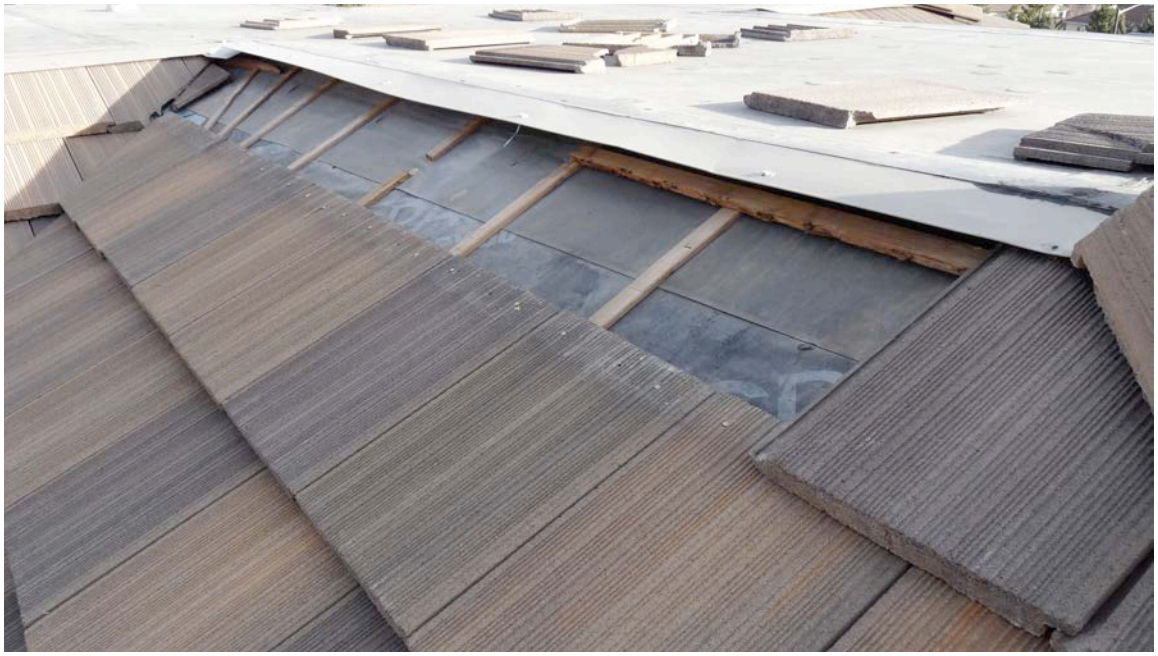
Cap tiles are more vulnerable to wind damage than field tiles. Although you may find either field or cap tiles held in place with adhesives, rake tiles will usually be held in place with fasteners.

If the wrong mortar mix is used, or applied incorrectly, it may fail prematurely. Using more mortar than required doesn't necessarily correct the problem.


This is a common condition. Lack of fasteners and failure of the adhesive have allowed tiles to slide down the roof slope.

It’s even more common in areas that are awkward to reach, or are difficult to nail.

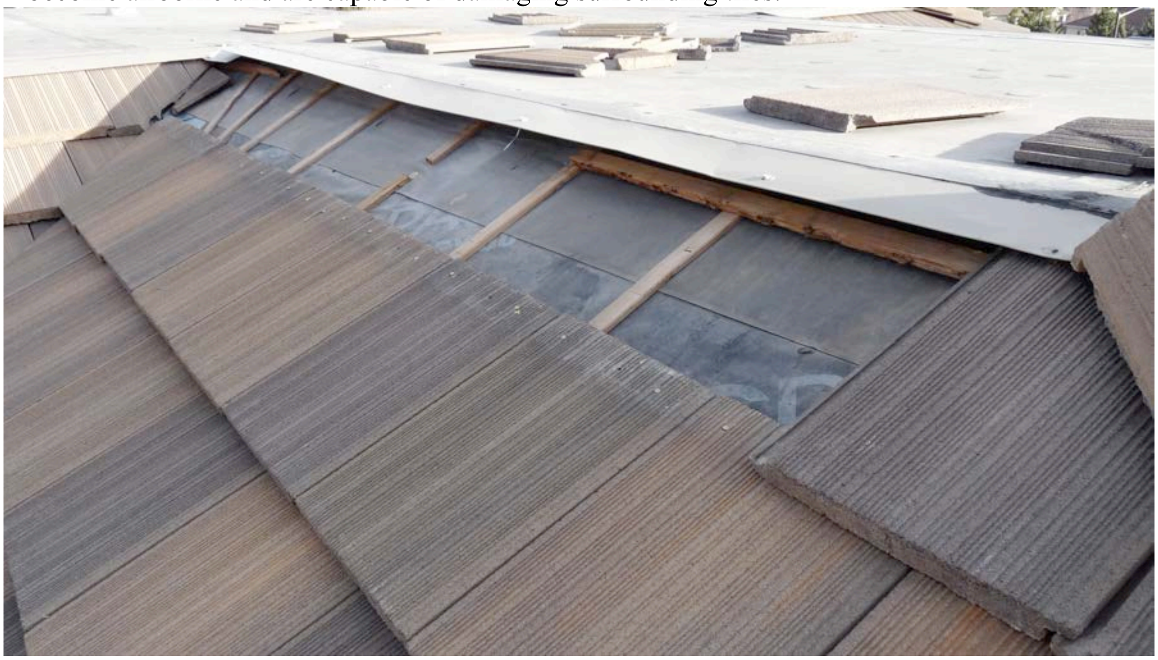
Here the headwall flashing was installed before the tile.


These tiles were held in place using the friction method, which failed in a high wind.


Here's a roof with plenty of mortar. Although this roof is 8 layers thick at the eve, chances are good that it's only one layer thick at the peak. Still, it's heavy, and you'd want to check carefully for sagging of roof framing components like rafters, trusses or sheathing.

WIND DAMAGE

Tile roofs generally do well in wind events due to their weight. Their wind resistance will depend on the quality of the installation, especially the method of fastening and the use of the proper type and application of adhesives. If wind is strong enough to loosen tiles, they may become airborne and are capable of damaging surrounding tiles.



Wind damage
Wind can move even heavy concrete tile if it's not fastened down well. Wind was able to get beneath these tiles and flip them onto the flat roof above.

FLASHING

Because of the great variety of tile profiles available, there are a number of different flashing profiles available. You don't need to confirm that the flashing recommended by the manufacturer is used, but you should check to see if the flashing installed appears to keep the water out of the roof system.

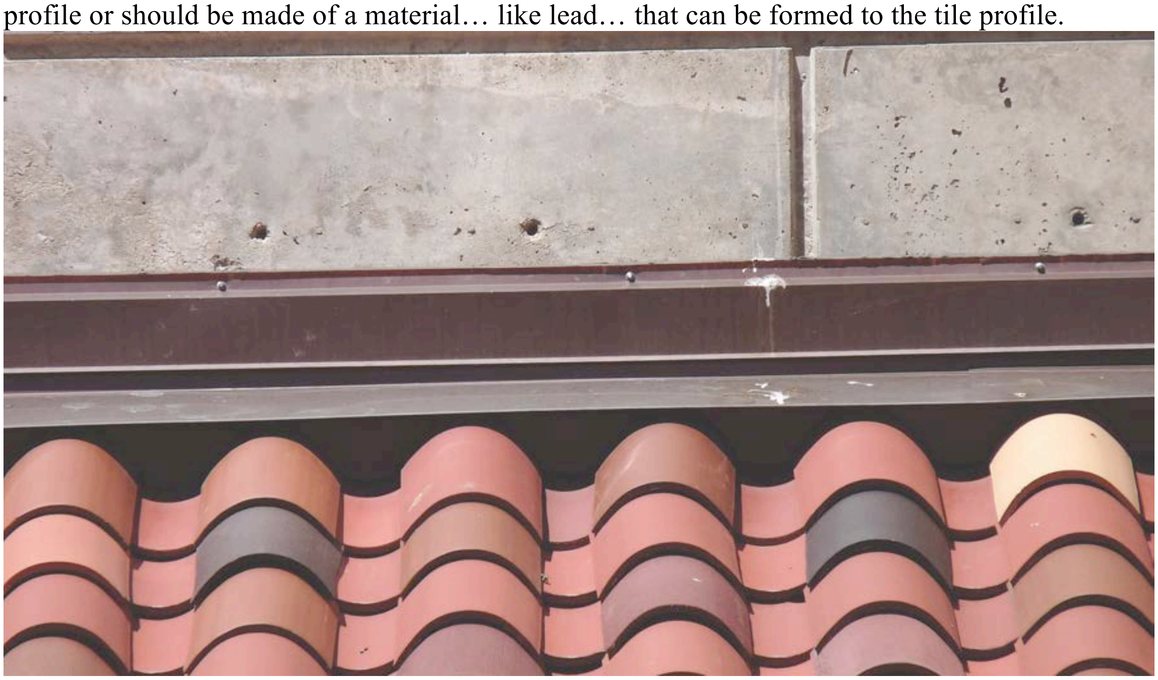
Areas of a roof with medium or high profile tile that have gaps, like ridges, hips and valleys and along the eves, should be filled with some type of pre-formed weather-blocking material. This may be made of sheet metal, plastic or other material and supplied by the manufacturer. It may also be a material like sheet lead, malleable aluminum or mortar that is formed and placed by the installer. The purpose of weather-blocking is to prevent wind-blown rain and snow from penetrating the roof, to improve the roof's wind resistance by keeping wind from getting underneath the tile, and also to improve it's fire resistance, since most underlayments are flammable.

Headwalls

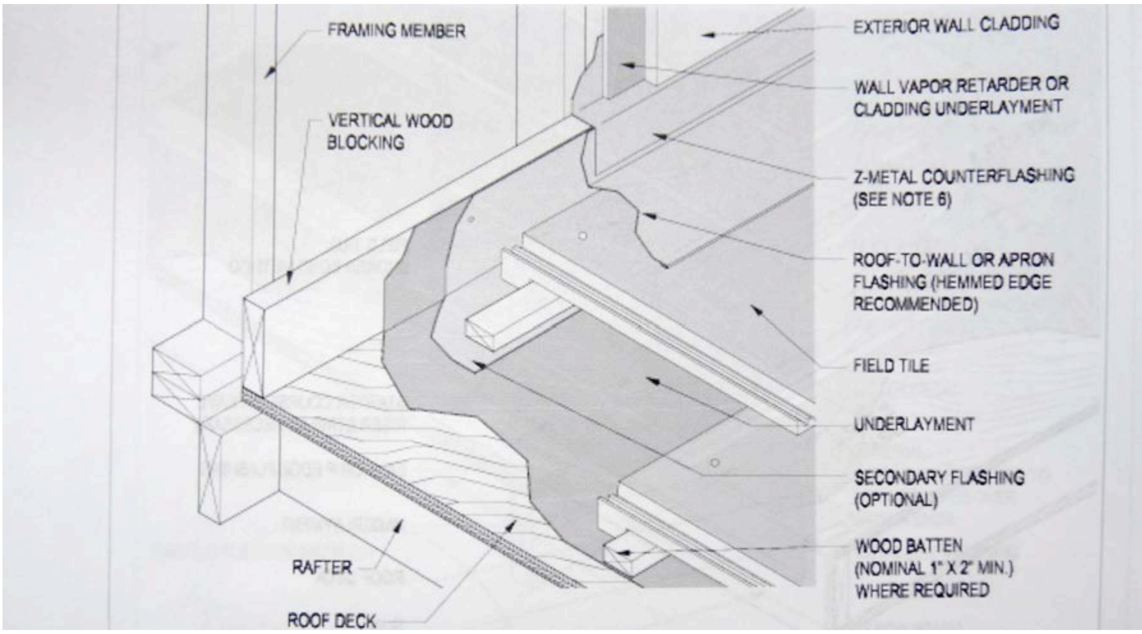
Common headwall flashing has flanges typically 4 to 5 inch in length and comes pre-bent to 120 degrees. There should be a gap between the top of the tile and the bottom of the exterior wall covering material, as you see here.

