the construction Solutions for the construction industry 1 february 2013

Avoiding Leaky Exterior

by John Ogilvie Photo courtesy Golden Gate Enterprises

MANY RESIDENTIAL AND LIGHT COMMERCIAL BUILDING OWNERS SEEM TO BELIEVE A TILE INSTALLATION IS WATERPROOF, AND FAIL TO PAY ENOUGH ATTENTION (OR MONEY) TO THE PROPER TREATMENT UNDERNEATH.

The resulting leaks can occur undiscovered for years, eventually causing rot that requires major renovations. Not only does the structure need replacement work, but the tile application must also be removed to access it.

The water most likely entered through cracked grout joints or on the perimeters. If the deck is in a cold climate, the moisture freezes, expands, and causes tiles to erupt. Still, a failure in the tile installation does not mean a failure in the waterproofing system. If the membrane is intact and performing its function of keeping the water out, replacing a cracked (or erupted) tile or grout joint is relatively easy and inexpensive.

This article examines some of the common reasons for tile failure, the methods for building a deck to ensure it is ready for a floor finish, and the critical installation details for longterm durability and successful waterproofing.

Installing tile on decks and balconies

There are two distinct methods of installing tile in waterproof

applications: thick-set (using a 38-mm [1 ¹/₂-in.] dry mud bed) and thin-set (using a 6.4-mm [¹/₄-in.] acrylic-modified mortar).¹

Thick-set

The thick-set method is more likely to be used where the tile is thick and irregular in order to achieve a flat walking surface. Installations (also known as 'thick-bed' and 'mortar-bed') are based on the traditional method of packing a mortar bed over a surface before installing the tile. The tile is adhered to the mortar bed either while it is 'green' (*i.e.* just beginning to dry) or after it has cured.

The mortar bed may be reinforced with wire, and either set over a cleavage membrane (that allows the mortar bed to 'float' free of the substrate) or bonded to the substrate. For wall applications, metal lath is mechanically anchored to the substrate and the mortar locks into it as it cures.

Thin-set

Thin-set mortar is a blend of cement, finely graded sand, and a water retention compound that allows the cement to properly hydrate. As its name suggests, the material is designed to adhere well in a thin layer—typically not greater than 4.8 mm (³/₁₆ in.) thick. For example, a 9.5-mm (³/₈-in.) notch trowel will produce that thickness after the tiles are pressed in to the cement.

A \$70,000 repair could likely have been avoided by spending an extra few dollars per square foot to have a proper, tile-compatible, roofing membrane installed.

While very minor adjustments in height can be made, this method is not appropriate for changing the level or flatness of a surface—rather, the tiles follow the plane of the substrate. Only 'gauged' tiles (with similar thickness) should be used in thin-set mortar applications.

Causes for tile failures

From deck design to adhesives to maintenance, tiles can fail for various reasons.

Building the deck

When it comes to slope, adding drains and scuppers increases the degree of difficulty. While it can still be accomplished with good design and careful framing, the most simple and effective way to deal with water is to let it flow over the side of the deck.

Assuming the joist spacing and sizing is appropriate for a tile assembly, the choice of materials and how they are fastened together plays a large part in keeping the grout lines from cracking or the tiles from popping off. The assembly needs to be very stiff and flat and built to substantially reduce structural deflection (*i.e.* the spring or give of the deck surface). A total thickness of at least 31.75 mm (1 ¹/₄ in.) is required.

One option involves 19-mm (¾-in.) plywood with a 13-mm (½-in.) cement backer unit (CBU) fastened with thin-set bonding adhesive and appropriate screws. The joints of the overlay should not be over top of the joists; they should be one quarter of the distance to the next joist. The fasteners should only be long enough to attach it to the plywood beneath (and not to the joists), allowing it to 'float.'

Flatness is important. If there are humps and bumps, the ensuing ponded water cannot be easily resolved by later floating it with filler. Any flatness issues need to be dealt with before the waterproofing membrane is applied.

Waterproofing

Based on projects this author has seen, there seems to be a great lack of understanding of this step's importance. To determine the best practice, several questions must be answered:

- Is this deck serving as the roof over habitable space?
- Does it require a roofing membrane to meet the local building code?
- Should that membrane be applied by trades who specialize in roofing details or by tile-setters?
- Is the membrane suitable for tile to be applied to?
- Is it compatible with polymers that are part of the thin-set bonding adhesives?
- Is it firm enough to prevent cracking of the tiles?
- Will it soften in the heat while still supporting the tile assembly?
- Has it been tested to meet the traffic requirements of the job?

