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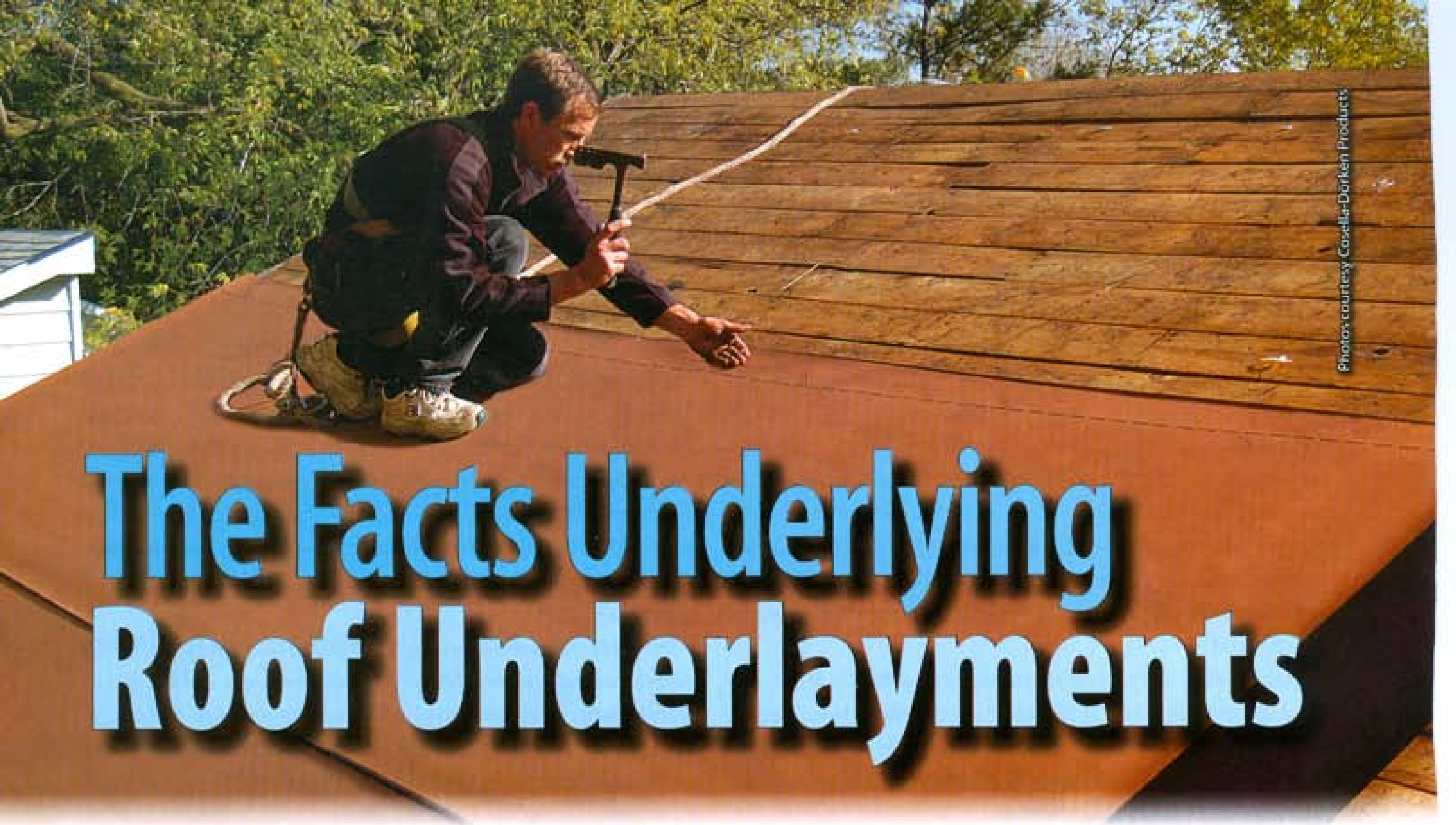


The Facts Underlying Roof Underlayments

by Marcus Jablonka, Dipl.Ing., Dipl.Wirt.Ing., and Peter Barrett, CSC, MBA

Up until 20 years ago, a roof's primary function was to keep building occupants warm, dry, and sheltered from the elements. Life for the sloped roof was fairly simple—it merely had to top the building, shed any snow and rain, and perhaps look nice. However, builders and architects have begun to demand more from roofing. Materials available today enable the design of higher-performing roofs. The roof is now part of the sophisticated, interdependent enclosure system known as the 'building envelope.'