It's not unusual to see the exterior installed wall-covering material too low. This can cause it to fail prematurely by absorbing moisture from the surface of the tile.

When medium or high profile tiles are used, headwall flashing should be pre-formed to the tile profile or should be made of a material… like lead… that can be formed to the tile profile.



The less expensive method, which is also the more common method, is to use straight flashing and hope for the best.



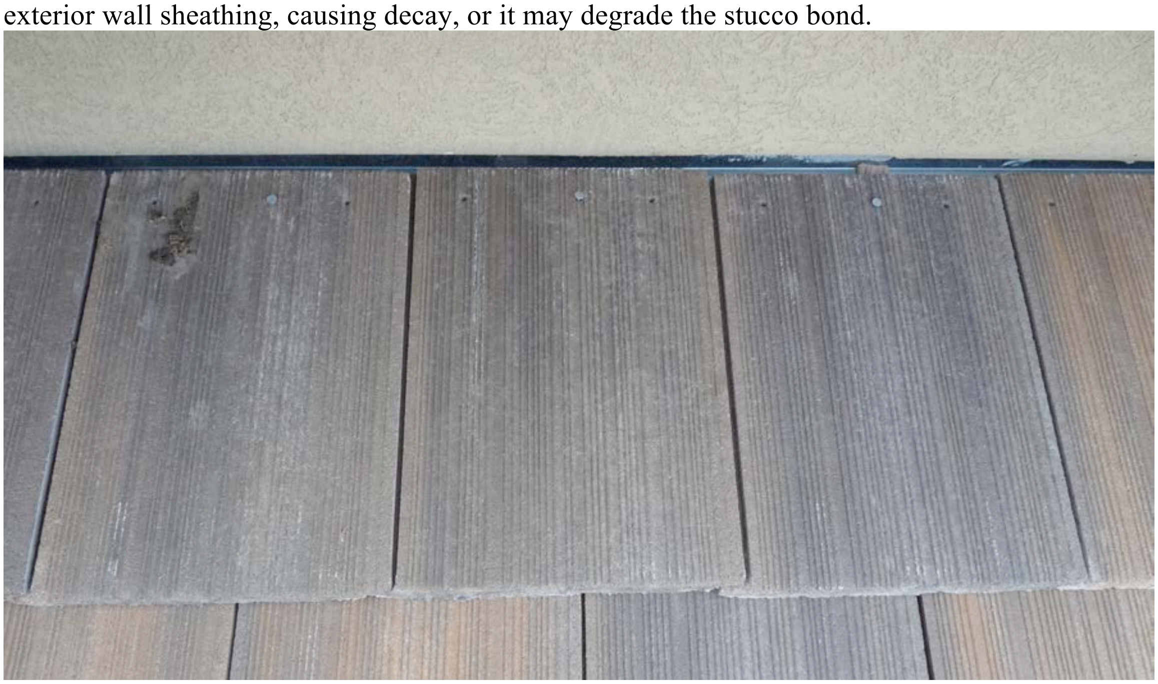
Headwall flashing is sometimes installed both above and below the tile, which would reduce the chances of leakage at this location.


This is a common headwall installation, although not a great one. The installer used conventional headwall flashing, but didn’t use any kind of weatherblocking, so the headwall is vulnerable to leakage from wind-driven rain.

Apparently the last piece of flashing on the truck was a little short, so the installer added some lead flashing to the corners that depend on a sealant that will eventually dry, shrink, crack and leak. Also, the installer should have terminated the stucco at least an inch and a half above the flashing.

In an effort to seal the headwall, the installers forced too much mortar beneath the flashing, forcing it up.

This will prevent runoff running down the stucco from draining and it may be absorbed by the exterior wall sheathing, causing decay, or it may degrade the stucco bond.

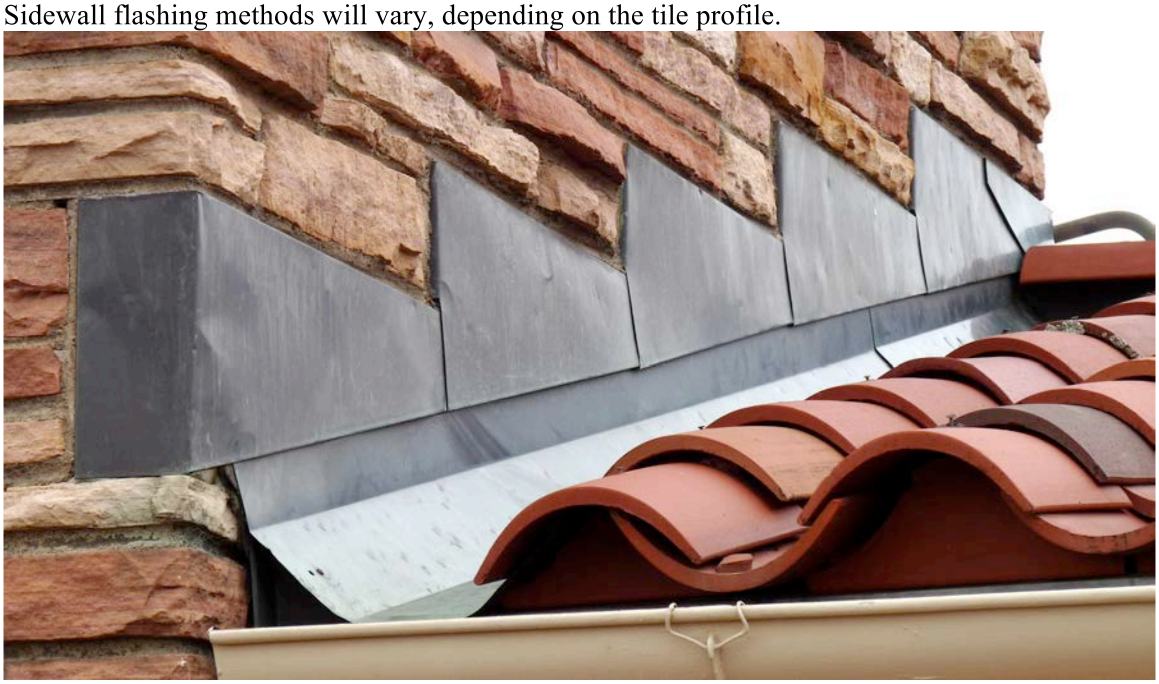


Here is a defective installation in which the headwall flashing was routed beneath the tile.

This can happen when flashing is installed for an asphalt shingle roof that has been changed to tile after the headwall and sidewall flashing has been installed.

Sidewalls

Sidewall flashing methods will vary, depending on the tile profile.

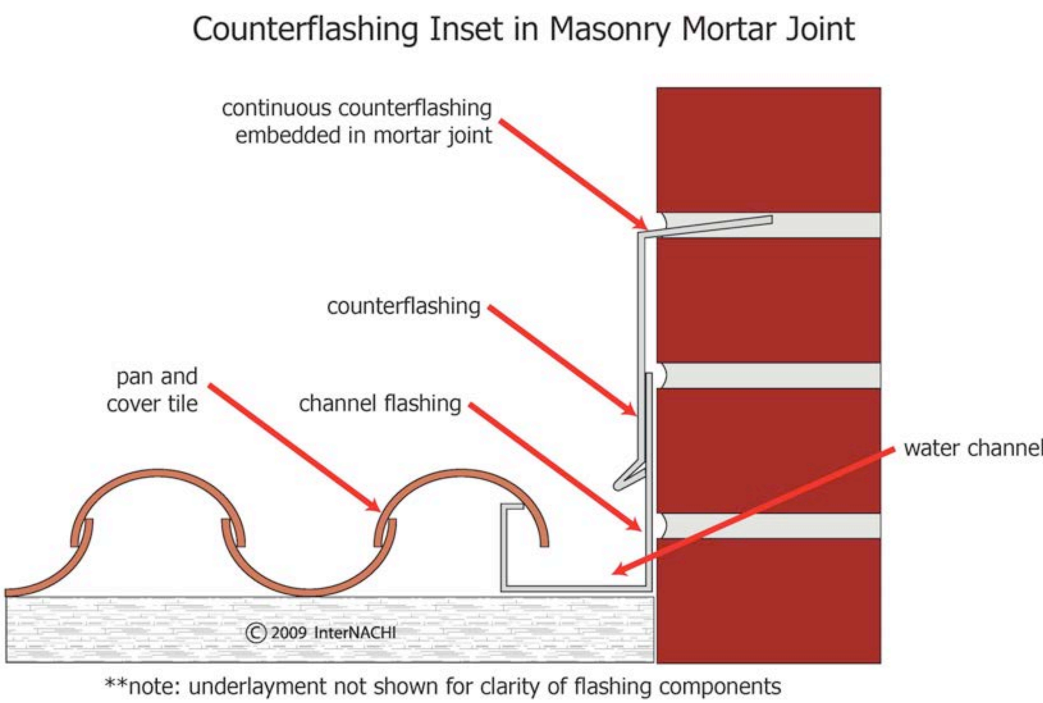


Sidewall flashing with medium or high profile tile should have continuous pan-flashing with a runoff channel that has an upward return or “hem” at least 3/4 of inch tall.

The flange should run up the wall at least 4 inches and out over the roof deck at least 6 inches. Sidewall flashing may be bent to whatever angle works in order to match the tile style.

This may require some craftsmanship with certain tile profiles.