• Does the manufacturer guarantee it for this end use? Many beautiful tile jobs have failed partly because they were installed directly over modified-bituminous (mod-bit) roofing—a material that is incompatible with the bonding adhesives, too soft, has no testing to support its use for this application, and not guaranteed by any of the manufacturers for this end use.

Thin-set bonding adhesive

The desire to save money by choosing a less expensive thin-set bonding adhesive (*i.e.* a polymer-modified mortar) has been a large source of failure. Not all products are equal, and certain properties are required for outdoor tile installations.

Higher-priced thin-set mortars tend to have better polymer additives, allowing for more movement. With the constant



Installing tile over a waterproofing membrane, using thin-set mortar.



Evidence of leaching from the system, due to improper or inexpensive thinset mortar. Photo courtesy Hillside Decking



Leaks can occur undiscovered for years, eventually causing rot that requires major renovations. Photos courtesy Duradek

movement resulting from changing temperatures, the thinset is trying to hold the tile in place. The better quality the thin-set, the longer it continues to provide adhesion.

Outdoor installations are obviously susceptible to dramatic temperature and humidity fluctuations; the thin-set must be capable of performing even under wet and freezing conditions. Some experienced tile-setters will not do an outdoor job unless it can be tarped off to keep it out of direct sun and rain for a significant period, allowing for proper curing of the materials. There are fast-setting thin-set adhesives available for cooler temperature installations manufacturer recommendations should be followed.

An improperly built and prepared surface may provide small areas that allow water to pond. Prolonged dampness may promote the re-emulsification of the mortar that would impact the adhesion. Manufacturers should provide guidance on this issue.

With respect to efflorescence, the white stains that seem to ooze out of the grout joints or from the outer edge of the tiled surface might be a result of the wrong choice of thin-set or grout material.² The manufacturer will recommend the correct materials to be used to reduce or eliminate efflorescence.

Choosing the tile or stone

Some of the failures of outdoor tile jobs are caused by wrong product choices. Freeze-thaw resistance and water absorption characteristics must be researched to ensure the product is matched to the climate in which it will be installed. For instance, this author has seen slate tile installed in a region that experiences many annual freeze/thaw cycles. The stone was flaking apart, which is something that could have been predicted considering the properties of the particular product. If the supplier does not have the information, another product or supplier should be chosen.



The perils of improper waterproofing under a tile deck go beyond aesthetic issues to rot and repairs.

Tile installation techniques

The tile-setter's skill is extremely important to the eventual success of the job. Voids in the thin-set coverage will provide space for moisture to collect.

While difficult to completely avoid air spaces, the goal is to get at least 95 percent coverage of the bonding adhesive.

Tile, thin-set, and grout are rigid materials. The tiled assembly is going to have substantial movement as the temperature changes and provisions are required to allow for that movement. Industry standards call for 'soft' expansion and control joints to be provided as per Tile Council of North America (TCNA) Detail EJ171 or Terrazzo, Tile, and Marble Association of Canada (TTMAC) Specification Guide 09 30 00, Detail 301MJ. These 'soft' joints tend to look visibly different than the other grout joints. As a result, some choose 'form' over 'function,' and suffer the consequence of erupting tiles. The laws of nature always prevail.

Details

Waterproofing is all about the details. Failures seldom happen in the center of a roof or deck, but rather on the perimeters. Special attention should be paid to corners, door openings, posts, pony walls, drains, scuppers, outside perimeter finish, inside perimeter (up the wall behind the siding and building paper), and railing attachments.

Waterproofing or roofing?

While it seems there are many manufacturers providing waterproofing products suitable under tile, only a few offer roofing materials for this purpose. Specifiers may be wondering where the difference lies. After all, a material is either capable or incapable of keeping water out.

The rationale involves the liability manufacturers are willing to take—roofing infers a lot more than waterproofing—and the skills required for properly applying the membrane. This application demands trade professionals be familiar with the intricate details presented by decks and balconies.



An example of efflorescence forming on tile.



Insufficient mortar coverage leaves voids in the mortar bed, which may allow water to hang in the system possibly leading to freeze/thaw issues and erupted tiles.

Photos courtesy Hillside Decking



This failed tile deck required a complete rebuild.

Railings

A surface-mounted rail should never be attached atop a tile or stone finish, as the fasteners required to hold the rails will penetrate the roofing membrane. Water flows on top of the waterproofing membrane, and any penetration will be almost impossible to seal.