In addition to offering architectural appearance and the ability to shed rain and snow, the sloped roof can now play a lead role in contributing to overall occupant comfort and building lifecycle. In this scenario, moisture management (of water both as liquid and vapor) is a vital performance criterion, and has become the measurement of a roofing system's intrinsic value.

As a strict definition, the underlayment is any product that goes under the primary roof covering and over the structural components. It may be inserted into the roof system to perform one or several functions, such as shedding rainwater driven under roof tiles by wind or preventing ice damming at the eaves. Newer building codes often necessitate inclusion of an underlayment or eave protection in some form.

Once the final roofing material is applied, the underlayment is rarely seen or given much thought. Therefore, even in the design stage, it may fall victim to the old adage, 'out of sight, out of mind.' When designing a building envelope system, neglecting the underlayment could diminish the long-term value of the roofing assembly.

Until recently, specifiers and roofers had a limited choice of underlayments. In fact, for many years, underlayments were not used at all. The primary roof covering was relied on to protect the building and its contents without secondary line of moisture control or waterproofing defense. In some jurisdictions where building codes do not require anything different, underlayments are still not commonly used. Without them, the roof has no secondary moisture protection layer. Any water that migrates inward past the primary cladding can wet moisture-sensitive materials and contribute to moisture-related problems such as decay and mold. As facilities in all jurisdictions are subject to weather conditions, using underlayments could mitigate the risk of building envelope degradation due to water mismanagement in sloped roof structures.

An underlayment with good moisture management characteristics is essential for creating a well-performing roof, especially in either cold or mixed climates. These characteristics determine how well a roof underlayment contributes to managing moisture on the outside as well as the inside of the underlayment. Today, many choices are available—the main ones are asphaltic felts, self-adhering membranes, and the mechanically attached synthetic underlayments. It is important to evaluate the intrinsic value each type provides to a roofing assembly.

Felts

When employing asphalt-impregnated felts became common, it seemed like a technological advancement. Felts shed water based on the principle that oil and water do not mix. They are nearly water vapor-impermeable and tend to absorb moisture. However, felts do little to rid the system of water vapor and can wrinkle and gap, causing an uneven look. The stored dampness can also lead to mold formation and rotting of structural wood members. Shortages of raw material inputs have further strained felt manufacturers. The amount of waterproofing oil and thickness of the reinforcing mat have been reduced to nearly half their original weights per 9.3 m^2 (100 sf) to save costs. As felt robustness diminishes, so does its ability to provide the defense expected and required.

The overall intrinsic value they offer is relatively low. Felt underlayments yield a small degree of protection by shedding water, but conversely retain moisture and trap water vapor in the roof. Nonetheless, felts remain popular for low-performance applications with shorter warranty periods (*i.e.* less than 20 years), such as three-tab asphaltic shingles over ventilated attic spaces.

Self-adhering membranes

The next innovation in roof underlayments was the self-adhering (or peel-and-stick) membrane, which is manufactured as two predominate types—reinforced granulated surface and non-reinforced smooth surface.

Underlayments are primarily asphaltic felts, self-adhering membranes, or mechanically attached synthetic types.

The reinforced type essentially takes felt one step further. Felt is impregnated with styrene-butadiene-styrene (SBS) rubberized asphalt for more flexibility. Ceramic or silica granules are applied to the top for walking ease and ultraviolet (UV) protection. The process closely resembles that used to manufacture shingles. Due to the rigidity of the mat employed as reinforcement, the product remains relatively stiff and can easily crack in delicate or subzero situations. Overall, it offers a slight improvement over felt, but the reinforcing mat still has the same water-absorptive qualities and the material is still vapor-impermeable. These underlayments are a popular upgrade for low-performance applications.