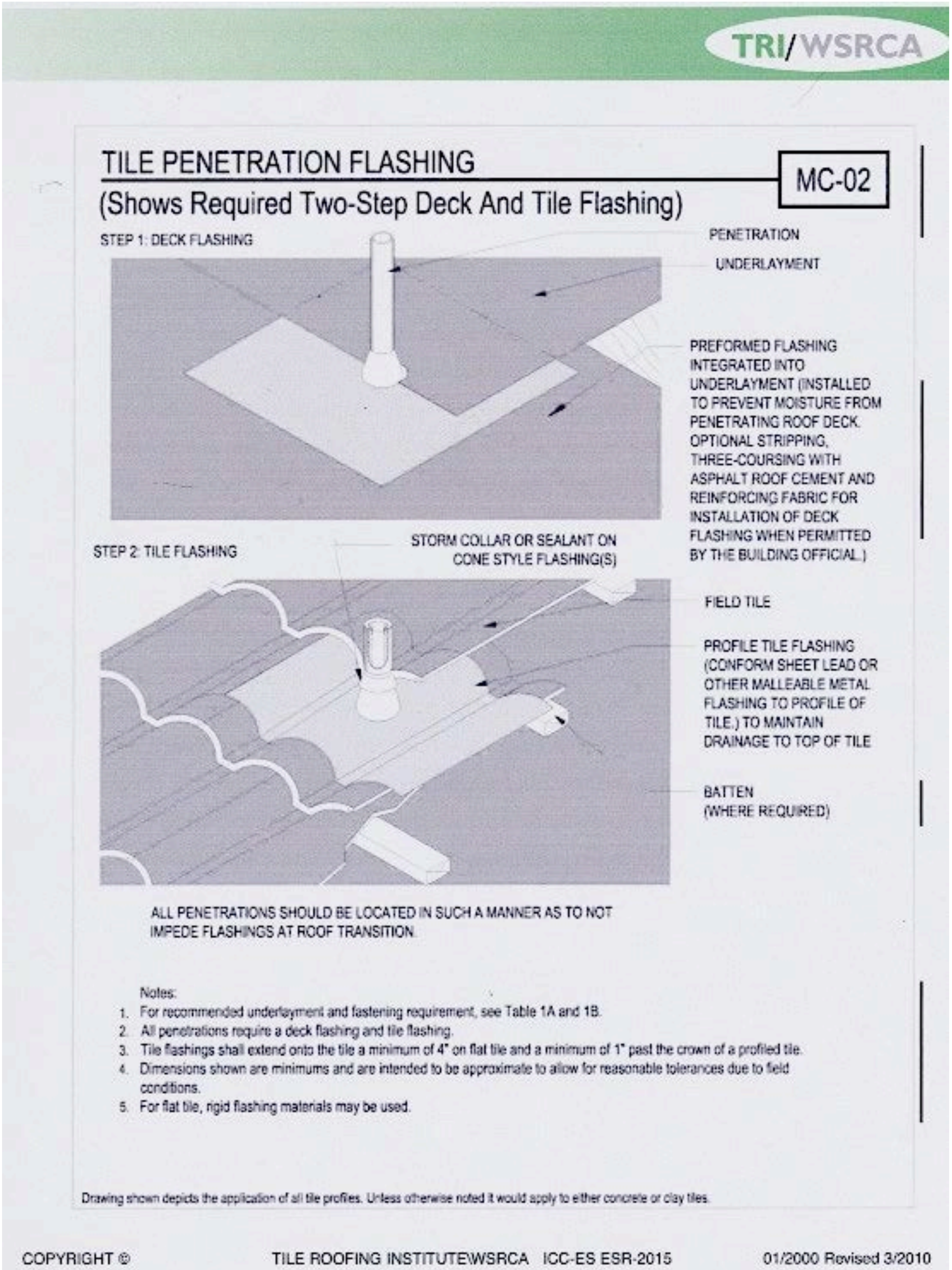
Flashing at both headwalls and sidewalls should have counter-flashing installed. The exterior wall covering may serve as the counter-flashing unless the exterior walls are brick or stone.



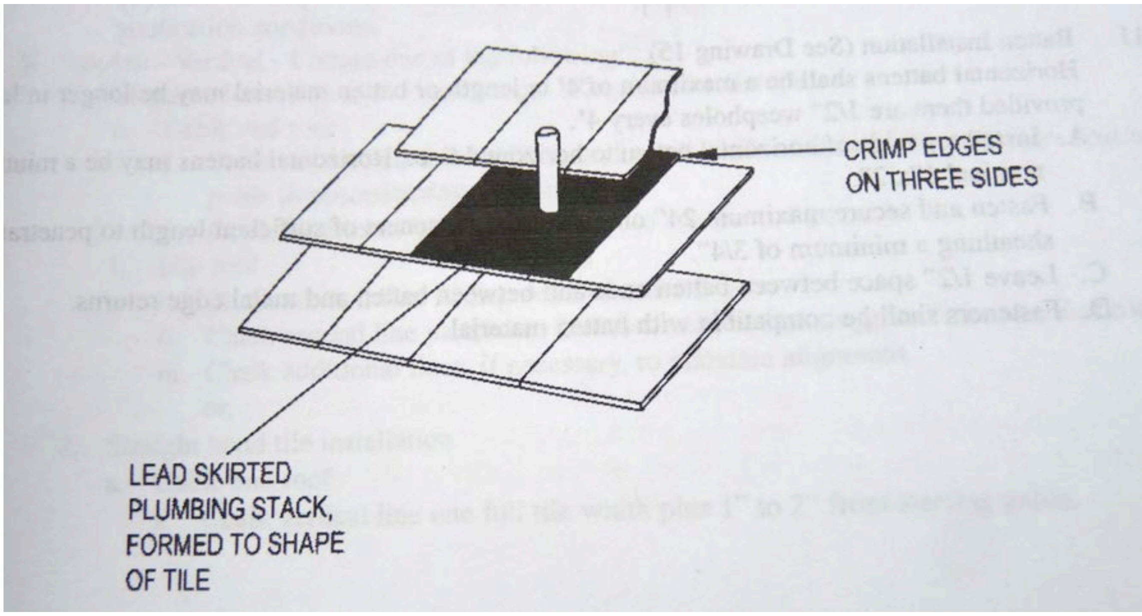
In both brick and stone, counter-flashing should be installed in mortar joints.

Plumbing stack pipes

Flashing for plumbing stack pipes will vary with the tile profile.



These illustrations show methods for flashing stack vents. You may not be able to confirm the presence of flashing that underlies the tiles. Low and high profile tiles should have flashing formed to the tile profile.

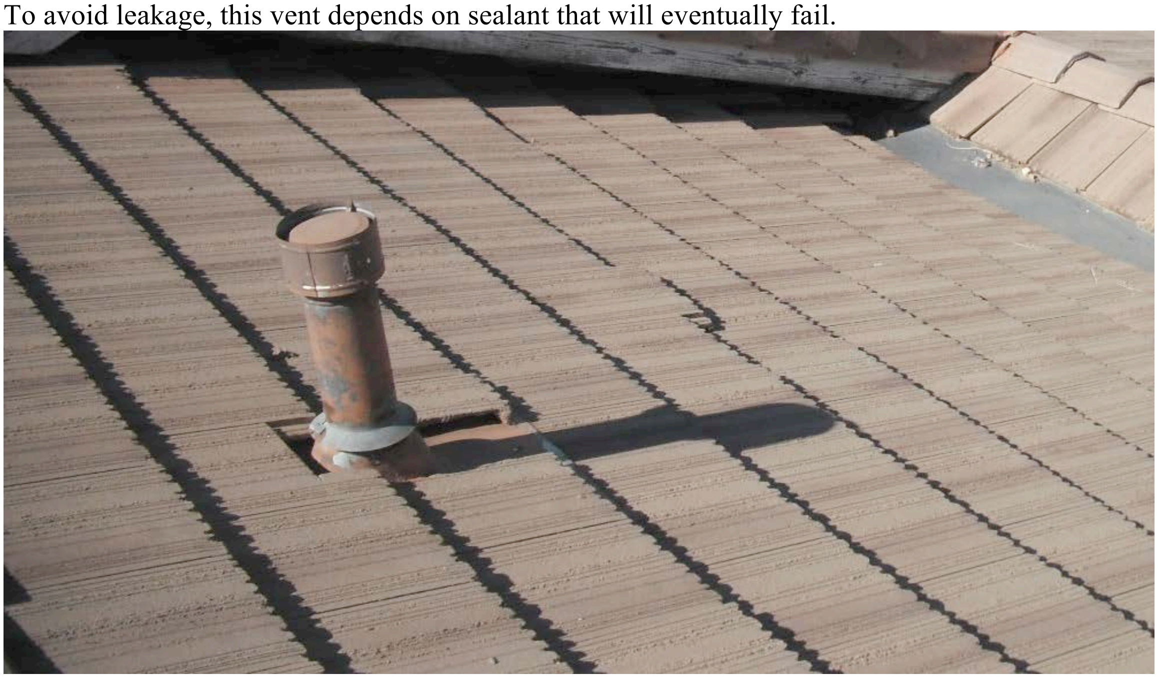


Flat tiles should have flashing adequately sealed at the edges.

Here you see that the sealant has failed and may allow moisture intrusion.

For low and high profile tiles, flashing made from a malleable metal like lead or aluminum will allow the flashing to be bent to match the tile profile.

To avoid leakage, this vent depends on sealant that will eventually fail.



When you see a vent installed like this, write it up as a defective condition. It needs to be correctly flashed.

Simply filling in the gap with mortar… as they did with this roof vent… won't prevent runoff from getting beneath the tile. And also…


These vents are typical of older cast iron vents that have been wrapped in lead that has been soldered to the flashing.

When you see a vent that has been bent like this, it may have been installed this way, or it may have been straight originally and suffered damage from some source like sliding snow. If it's been damaged, the solder joint on the uphill side may be open.

This illustration from the Tile Roof Institute shows a method for flashing a stack vent with flat tile. Note that the edges are

Roof vents

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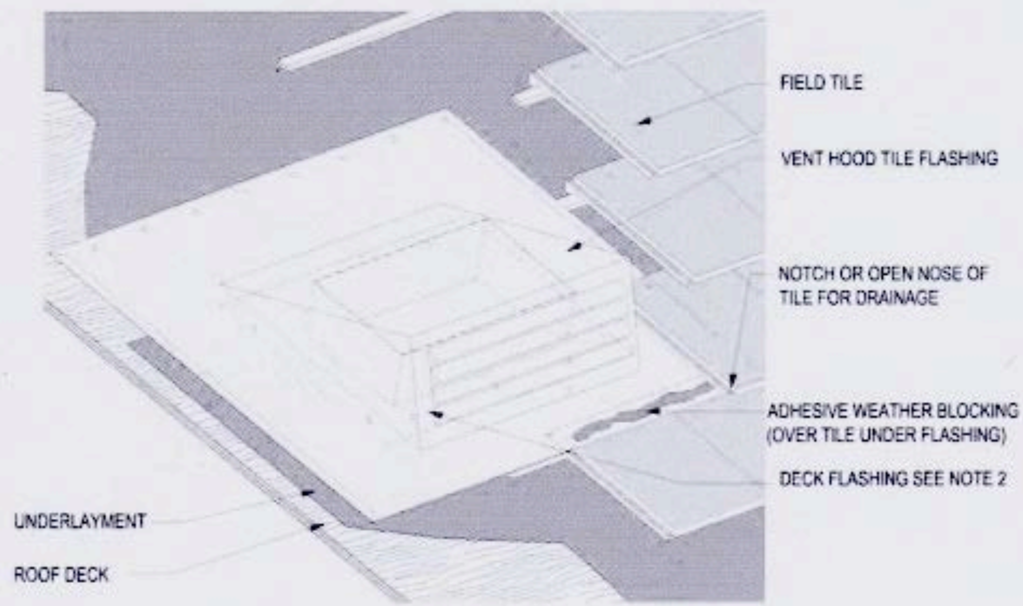
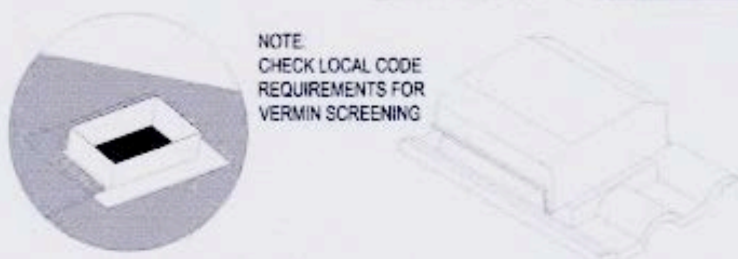
ROOF VENTS (OFF RIDGE)

MC-21

VENTS TO BE INSTALLED PER VENT MANUFACTURER INSTRUCTIONS





UNDERLAYMENT DETAIL
AT DECK FLASHING

VENTED TILES AVAILABLE TO MATCH
INDIVIDUAL TILE MANUFACTURER PROFILES.