The other issue with a surface-mounted rail relates to the likelihood of cracking the tile as the fastener is tightened. The best practice is to mount the rails on the fascia or on a curb.

If the rails are mounted on posts that penetrate the deck surface, special provisions must be made to provide a waterproof 'collar' up the post.

Maintenance

Some thin-set manufacturers recommended regularly applying the appropriate sealer to the tile and/or the grout. Their rationale is this reduces the penetrating moisture and helps prolong the assembly's life.

Failures

This author knows of a contractor in the San Francisco Bay area who recently completed a repair of a failed residential tile job that involved a new ceiling, replacement of rotted floor joists, door removal, and a new tile installation, this time with an appropriate roofing membrane. The problem was a waterproofing membrane had been present, but it was not a 'roofing' membrane or installed with 'roofing' details. The repair was more than \$70,000 for a deck that was only about 46.5 m² (500 sf). It could have been avoided by spending an extra few dollars per square foot to have a proper, tilecompatible, roofing membrane installed in the first place.

Preventing failures

A major cause of failure of tile over decks and balconies is the structure to which it is applied allows too much deflection. Tile has little tolerance for deflection, and cracking grout lines or units is the result.

Deflection is a product of the joist spacing and thickness of the flooring materials. The TTMAC specification for flooring under tile or slate (*i.e.* Exterior Decks 325ED–2009/2010 Detail C) notes:

Sub-floor—16-mm [%-in.] exterior-grade plywood meeting, sloped a minimum of 2%. Backer unit 13 mm [½ in.] minimum and must be exterior-rated. Backer unit bond-coat and fasteners as recommended by manufacturer. Backbuttering recommended to bond tile to achieve 95% mortar contact. Apply approved roofing membrane and primer as recommended by manufacturer.



An improper post detail can allow water to penetrate the membrane and may crack the tile. Posts should be fascia mounted. Photos courtesy Duradek

The use of a cement board overlay is recommended by most tile associations and manufacturers, but it is important to remember there may be regional differences. Cement board, unlike plywood, is not affected by varying levels of moisture. Indeed, for the money being invested in the whole system, it would seem unwise to scrimp on the subsurface. In case of a failure (*i.e.* cracking), the first thing anyone will look at to lay blame is whether the floor was strong enough and provided the necessary deflection resistance. Concrete decks and balconies are suitable for tile application, but still require proper waterproofing or roofing protection.

Sloping the surface

Puddles are both annoying and a potential source of damage to the tile assembly. The easiest way to direct water away is via adequate slope. Nevertheless, sound roofing/waterproofing practice needs to be employed even when tile is applied over top. One should operate on the expectation of water getting through the tile installation. The waterproofing membrane will be applied to a surface sloped toward drains, scuppers, or an outside edge that allows water to escape.

Moisture will still run downhill, even under tile applications. This can happen without negatively affecting the bond of the thin-set mortar to either the tile or membrane. If there are seams in the waterproofing membrane, they should run parallel to the slope to avoid any puddling water behind the bump.

A two-percent slope (*i.e.* approximately 63.5 mm [2.5 in.] in 3 m [10 ft]) is safe. Many people consider this excessive and try to reduce it, only to find that with settling of the building, frame shrinkage, and the possibility of the crowns on the floor joists not all being up, there are puddles.

While it is possible to provide a slope to a flat, waterproof surface with thick-set mortar, there are problems to consider with this decision. If the waterproof



A prefabricated edge trim which allows the water to flow out behind the trim.

membrane is flat or allows water to pond on it, providing a sloped mortar bed will not remove all the water from the deck. Although most of the moisture will drain off the top surface, water can still enter

under the tile through cracks in the grout joints, cracks in the tile, or on perimeters.

The water that enters will follow the waterproofing membrane's slope. If it ponds before the thickset mortar goes on, it will also do so after the tile job is completed, potentially causing mold and an unpleasant odor.

Any 'bellies' or depressions need to be taken out of the deck surface before the waterproofing membrane is installed. Since water will not penetrate the waterproofing membrane, if the depression has been eliminated any water reaching it will be shed away.

Waterproofing options for under exterior tile

When the deck is over living quarters, there must be a roofing membrane and the assembly needs to be installed with roofing principles in mind. However, even when it is over unoccupied space and there is no specific building code requirement, the installation details should not be less stringent, considering the consequences of leaks.