Non-reinforced underlayments are self-adhering membranes consisting of a thick blend of SBS, rubberized asphalt laminated to a top carrier sheet, usually made of high-density polyethylene (HDPE). In essence, this assembly is below-grade waterproofing technology reworked for roof applications. As there is no mat core, the absorptive quality of the reinforced underlayment is eliminated and flexibility is improved.

These non-reinforced membranes offer slightly more intrinsic value than their reinforced counterparts by providing better waterproofing and retaining less moisture. However, as these membranes are completely vapor-impermeable, they prevent trapped moisture from diffusing to the outside.

Synthetic underlayments

Synthetic products represent the newest innovations and fastest growing market segment of underlayments. Synthetic roof underlayments are intended to replace felt or self-adhering membranes over the full roofing substrate. A peel and stick membrane is often required by building codes in cold or mixed climates for the roof perimeter to protect against water leakage caused by ice damming. The synthetic membrane is used to waterproof the rest of the roof.

Membranes come in different configurations and at various price points, but share common features. As with felt-based

An underlayment with good moisture management characteristics is critical for a long-lasting roof, especially in cold climates.

underlayments, most are rolled out and mechanically fastened. However, they tend to be much lighter and stronger, and cover more area per roll than felt. The ease of handling and speedy application (which reduces labor costs) can make synthetic membranes an attractive alternative. Additionally, as they are waterproof and resist tearing at fasteners, these underlayments are popular for the 'drying in' of a building, where an unfinished roof is made watertight so interior construction can begin.

Plastic sheet types

Many synthetic underlayments are descendants of the tarpaulin family, and consist of simple plastic sheets, some with reinforcing scrims to add physical strength and slip resistance. These products have merely been repackaged, relabeled, and repurposed for the roofing trade. Like their ancestors, they shed water, but are not specifically designed for use under roofing materials.

Their intrinsic value is very similar to that of self-adhering membranes. They provide waterproofing and possibly a slightly easier application, but most are vapor-impermeable; like the other underlayments discussed, these plastic sheets do not allow trapped moisture to escape.

Impermeable membranes are suitable for low-performance roofing systems, such as shingles over a ventilated attic space. As shingles themselves are vapor-impermeable, these synthetic underlayments have no adverse effect on the system's overall performance. However, they do not contribute to an energy-efficient, long-lasting roof.

Breathable types

Some synthetic underlayments have been engineered for use in the roofing industry, and are different to plastic sheet materials. The technology designed into these synthetics allows them to be waterproof yet highly vapor-permeable (often referred to as 'breathable'). When designing a roof assembly, specifiers can manage moisture vapor transmission, energy efficiency, and lifecycle with these materials, just as they would in a wall system.

Moisture vapor that might otherwise be problematic when trapped within the roof system can now pass through the membrane. A breathable, synthetic underlayment can make a roof airtight—and therefore, also highly energy-efficient—without encountering moisture problems. This characteristic makes for a long-lasting roof, as substrates and structural components are much less likely to rot or grow mold when humidity is controlled. These highly vapor-permeable underlayments have been the standard type used in Europe since the mid-1960s.

Underlayments may also have an impact on specific roofing components. Cladding, such as natural metals (*e.g.* zinc, copper, bronze), slate, and concrete or ceramic tiles, should be considered high-performance materials. Ventilation, moisture control, and bulk water management are important criteria for a properly performing roof—correctly managing these requirements may dramatically affect the lifespan of the cladding materials. Condensation, corrosion, or rot may quickly shorten an expected operating life from 50 years to a decade or two.

Vapor-permeable underlayments are also critical in specific roofing design configurations where moisture vapor issues warrant particular attention. Such situations include non-ventilated attics, attics that are being used as living space, and cathedral ceilings.