HEIGHT OF FLASHING TO BE MINIMUM 1/2"

Notes:

1. One layer of No. 30 asphalt-saturated felt complying with ASTM D-226 (ASTM D4869 Type IV) or approved equal is required as a minimum underlayment on all tile roof applications. Other underlayments as approved by local building officials will be allowed.
2. A secondary flashing, as depicted in the left inset drawing, is required around the penetration to prevent moisture intrusion should water reach the underlayment, under the roof tile. This secondary or deck flashing is required with all tiles.
3. For climates with wind driven rain or blowing snow, consult local building official for approved application.
4. Where flashing is of metal should be minimum of (No. 26 galvanized sheet gauge) not less than 0.019 inch corrosion-resistant metal (G90). See Table A for additional options.

Drawing shown depicts the application of all tile profiles. Unless otherwise noted it would apply to either concrete or clay tiles.

Roof vents should be installed as a two-part system. A flanged sheet-metal box open to the sky is first installed on the roof deck, overlapping underlayment on the downhill side and overlapped by underlayment on the uphill side. If battens are installed, they extend to butt the sides of the box but are not nailed through the flashing. The roof vent is installed on the battens. The sides of the flanges should be hemmed to direct runoff onto the surface of tiles below the vent.

This is a good installation. You'll see variations, but whatever method is used to install the roof vent, check to see that it will keep water from penetrating the roof structure.

This is a defective installation.

Chimney

Flashing around a chimney can be installed in a number of ways, but must keep the water out. Where inadequate methods have been used, you may see attempts to stop leakage by applying sealant.

The proper recommendation would be to remove tile and install a cricket to prevent moisture from pooling on the uphill side of the chimney.

Where a second penetration exists, like this skylight, the chances of leakage increase.

Chimneys less than 30 inches wide can be installed without a cricket. Chimneys 30 inches wide or wider should have a cricket installed to keep runoff from pooling on the uphill side of the chimney.

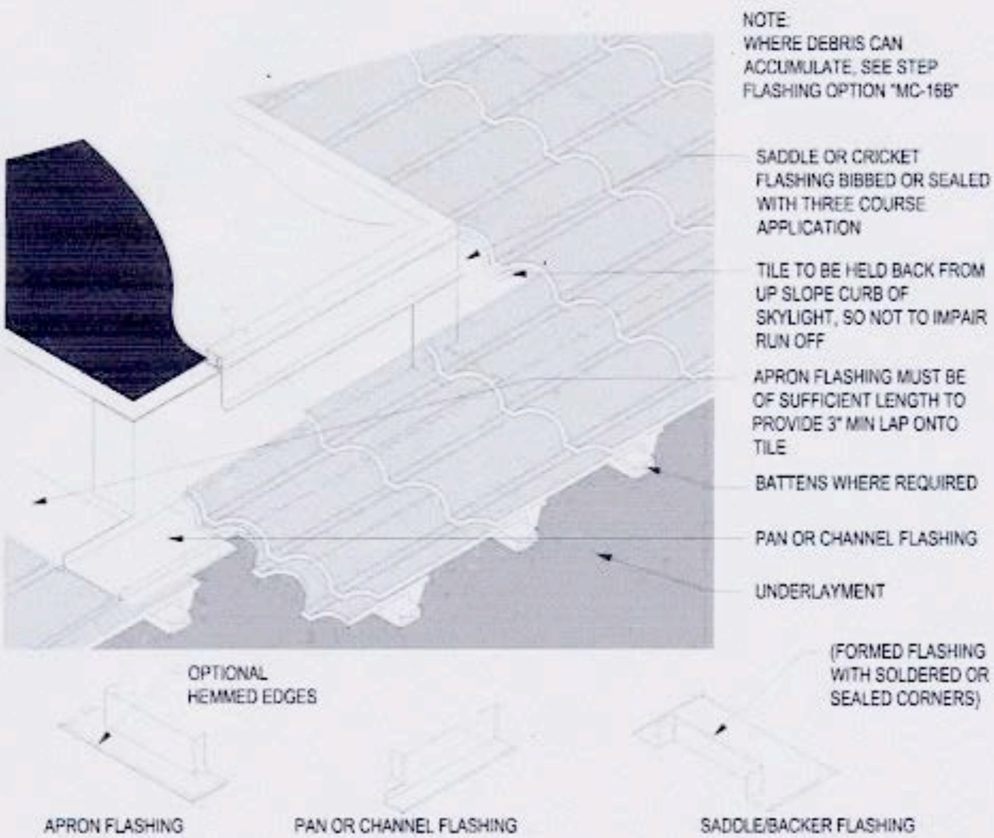
Skylight

Skylight flashing is installed in a manner similar to chimney flashing, except that crickets are seldom installed at skylights, even though the risk of leakage from runoff pooling on the uphill side is the same. Tile should be held back from the skylight flashing at least an inch at the uphill side to improve runoff flow.

TRI/WSRCA

SKYLIGHT FLASHING - PAN TYPE

MC-16A



Notes:

1. Skylight flashing dimensions may vary according to local weather conditions, curb size, location, slope of roof, rafter length behind skylight and contributory run off area.
2. A backer or saddle flashing may be used for skylights and other penetrations less than 30" in width. Extend a minimum of 6" up or to top of curb, and 14" up roof slope.
3. A cricket flashing is recommended for skylights and penetrations equal to or greater than 30" in width to promote positive runoff, unless supporting data shows otherwise.
4. For recommended underlayment and fastening requirement, see Table 1A and 1B.
5. Dimensions shown are minimums and are intended to be approximate to allow for reasonable tolerances due to field conditions.
6. Malleable metal or weather blocking material, required for weather closure with profiled tile.
7. All skylight flashing shall be minimum of (No. 26 galvanized sheet gauge) not less than 0.019 inch corrosion-resistant metal (G90). See Table A for additional options.

Drawing shown depicts the application of all tile profiles. Unless otherwise noted it would apply to either concrete or clay tiles.

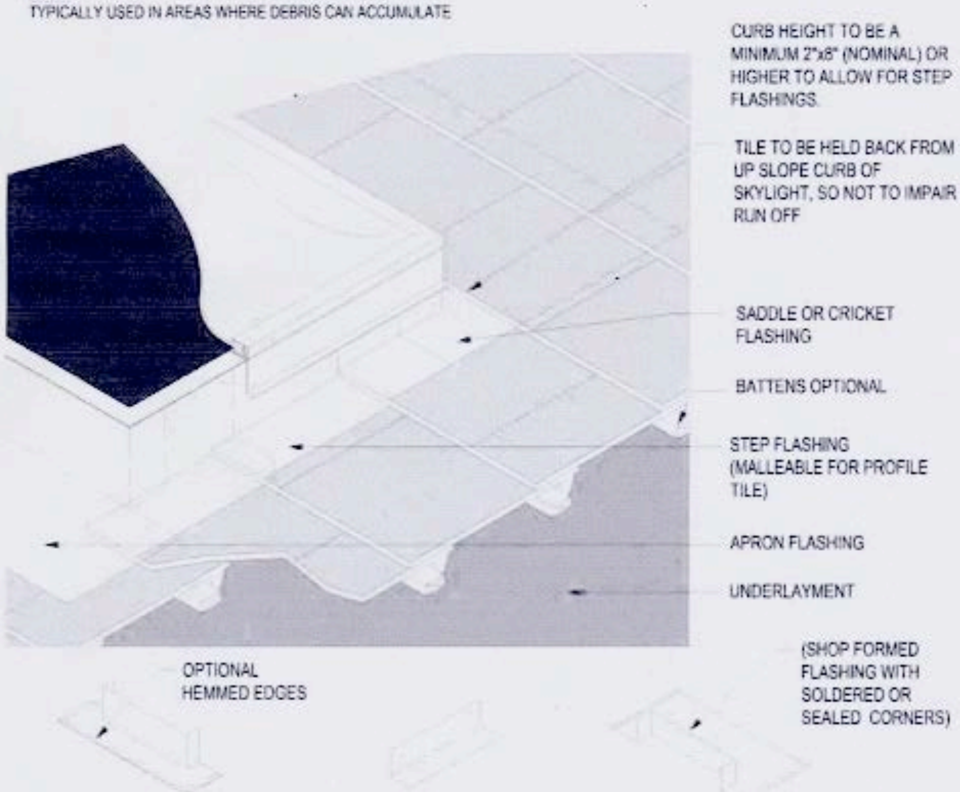
The type of sidewall flashing will vary depending on the tile profile used. Medium and high profile tile will typically use one-piece pan-flashing, which should overlap the apron flashing at the lower corners.

TRI/WSRCA

SKYLIGHT STEP FLASHING

MC-16B

NOTE:
TYPICALLY USED IN AREAS WHERE DEBRIS CAN ACCUMULATE



Notes:
1. Skylight flashing dimensions will vary according to local weather conditions, size, location, slope of roof, rafter length behind skylight and contributory run off area.
2. A backer or saddle flashing may be used for skylights and other penetrations less than 30" in width. Extend a minimum of 6" up or to top of curb and 14" up roof slope.
3. A cricket flashing is recommended for skylights and penetrations equal to or greater than 30" in width to promote positive runoff.
4. For recommended underlayment and fastening requirement, see Table 1A and 1B.
5. Dimensions shown are minimums and are intended to be approximate to allow for reasonable tolerances due to field conditions, and area practices.
6. Maleable metal, or weather blocking material, required for weather closure with profiled tile.
7. All skylight flashing shall be minimum of (No. 26 galvanized sheet gauge) not less than 0.019 inch corrosion-resistant metal (G90). See Table A for additional options.

Drawing shown depicts the application of all tile profiles. Unless otherwise noted it would apply to either concrete or clay tiles.

Flat tile may require step flashing. Unless you walk the tile, it can be difficult to confirm proper flashing installation. If you can't, you should disclaim it.

Every once in a while you'll see a condition in which someone has become convinced that they've hit upon a great idea.

Here, you'd want to try to determine what the fasteners are actually anchored into, and mention the fact that the flashing is vulnerable to wind-driven rain.

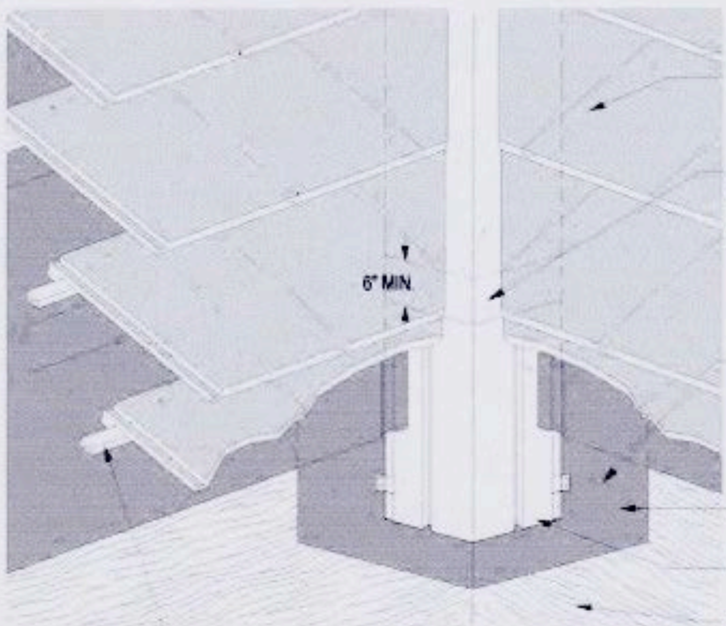
Valley flashing

You may see valleys installed using a variety of methods, depending on the climate zone, the type of tile, local practices and homesite conditions. Although both open and closed valleys are used with tile roofs, tile is never continuous across the valley, and all valleys should be lined with metal flashing.