When researching products for waterproofing decks and balconies to which tile will be applied, specifiers may notice the frequent absence of the word 'roofing.' As mentioned, many manufacturers of these systems want nothing to do with the headaches and liabilities involved. There are also details one would never consider using in a non-roofing application, such as finishing a membrane on the flat horizontal surface without turning it over the edge and then caulking the leading edge. Granted, most details are intended for concrete decks and balconies, but for light-commercial and multi-family construction discussed in this article, wood framing is more likely.

In terms of specific 'roofing' products, mod-bit materials are among the most common. Mod-bit is asphalt with added modifiers (*e.g.* atactic polypropylene [APP] or styrene butadiene styrene [SBS]) to give it plastic or rubber-like



A finished tile deck with a waterproof membrane.

properties. Rolls of modified bitumen membrane come in widths of 914 mm (36 in.) to approximately 990 mm (39 in.) and cover an area of about 9.3 to 10.4 m^2 (100 to 112 sf).

Mod-bit roof systems consist of one-, two-, or threeply systems (base sheets with no cosmetic finish and cap This sheets). The cap sheet membranes may be applied using a torch (the back of the sheet has extra asphalt on it that, when heated, bonds to the substrate) or be self-adhered (removing a release paper on the back exposes a sticky surface which adheres to the substrate).

To the best of this author's knowledge, none of the manufacturers of mod-bit products supports tile installations directly to the roof membrane; therefore, there is no promise it works in these applications. Additionally, the asphalt in these products is incompatible with the mortar in the thin-set or the grout lines; it may bleed through, causing discoloration. An uncoupling system is usually required to isolate the mod-bit membrane from the tile and bond-coat layer.

More importantly, when the mod-bit softens as it heats up, it can be compressed. This could allow the tile or the grouting to crack from the movement from traffic on top. Any product designed to have tile installed overtop will have test results from the Robinson test (ASTM C627, *Standard Test Method for Evaluating Ceramic Floor Tile Installation Systems Using the Robinson-type Floor Tester*) to verify it is capable of supporting weight of people and equipment.³

The traditional method of providing roofing protection under tile would be to install a suitable roofing product like polyvinyl chloride (PVC), ethylene propylene diene monomer (EPDM), thermoplastic polyolefin (TPO), modbit, or liquid-applied urethanes with a thick-bed mortar system on top to which the tile is attached. (It is important to know whether the manufacturer supports use of its product in such a way.)

The tile may be uncoupled from the mortar bed, the mortar bed uncoupled from the roofing membrane, or both. There may be a drainage layer above the roofing membrane



This waterproofing membrane is ready to accept thin-set mortar and tiles.

to allow any moisture to escape along the drainage plane. This system is expensive, heavy and thick (at least $[1 \frac{1}{2} \text{ in.}]$ above the membrane); it is also complicated—there may be as many as seven or eight layers involved in the system.

Other components

There is a frequent misconception anti-fracture membranes allow elimination of expansion joints. There must always be soft joints in the tilework to allow for expansion and contraction. Guidelines for expansion joint placement are given in the *TCNA Handbook*. The exact placement of expansion joints is a function of many items, including:

- exposure to sunlight and the range of high to low temperature;moisture;
- moisture,
- aging of the concrete (where relevant);
- structural movement; and
- expected loading.

There seems to be at least two theories about the necessity of a drainage or uncoupling mat. One is tile or stone can be directly bonded to an appropriate membrane with some crack-isolation properties, when used with the appropriate thin-set adhesive recommended by the manufacturer for the specific climatic region and job conditions (*i.e.* it can withstand the elements and provide the adhesion required even in the presence of moisture).

The other theory is since water is going to penetrate the grout lines and get under the tile, a drainage path needs to be provided to allow its escape. This brings up some other issues, such as the method of fastening the drainage mat (with a thin-set bonding adhesive, but not necessarily the same one used for the tile). Following the manufacturer's



A properly installed and waterproofed tile deck ensures no water penetration into subsurface or structure.

recommendations is essential for success and to ensure warranty coverage.⁴

The assembly has little tolerance for movement and is likely to crack if there are not steps to reduce (isolate) the movement of the subsurface from the tile/grout assembly. Waterproofing membranes likely provide some crack isolation themselves; this protection is increased by adding a drainage/decoupling mat.

Critical installation details

There are a few finish details that are critical to a successful waterproof tile deck.

Outside perimeters

Since there are many ways to finish a tile deck's outside perimeter, the design team needs to establish the desired look, consulting with the owner, builder, and tile-setter. Depending on the chosen finish, the details can be altered accordingly. Attention to these details contributes to the job's overall success.