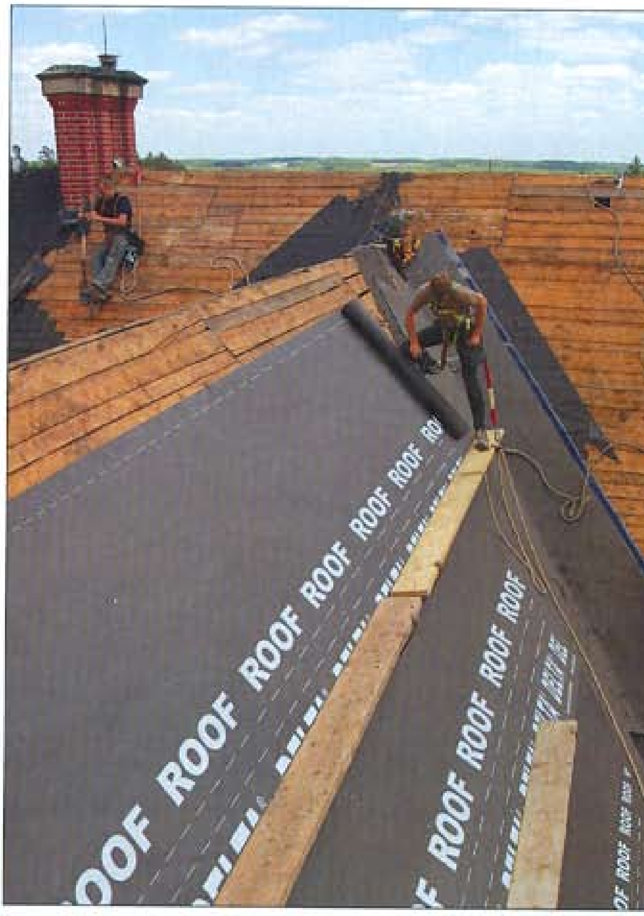
Selecting underlayments

When designers evaluate underlayment products for inclusion in roofing systems, several factors must be considered.

Resistance to water penetration

One of the first things to assess is the liquid water penetration resistance. The standard building code requirement to test this characteristic is based on a static water column as per ASTM International D 779, *Standard Test Method for Water Resistance of Paper, Paperboard, and Other Sheet Materials by the Dry Indicator Method.*

This test provides comparative data, but does not reflect real world conditions. For example, wind-driven rain can pound under a tile roof. Alternatively, the roof underlayment may be used as a temporary cover during the construction process. In



In a roof assembly, underlayments can help shed rainwater driven under roof tiles or prevent ice damming at eaves.

these conditions, rain places a dynamic load on the membrane. The static water column test cannot indicate how a membrane will perform in such conditions; it can only measure resistance to a static load.

A more informative and realistic test would be a rain impact resistance test, as suggested and commonly used by European underlayment manufacturers.(There is no equivalent ASTM standard for this test.) The membrane's water penetration resistance is challenged by putting it through actual simulated rainstorms at varying loads. During the test, water is sprayed on to the membranes at different rates under controlled conditions to simulate the dynamic loads of actual weather events. The membrane is then observed for leaks. Although specifiers may not be able to request relevant results from all manufacturers, the test represents an important real-life concept to be considered in the selection process.

Durability

Durability is an important consideration. The membrane should be strong enough to endure wear and tear during roofing application, from the loading of roof cladding to work crew traffic. Consequently, the material must resist surface abrasion from roofers' shoes, not tear at fasteners due to stress, and be slip-resistant (for worker safety).

The underlayment should also survive weather conditions while exposed on the jobsite. Exposure limits vary widely by product and manufacturer. Despite any grandiose claims, all underlayments should be covered as soon as possible after application. UV light, heat, and oxygen break down any plastic over time. Deterioration may not be visible, but is still occurring. When a membrane is exposed for an extended period before being covered by a cladding, degradation that occurs is now incorporated into the system—heat and oxygen then continue to accelerate the process.

As a result, the underlayment's functional life expectancy is significantly reduced by excessive exposure to UV light. Deterioration rates depend on membrane thickness and stabilizing additives used by the manufacturer, but some degree of degradation always occurs, adversely affecting the underlayment's lifespan even after covering.