TRI/WSRCA

OPEN VALLEY - TILE INSTALLED WITH GAP AT CENTER OF VALLEY

MC-17



Note: Tile at valleys may be cut to form closed or open metal valley detail. When flat profiled tile is installed as "closed valley" a ribbed valley metal or a single crown valley metal with a batten extension shall be used.

When using standing hem flashing, used woven underlayment method. See MC-03 & MC-17B.

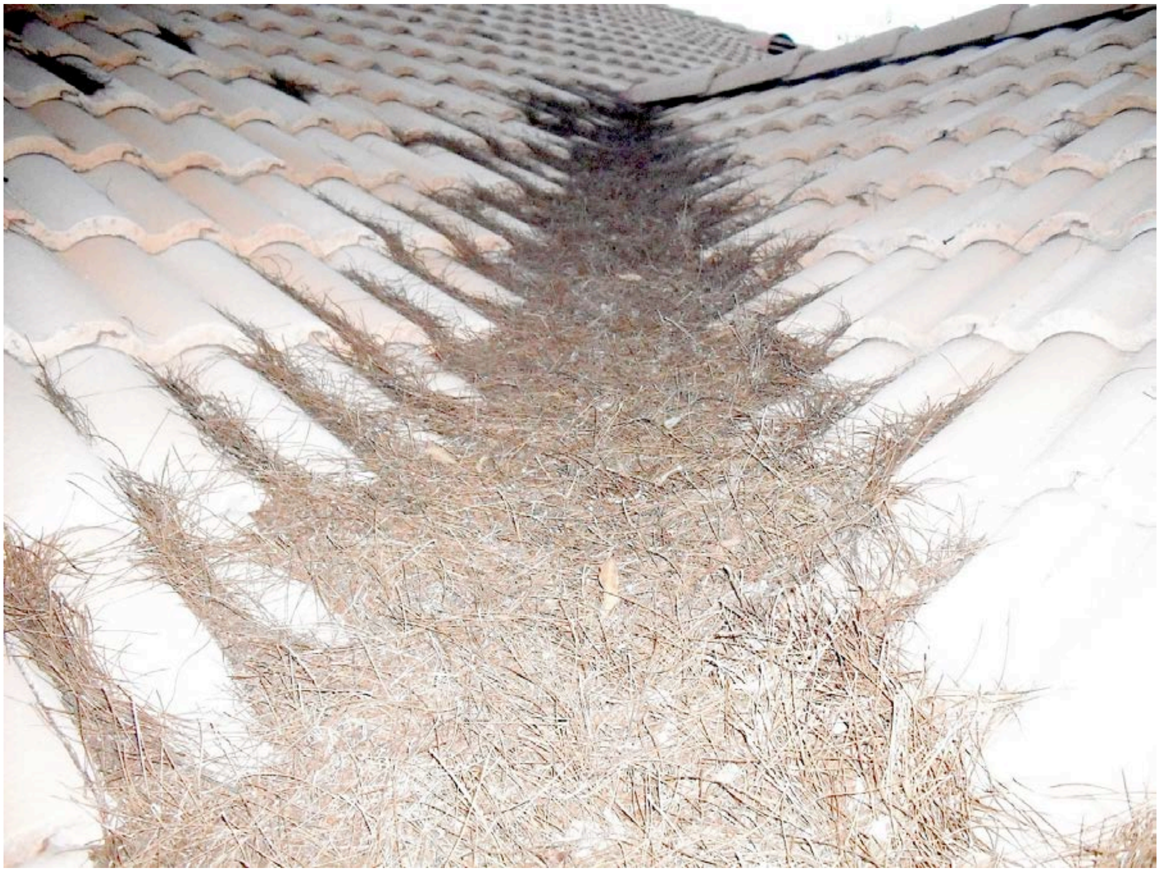
Notes:
1. For recommended underlayment and fastening requirement, see Table 1A and 1B.
2. Cut tile pieces should be secured by one or a combination of the following: (a) code approved adhesive; (b) wire ties (c) batten extension (d) cut tile clip or (e) other code approved fastening device.
3. Metal valley flashing is required to be a minimum of (No. 26 galvanized sheet gauge) not less than 0.019 inch corrosion-resistant metal (G90). See Table A for additional options. Valley flashing shall extend at least 11 inches from center line each way and have a splash diverter rib not less than 1 inch high at flow line formed as part of the flashing.
4. Other valley metal profiles are available. See MC-12B for example.
5. Tile must extend a minimum of 4" over the valley metal.
6. Dimensions shown are minimums and are intended to be approximate to allow for reasonable tolerances due to field conditions, and area practices.
7. Valley details should be designed to suit climatic area, control water runoff, and discharge expected water flows.

Drawing shown depicts the application of all tile profiles. Unless otherwise noted it would apply to either concrete or clay tiles.

You'll have a limited view of the valley, but you should be able to confirm that it is lined with metal, and is open enough to allow drainage to carry off small debris.


Open valleys will encourage runoff to drain well and help to wash away debris.


Closed valleys will tend to trap debris, which will accelerate deterioration by holding moisture against the tile.

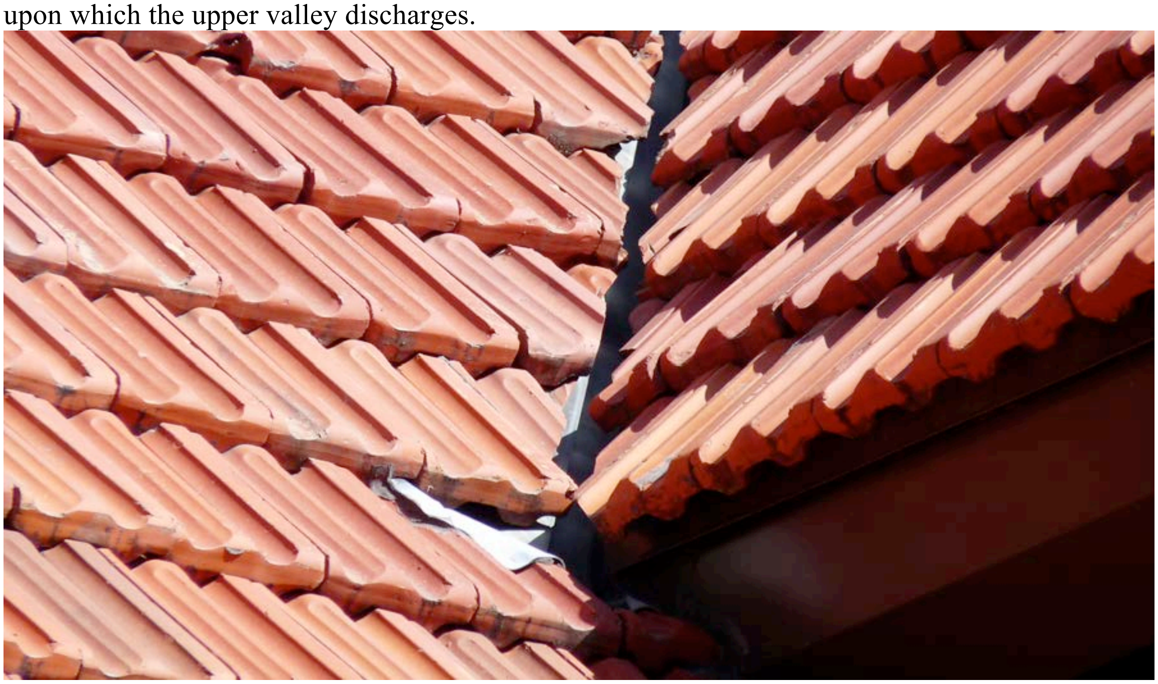


This is mainly a problem when there is a source of debris nearby, like… trees.

This is about as closed as a valley can get, and it's a defective condition. This sort of thing is typically done when a homeowner does not want to pay a roofer to replace badly corroded and leaking valley flashing. Concrete bonded to the tile means that tiles along the valley will need to be replaced to correct this condition. That means that matching tiles will need to be found, which can sometimes be difficult.

Valley transitions
Valley transitions are places where a valley on an upper roof drains directly onto a lower roof. The valley metal should extend past the transition. With flat tiles, the valley can discharge runoff directly onto the tile.

With profile tile, a sheet of lead or malleable aluminum should be installed to waterproof the tiles upon which the upper valley discharges.



This is called a “soaker”. You can see that the edge metal of the roof to the right has been cut back to allow the valley metal to extend well into the transition.

HIP FLASHING
Hips are difficult to make watertight and so they’re vulnerable to leakage, especially from wind-

driven rain. You'll see a variety of methods used to try to keep the water out.

TRI/WSRCA 54

HIP AND RIDGE

MC-18A

Openings at hips, ridges and head walls including chimneys, skylights, solar panels, and downslope horizontal abutments shall be fitted with weather blocking material to keep water on the surface of the field tile. Other methods approved by local building official will be allowed.

Wrapping of nailer board is optional except with the use of mortar. (All profiles of tile)

Notes:

1. For recommended underlayment and fastening requirement, see Table 1A and 1B.
2. All hip and ridge tile are required to have a code approved adhesive or special clip between laps of trim tile to cover nail hole and create a bond between ridge tiles.
3. Battens for tiles with protruding anchor lugs are optional for slopes between 3:12 and 7:12. Direct deck attachment of tile as approved by local building official will be allowed.
4. Dimension shown are minimum and are intended to be approximate to allow for reasonable tolerance due to field conditions, and are practices.

Drawing shown depicts the application of all tile profiles. Unless otherwise noted it would apply to either concrete or clay tiles.

Appendix A

Hip and ridge installations typically use a nailer, usually a 2x4 on edge, to provide backing for fasteners holding tiles in place. Ridges that provide venting will have a mesh of some type installed beneath the tie to allow air to flow.

Where a nailer is not used, fasteners must be long enough to anchor into the hip rafter, or cap tiles will suffer reduced wind resistance

Hip cap tiles need to be sealed against weather. Mortar and underlayment are two commonly-used materials.


Mortar also acts as an adhesive, but is subject to failure if improperly installed.

Hip step-flashing is most common with flat tiles and is effective, but not very pleasing aesthetically.

BIOLOGICAL GROWTH

The types of biological growth commonly found on tile are the same as on other roof-covering materials… moss, algae and lichen. All three are signs of high moisture levels and will hold moisture against the roof to some degree. Moisture held against the roof can cause spalling or flaking in cold climates.

This home was located in Colorado, which has a fairly dry climate, but had a clay tile roof with a lot of lichen and moss growing on it, which is a sign of high moisture levels.


The roof was shaded by nearby trees and by a high roof peak, and the tile was of an absorbent clay.

You are not required to identify the organism growing on the tile. This is obviously some type of biological growth, and that's all you need to say.

You can see how runoff from zinc in the galvanized flashing has inhibited growth, which is typical of algae. This home was located near salt water.


This is what clay tile looks like different biological organisms growing on it. The lichen and moss are obvious, but the dark discoloration might be algae or a fungus of some sort.