Tiled roof decks can be found in residential and hospitality projects.

Drains

Should drains be necessary, a special cast drain with a square top makes it easier and more attractive for the tile applicator's finishing.

Rail attachments

As mentioned, this author strongly recommends attaching rails to the fascia instead of the surface of the deck. Rails installed over the tile may cause the overlay to crack. There are special details for surface mounted rails if there is no other alternative.

Inside perimeter

If the owner wants the tile to return up the wall as part of the finished look, appropriate flashings are needed. If not, then consideration must be given to the visibility of the part of the membrane that returns up the wall and hiding the gap that must be left on the inside of the tile application.

Surface preparation

Apart from a thorough inspection for a properly fastened substrate, there is little preparation work necessary. A light sanding of the joints of the cement board or a scraping of the entire surface to take care of any bumps will suffice; no filling is required.

Installation qualifications

A waterproofing membrane, especially in a roofing application over living space, should be installed by a qualified applicator who has gone through a training program, can work with the critical details as specified above, and, most importantly, understands proper roofing principles.

Conclusion

There are few outdoor surfaces as attractive and durable as tile or stone. They can be used outdoors even in extreme climates, providing there is a great deal of care put into the choices of materials and trades people.

As so often happens, attempts to cut corners on costs or by taking shortcuts—even ones that seem to make sense—result in the most expensive installations. The common theme is to follow the manufacturer's recommendations to the letter and employ only experienced professionals for each part of the job. The chances of a successful, longlasting installation exponentially increase when this occurs.

Notes

¹ Medium-set mortars can be used to adjust for slightly larger variations in the substrate than can be accommodated with thin-set mortar. They are also



Attempting to save money on various elements of the system – thinset, waterproofing membrane, tile, grout, etc. – will lead to problems. Use approved products and follow the manufacturer's specs to the letter.

used with large, heavy, thick, or 'ungauged' (varying thickness) tiles, where a thicker setting bed and a coarser

aggregate may be required to achieve a flat installation and to support the tile's weight the cement is curing.

² For more on this topic, see the article, "Why Red Brick Turns White: Understanding Efflorescence," by Joseph "Cris" Crissinger, CSI, CCS, CCCA, ASQ, which can be found in the November 2012 issue of *The Construction Specifier.* To read it, visit www.

constructionspecifier.com and select "Archives." ³ The Robinson Floor-tester is a unique machine

capable of carrying out the test for an ASTM C627 designation. It verifies the suitability of a flooring system for a particular type of installation, such as tile. At the very least, a 'Residential' rating should be required.

⁴ It is important to ensure the waterproofing membrane being used is covered with a warranty. Often, the warranty is void when it is covered by another product, like tile. Specific terms and conditions need to be

checked with the manufacturer.

ADDITIONAL INFORMATION

Author

John Ogilvie is the president and co-owner of Duradek Ltd., which has been waterproofing decks and balconies since 1974. He helped develop a roof membrane specifically designed and tested for the application of tile or stone overlays. Nearly 40 years ago, Ogilvie also was a key figure in developing the industry's first approved walkable vinyl roof deck system. He continues to certify journeymen installers and runs building envelope seminars across North America. Ogilvie can be contacted via e-mail at jogilvie@duradek.com.

Abstract

Many residential and light commercial building owners seem to believe a tile installation is waterproof, and fail to pay enough attention (or money) to the proper treatment underneath. The resulting leaks can occur undiscovered for years, eventually causing rot that requires major renovation work. Not only does the tile application need to be torn up, but the entire structure may need to be replaced. This article examines commons reasons for failure, methods for building a deck to ensure it is ready for a floor finish, and critical installation details for long-term durability and successful waterproofing.

MasterFormat No.

07 10 00–Dampproofing and Waterproofing 07 76 16–Roof Decking Pavers 09 30 00–Tiling

UniFormat No.

B1010.20–Floor Decks, Slabs, and Toppings B3040–Traffic Bearing Horizontal Enclosures C2030.20–Tile Flooring

Key Words

Divisions 07, 09 Exterior decks Tiles Waterproofing

Contents of The Construction Specifier are copyrighted and are reproduced by Foster Printing Service with consent of Kenilworth Media Inc. The publisher and The Construction Specifications Institute shall not be liable for any of the views expressed by the authors, nor shall these opinions necessarily reflect those of the publisher.