Durability can be assessed by tests of accelerated aging under ultraviolet exposure and elevated temperature, such as those described in International Code Council (ICC) AC 48, *Acceptance Criteria for Roof Underlayment for Use in Severe Climate Areas*. Products available vary widely in weight, some weighing less than 100 g/m^2 (0.07 lb/sf). Generally, lighter products do not perform as well in these tests. The difference between the more durable, high-end, vapor-permeable, synthetic underlayments and lower-performing products usually becomes apparent.

Permeability

Energy efficiency is a critical factor. Consequently, builders and architects wil try to incorporate as much insulation (*i.e.* R-value) into building envelopes as possible without compromising the structure's life. In walls, more insulation is added while maintaining moisture management techniques, such as air barriers and vapor retarders. In cold and mixed climates, roofs with non-ventilated attics are often insulated by spraying foam into the space between trusses.

Unfortunately, this particular procedure frequently entails the placement of an impermeable underlayment over the entire roof deck. In theory, the dewpoint should be in the middle of the insulation, which, in turn, is unaffected by moisture. However, several other issues arise. While the dewpoint may indeed lie in the middle of the insulation, it also falls in the middle of the wood trusses, which are adversely affected by moisture. This positioning also places the drainage plane (*i.e.* underlayment) above, rather than below, the condensate.

Although this method offers good exterior liquid moisture control, it does not perform well in terms of interior moisture vapor management because it places a vapor barrier on the cold side of the insulation. If this same system was proposed for a vertical wall, wrapping the structure's exterior in a vapor-impermeable membrane would be unacceptable, particularly with vapor barrier material already on the interior. A highly permeable, yet waterproof, underlayment can manage moisture vapor better by enabling the roof assembly to meet the same performance demands as a wall. Although this concept is logical from a building science point of view, building codes are yet to address it. The primary reason for this lag is the only recently wide availability of vapor-permeable underlayments in North America.

As infill construction becomes more prevalent and municipal density requirements increase, demand for minimum footprints with maximum living space has added complexity to the mix. A response to this trend has been the growth of non-ventilated attics for use as living spaces. (This practice is already common in parts of the world that do not have vast tracts of land for building.)

When ventilation is minimal or non-existent, then highly vapor-permeable underlayments are an important component of the roof assembly. These underlayments allow the moisture of daily life to escape, instead of trapping it within the building envelope.

Figure 1

Concrete and clay tiles

Specifiers of concrete or clay tile should take particular note. The best way to apply tiles is with a lath/counter lath system. (See Figure 1.) This approach raises the tiles on wood strapping applied vertically onto the roof deck and then crossed horizontally with more wood strapping. In addition to facilitating good drainage, a lath/counter lath system provides a small ventilation cavity above the roof deck, allowing a waterproof underlayment that is highly permeable onto the deck to show its greatest potential—it rids the roof cavity of moisture and ensures bulk water (aforementioned wind-driven rain pushed under the tiles) stays outside. The ventilation cavity also enables inclusion of an underlayment with radiant barrier characteristics to further reduce heat transfer and potentially achieve additional energy savings.

Careful planning is essential whenever specifying underlayments for use under tile to design a roof with good moisture management and energy saving properties.

Conclusion

When selecting roofing components, designers should consider high-performance roofs in the same way they view high-performance walls. The roof is a key component of a properly performing building envelope, and its life is no longer as simple as it once was. Moisture trapped within roofs or walls contributes to mold and the degradation of a building's structural components. Preventing intrusion of bulk liquid water while managing the movement of water vapor is essential for creating a long-lasting, warm, and dry building. Assessing the intrinsic value of the components, especially underlayments, is important when designing and creating a roof system.

Additional Information

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Abstract

There have been new technical developments in underlayment technology for sloped roofing. Advances from building paper to impermeable and permeable membranes offer advantages for certain roofing materials, systems, and climatic zones. Advanced moisture and energy management techniques, particularly in high R-value construction and heat transfer control, are discussed in the context of evolving market conditions and trends, as well as the building envelope issues driving those changes.