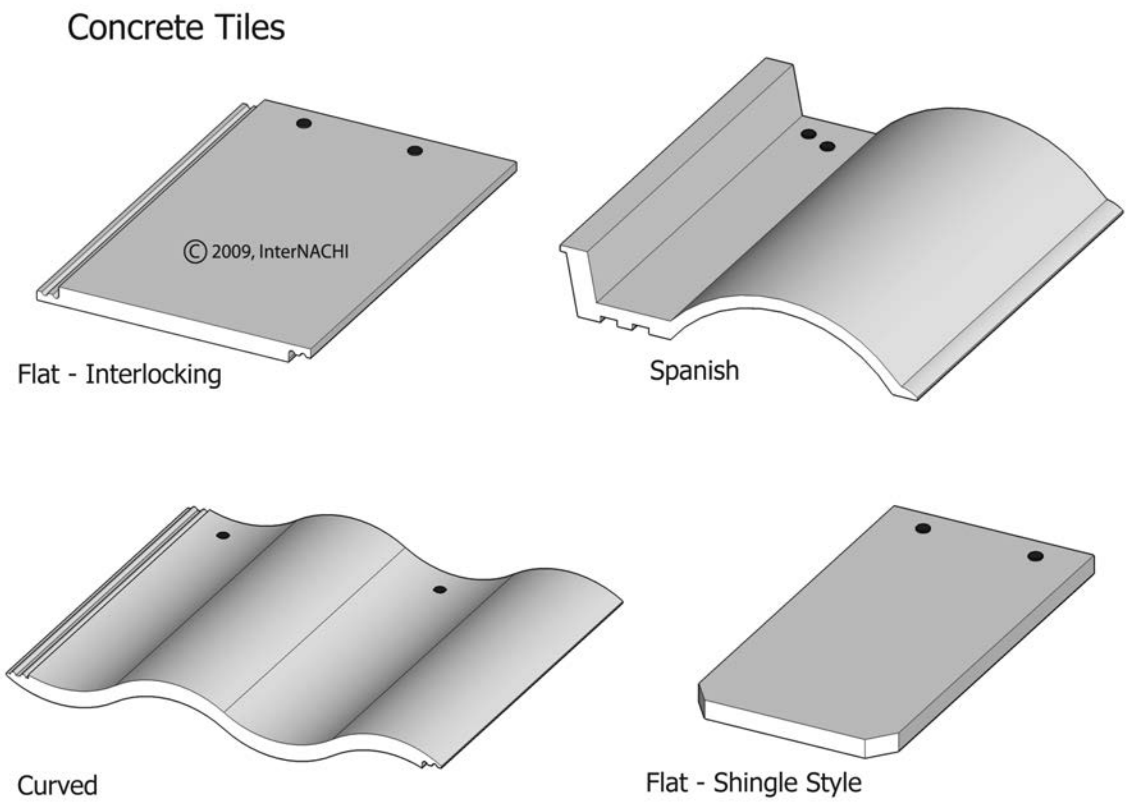
According to the manufacturer, the general dark discoloration is part of the manufacturing process. It’s a black manganese glaze (sometimes thick or thin) that is usually sprayed on prior to firing the tile at high temperature.

So, think twice before identifying something as biological growth!

Look closely, what looks like lichen at first, may be just paint!

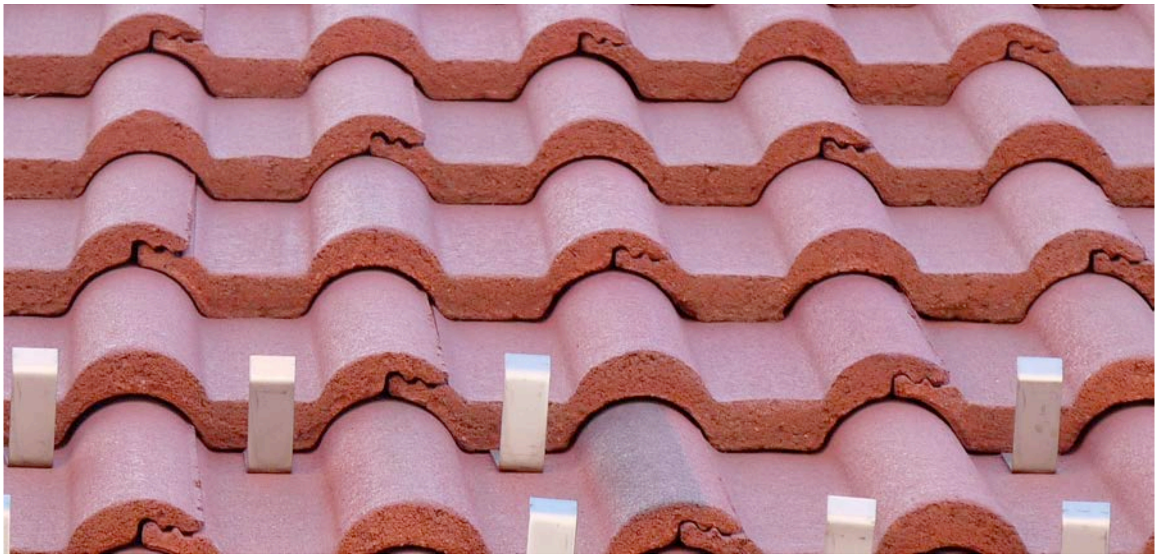
A pressure washer will remove both algae and moss from tiles in good condition. Older tiles will be more fragile and may be easily broken by attempts to walk on it, and clay tile in poor condition may be damaged by high-pressure spray.

CONCRETE TILES



Concrete tiles are available in all three height profiles and as butting or interlocking tiles.

They're manufactured from a variety of cementicious materials; Portland, modified Portland or blended cement, normal and light-weight aggregates and a variety of other materials designed to increase tile strength and durability.



Like clay tiles, concrete tiles are cast in a mold.

We visited Westile, a concrete tile manufacturer in Colorado, for a closer look at the manufacturing process. Let's take a look…

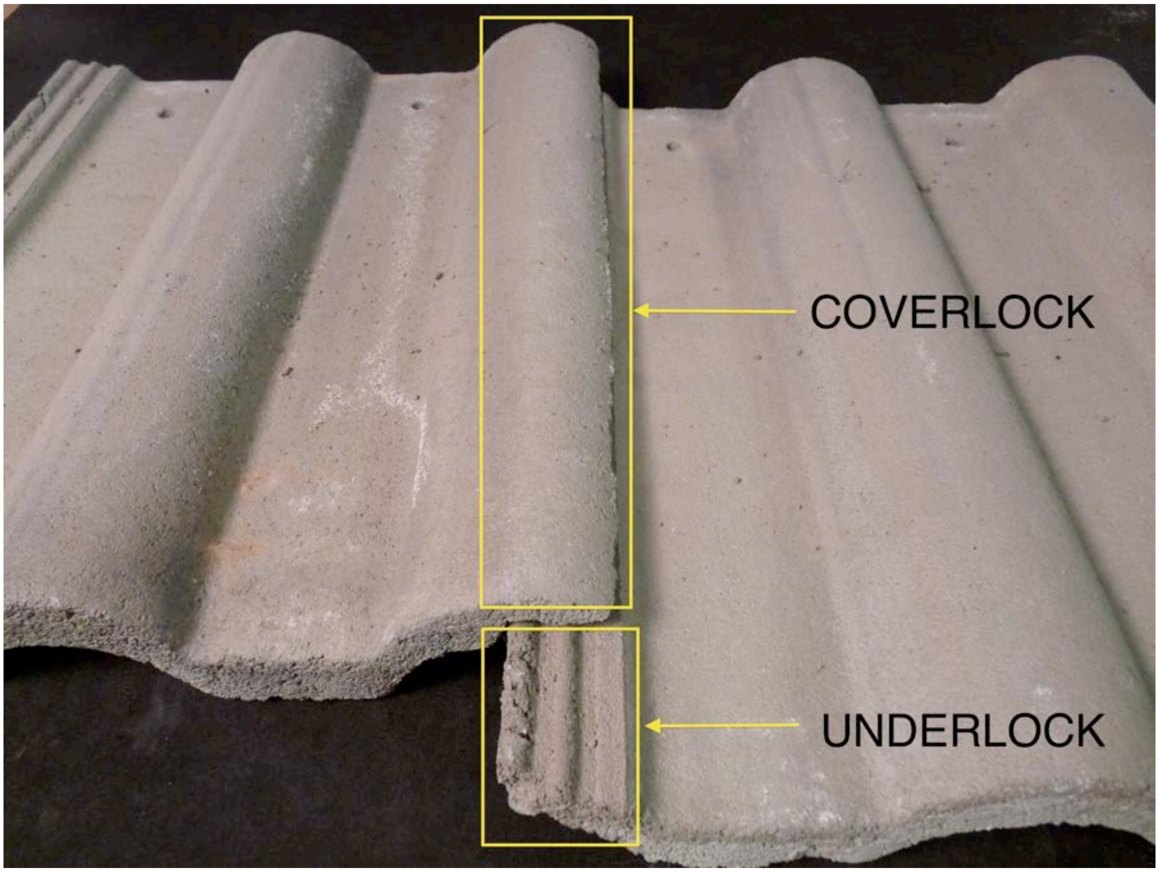
Installation methods for concrete tiles will vary. They may rest directly on the underlayment, or they may rest on batten or counter-batten systems.

Tiles should have an anti-ponding strip installed at the eves to raise the bottom edge of the first course up to the same plane as field tiles. The cant strip should have some provision for drainage so that runoff doesn't pool on the uphill side of the strip.

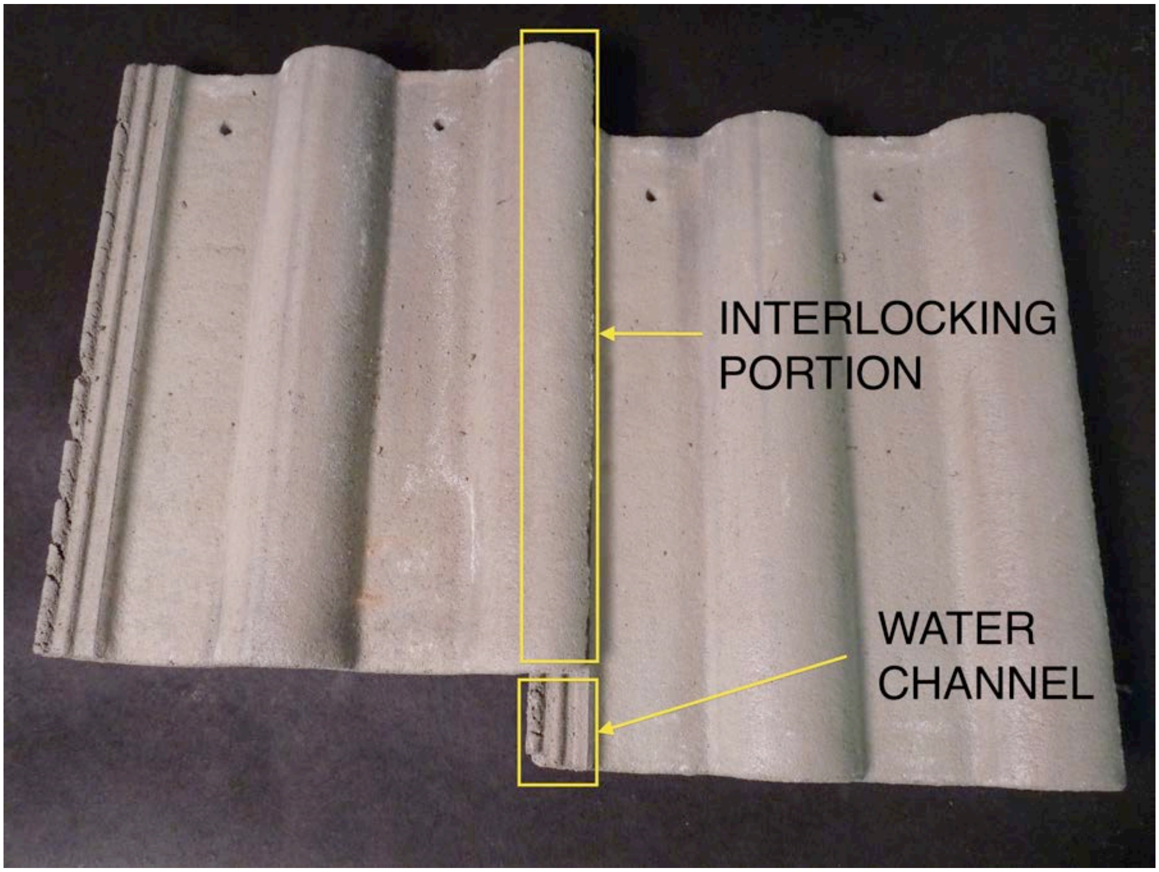
To reduce the chances of leakage, joints should align at alternate courses like you see here… not at each course, like you see here.

Concrete Tile Failures

A common failure of interlocking tiles is broken lower right corners. Although it’s commonly thought that this is due to installation that leaves inadequate room for thermal expansion, that’s not the case. Lower right corners may be broken in a number of ways.

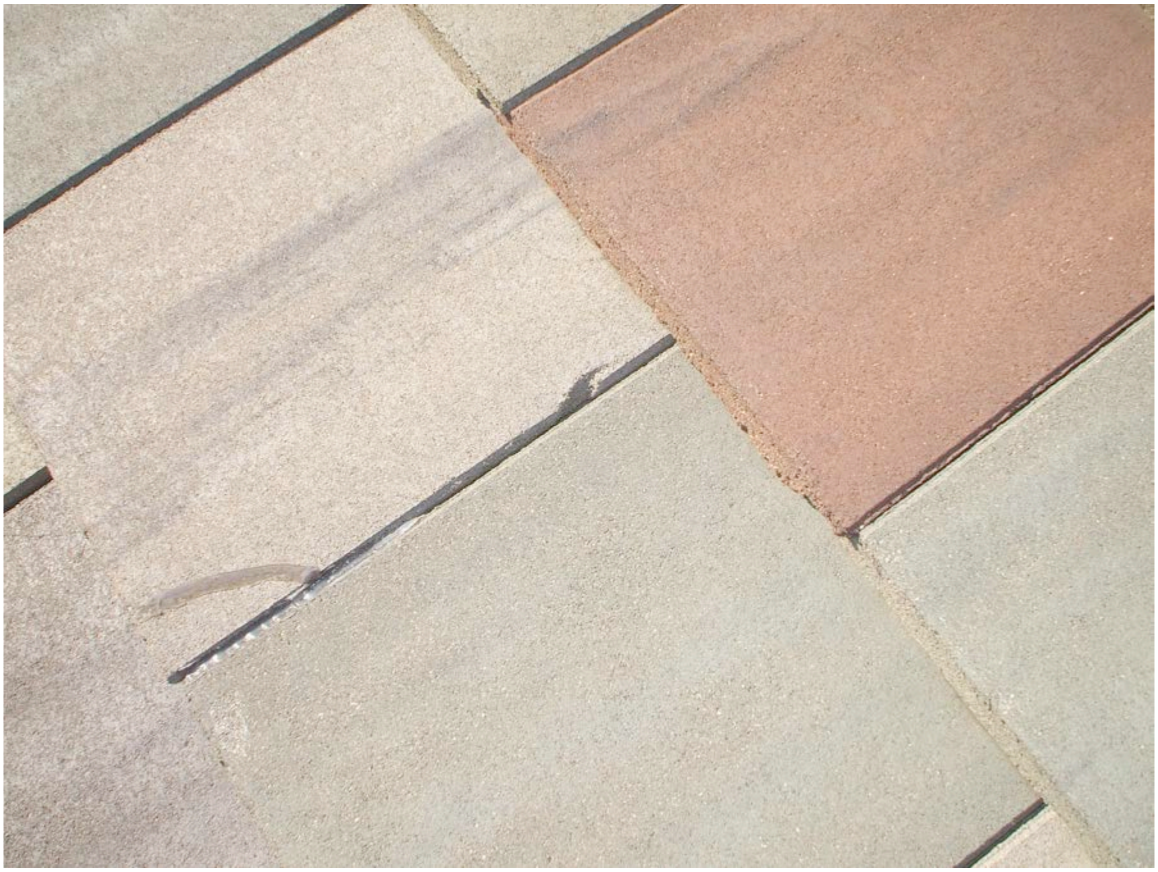


The portion of tiles that interlocks consists of two parts… and underlock… typically located on the left side of a tile when it's in place… and a coverlock… … typically located on the right side of a tile when it's in place. The coverlock and underlock interlock to help hold tiles in place, and the underlock forms a water channel.

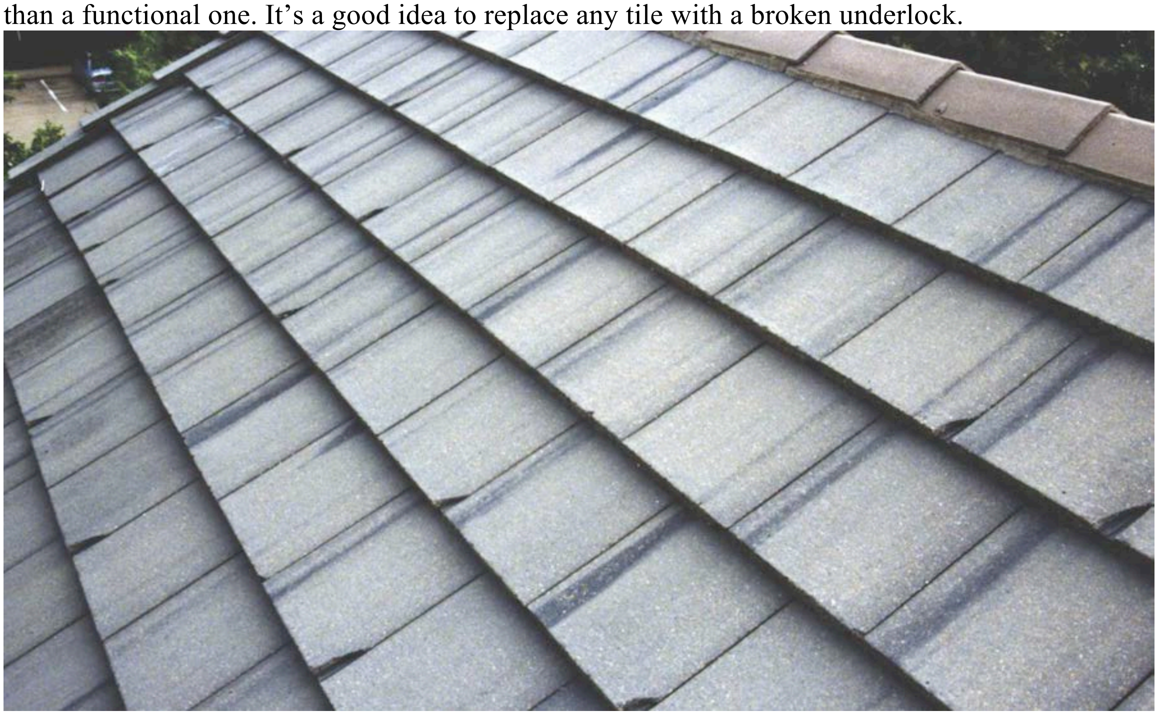


These interlocking portions are where tiles are thinnest and most likely to break first. The coverlock is more exposed to damage than the underlock and the weakest part of the coverlap is the lower corner. This is because the corner lacks the support of a surrounding tile on two sides.

Interlocking tiles that suffer a broken coverlock can still channel water off the roof, especially if only a small portion near the butt is broken. Recently broken tiles can sometimes be repaired with an adhesive.



Since the common headlap for tiles is 3 inches, chips off lower corners that extend more than 3 inches up from the lower edge should be replaced. Smaller chips are more of an aesthetic problem than a functional one. It's a good idea to replace any tile with a broken underlock.



Right corner cracks and breakage in general can have a number of causes:

1. Tiles may be damaged in shipping. Sometimes pallets of tile are handled roughly

2. Tiles may be misaligned when they're installed. This can create point loads that cause tiles to break more easily.
3. Debris left in the interlocking channel can also create point loads.

4. Tiles may develop shrinkage cracks during the drying or firing process that will be weak points where tiles will break more easily.

5. Impact from hail, tree limbs or ice falling from an upper roof onto a lower one.

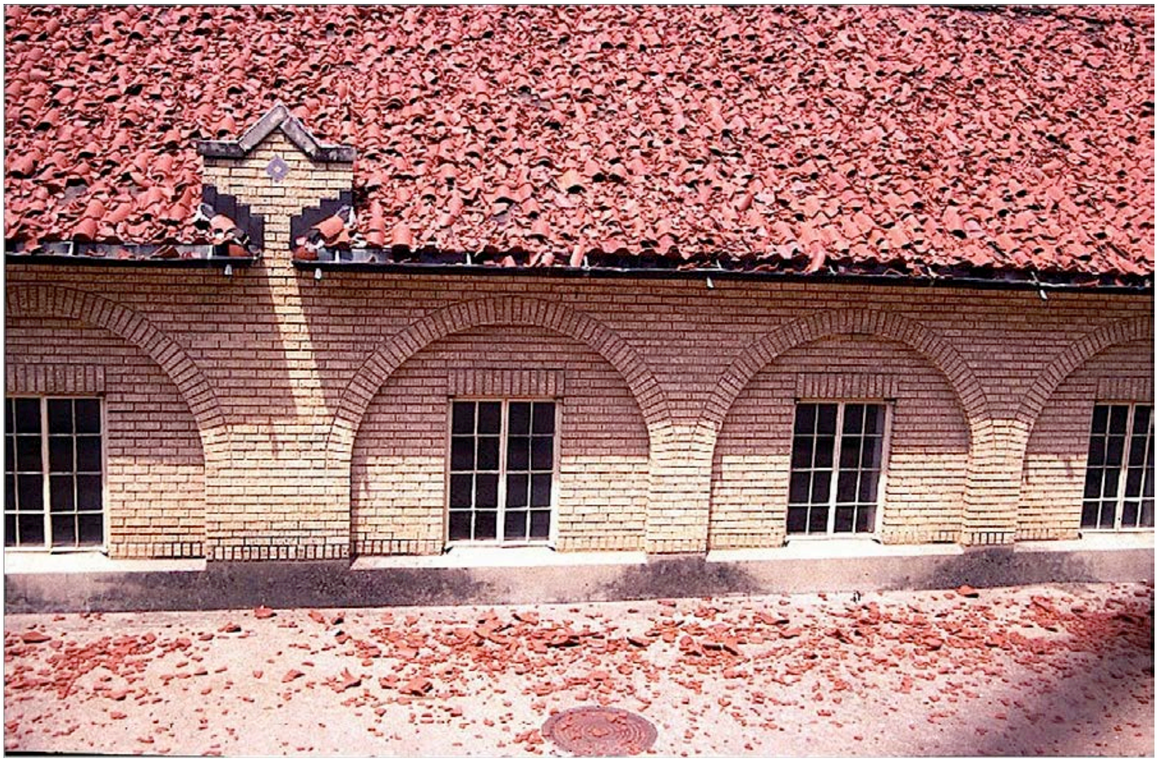
6. Footfall can damage tiles, especially if the tiles are not lying flat.

You may be able to identify damage from footfall by the overall pattern of damage, like where damage occurs at intervals about the same length as a person's stride.

Damage from footfall will often show a main crack located above the headlap where the tile has no underlying support. Cracks from footfall are more likely to cause a few major cracks rather than shattering. Shattering is more typical of damage from an impact.

Damage from footfall is more likely to be located in a natural path of travel, like between this hip and valley.

Tile in general has good resistance to hail impact, but if hail is dense and larger than about inches in diameter tile is going to be broken!



This is the result of an intense hailstorm dropping large hail. Of course this roof is an exception, 2 large hail carrying a lot of impact energy is required to do this type of damage, like this hailstone

that fell right through a garage roof.
H

ail damage typically shows up as shattering emanating from the point of hailstone impact.

AGING PROCESS

Over the long term, cement in concrete tiles slowly erodes away, making them more porous. This process allows tiles to absorb more moisture. This is especially damaging in cold climates where absorbed moisture freezes and causes damage as it turns to ice. As moisture turns to ice, it expands by about 10%.

End of useful life

Although the ways in which clay and concrete tile age are both related to their porosity and their hardness, clay and concrete tiles age differently.

As concrete tiles age, erosion of the cement and exposure of the mix aggregate cause them to become more absorbent, so that they absorb moisture increasingly easily as they get older. As concrete tile near the end of their useful lives, they reach a condition in which they can become completely saturated. Clues that concrete tile are nearing the end of their long-term service lives are:

- Efflorescence forming on the tile.
- Moisture dripping from the underside of the tile.
- Thinning of the glaze
- Displaced or missing tiles
- Cracking, and
- Pitting

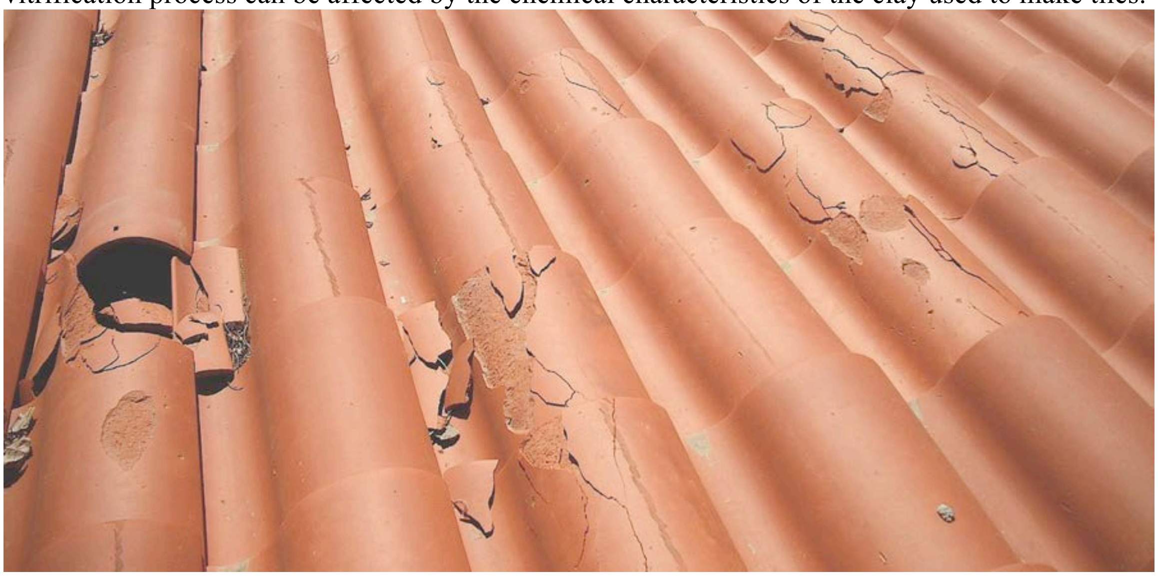
Concrete Tile Replacement

How easily profile tiles can be removed and replaced will depend on the fastening system, which will vary with local conditions and regulations and with the manufacturer's installation recommendations. It is challenging to finding matching tiles. If matching existing tile is difficult, tiles for a repair can be taken from an inconspicuous part of the roof and the resulting gaps can be filled with tiles that don't match well. I won't matter if they're not visible.

CLAY TILES

Clay tiles are another roofing material that's been around for a long, long time. They're manufactured using a casting process. Molds are filled with a fine, wet clay, and then baked in a kiln until vitrification takes place.

Vitrification happens when the various minerals in clay change and bond chemically to form a single, dense, non-porous tile. Full vitrification turns clay to a glass-like material. For clay tile, the vitrification process is key to long-term durability. Incomplete vitrification will result in the finished tiles being more porous, which means they'll absorb moisture more easily. The vitrification process can be affected by the chemical characteristics of the clay used to make tiles.



When moisture in tiles freezes, it expands, causing delamination and surface deterioration, called "spalling". Lower quality tiles are more porous and so they're more vulnerable to freeze damage.

This home was located in the high desert of California where it can be warm during the day, but drop below freezing at night.

Incomplete vitrification

Glazing is sometimes applied to the top surface of tiles for decorative effect and to help reduce moisture absorption.

Both clay and concrete tile installed in areas subject to freezing temperatures should comply with ASTM manufacturing standards t hat test tiles for resistance to freeze damage.

This is just background information; you are not required to confirm compliance to standards.

The dark surface of this tile is a glaze. From long-term exposure to weather, the glaze has become thin and has cracked in areas. Tiles with cracks that penetrate the glaze are vulnerable to spalling and flaking from moisture absorption and freeze damage, and you can see areas where this has happened.

Another problem that can develop from the manufacturing process is shrinkage cracks. They happen to clay tiles for the same reason they happen to concrete tiles. That is differential shrinkage rates between the clay at the surface and the clay at the inner core of the tile. The surface layer loses moisture and shrinks faster than the core. This process creates stresses that are relieved by cracking.

These cracks may be barely visible when the tiles are newer. As tiles age, cracks become more pronounced, increasing moisture absorption and making them more vulnerable to breakage from things like foot traffic, hail impact and freeze damage.

This is the roof on which that tile was used. Apparently, the installers refused to let themselves be limited by good practices developed by those who had gone before. Tiles range in color, texture and in length from about 4 inches to full tiles, with all sorts of lengths in between thrown in to keep things interesting. Some tiles are upside down. You can see the fastener holes. Tiles appear to be held in place by… the tile in the course above… and lichen… although there does seem to be some kind of adhesive dribbled around in a random method. This was the windward slope in a high-wind area, which would account for some of the tile displacement, but a large portion of this strange installation appears to be due to the unique frame of mind in which the installers worked.

AGING PROCESS

Clay tile exhibits different characteristics near the end of its service life. Let's talk about recognizing failures in clay tile.

As clay tile ages, the protective glaze weathers away. The rate at which it deteriorates will vary, depending on tile quality and the site environment. As tiles lose glaze, they become more moisture absorbent that, over time, makes them softer, more fragile and vulnerable to freeze damage.

Here's an example of a roof in Southern California that's into the downhill part of the aging curve. You can see that edges are weathered and chipped, and the roof has displaced and broken tiles and crumbling mortar.

With this many layers and intact tiles, it may not leak for years to come, so in your report, you'd describe its condition, including that mortar blocked efficient drainage, mention that it needs maintenance and that it may need to be replaced soon, but not actually recommend replacement.

Natural VS accelerated failure

Especially in cold climates, failure is often due to delamination and surface spalling caused by freeze damage. In inspecting clay tile, you need to differentiate deterioration common to the natural aging process from manufacturing defect that cause tiles to fail prematurely through delamination caused by excessive moisture absorption and freezing.

During close examination of representative tiles, you should dislodge some of the flaking.
If algae or lichen are present beneath the flaking, the process is slow and natural.

If you pull flakes loose and the clay underneath looks clean and bright, the deterioration process is newer and faster.

This newer, faster deterioration may be due to manufacturing defects like incomplete vitrification caused by poor clay mixing, poor glazing or inadequate control of firing procedures.
Environmental factors like hail or temperature extremes may contribute to delamination.

System failure VS localized failure

Finding problems in one area of the roof doesn't necessarily mean that the problem extends to the whole roofing system. Examples of localized failure include:

- Poorly mixed individual batches of mortar or mortar applied when outside temperatures were too low. This problem can apply to only one section of roof or all of it.
- Improper vitrification in a single batch of tiles.
- Repairs made with salvaged tiles that have characteristics different from the rest of the roof tiles.

And there can be many others. The point is that if possible, you need to check representative tiles from across the entire roof system before you make your final evaluation.

Along with clay and concrete tiles, you may encounter tiles made from a few other materials.

Metal tiles

Metal tiles may look like clay tiles from a distance, but are hard to miss upon closer examination.

Especially if they show corrosion… or dents.

FIBER-CEMENT TILES

Fiber-cement tiles were originally made by mixing asbestos fibers with cementicious mixtures that usually included Portland cement and sand.

With the realization that asbestos fibers were a health hazard came legislation that eventually prevented the use of asbestos fibers in many products, including fiber-cement roofing tiles.

Manufacturers who wanted to continue to sell similar tiles needed to find a material to substitute for asbestos, and many chose cellulose fibers. It turned out to be a bad choice. Cellulose fibers used in this application deteriorated from moisture and from chemical reactions with the cement mixture. Asbestos and cement had similar expansion and contraction rates, but that wasn't true for cellulose. Manufacturers offered 50-year warranties. Tiles failed after only a few years… then the fiber-cement roof tile industry failed; at least for the most part. For that reason we won't talk much about inspection of fiber-cement tiles. You may still see them, since they were originally very durable. They have properties similar to concrete tiles. They should be an effective barrier against moisture penetration of the roof structure.

Fiber-cement tiles may be able to come in different profiles. These were on a houseboat in California.

COMPOSITE TILES

Although they're less common, you may see tiles made from recycled plastic installed on roofs. These are typically called "composite" tiles because they're often made from a combination of materials mixed together. Composite tiles typically have a 50-year warranty, but although a couple of companies have been around since the early 1990's. Most have only been in production since around the turn of the century, which at this point is only about 11 years, so we won't know for a while what kind of longevity we can realistically expect from them. Examine composite tiles carefully before you try to walk them. Some types of plastic tile are safe to walk as long as they're in the sun, but become very slippery once they're in the shade. Some types become brittle as they age and will break easily when they're walked on.

Composite tiles may be made from a wide variety of materials. These particular tiles were made from reycled plastic.

Walking tiles

Whether or not you should walk tiles is a judgment call. How easily tiles break will depend on the tile material, profile, quality, condition, and installation method. Of course, this will vary from structure to structure so you'll need to evaluate each roof independently. Even if homes side-by-side appear to have identical tile, look carefully before you walk. Tile may not be exactly the same, or it may have been installed differently or at different times. Unless you are very familiar with the type of tiles you're walking on, don't walk clay tiles. Rent a boom truck, hook a ladder over the ridge, or use sheets of plywood hung ropes. Any method that distributes your weight across a larger area will reduce the pressure on individual tiles and reduce the chance that you will break tiles.

Walking tiles

Whether or not you should walk tiles is a judgment call. How easily tiles break will depend on the tile material, profile, quality, condition, and installation method. Of course, this will vary from structure to structure so you'll need to evaluate each roof independently. Even if homes side-by-side appear to have identical tile, look carefully before you walk. Tile may not be exactly the same, or it may have been installed differently or at different times. Don't walk clay tiles. It's better to recommend evaluation by a qualified contractor, than to risk having to pay to have tiles replaced.

Hail Damage

Where tile roofs are designed and installed to perform well, they may be damaged by hail larger than 2 inches. This can vary with the hail density, velocity, wind speed and other variables that affect the amount of impact energy carried by the hail.