Benefit and Necessity of Roof Design and Maintenance:
Designing for No/Low Maintenance

Abstract

Roofing systems are a significant investment not only due to their cost but because of the value of the contents they protect. Many manufacturers issue watertight guarantees for terms up to 30 years on select roofing systems; however, many items interact with these roofing systems that don't last nearly that long. Products such as caulking/sealants and some coatings, when left exposed to the elements, have closer to a 2-5 year life span. When exposed to conditions such as, ponding water or chemical output and contamination, these times can be shortened dramatically.

Properly draining roofing systems, redundant flashing details, and minimizing penetrations are all design items that can eliminate dependency on products that aren't designed to last for the long term. In addition to the design, maintenance should be conducted to prolong the life of your roof, similar to how changing the oil in your vehicle prolongs the life of the engine. As each building site is unique, there are environmental and geographic conditions that deserve individual consideration.

When designing for long-term performance, all of these items must be considered together to create an environment with straightforward details and systems that a building owner can manage with relative ease.

Introduction

Contrary to popular opinion, the maintenance-free roof system is a misnomer. All roofs require a certain level of attention. In fact, from the moment of installation, the roofing system undergoes continuous deterioration. Extreme temperature fluctuations, as well as snow, ice, hail, and wind prevail upon the roofing surface. In essence, the elements that we construct roofs to protect us from also contribute the most to the aging of the roof systems over their service life. Traffic on the roof and the installation of mechanical and other types of equipment can also cause physical damage that contributes significantly to roofing deterioration.

In addition to concern about the elements, several components and materials that serve as accessories to roof systems require continual maintenance. These accessories are frequently overlooked in the design phase, where the emphasis is on the type of membrane system, which is often dictated by price and length of warranties.

In the design of a new building, many designers view the roof as just another exterior component. This is not meant as criticism; it is simply based on the common perception of roofs, which is 'out of sight, out of mind'. This perception is heightened by the fact that initial roof construction costs are only a fraction of the total building costs, and because low-slope roofs do not contribute to the aesthetics of the building. Consequently, this means roof design is an afterthought. What is often overlooked is that the roof is one of the largest exterior components (comprising up to 70 percent* of the total exterior) and maintenance costs are typically 60+ percent* of the building's lifetime maintenance budget. These are costs that building owners are becoming well aware of and that is why there is now a more concentrated effort to encourage design for no/low maintenance systems.

While the weathering process of roof systems cannot be prevented, certain design elements, combined with technological advancements in roof maintenance materials, can amount to a major step in minimizing maintenance requirements. Design of no/low-maintenance roof systems can minimize roof ownership costs, maintain good roof integrity, extend the service life, and keep roof warranties intact.

*Source: American Institute of Architects

Why Roofs Need Maintenance

Roofs are exposed to the elements 24 hours a day, every day of the year, and the levels of exposure they're subjected to are intense. In the summer, the roof surface temperature can exceed 180 degrees °F. In the winter, the roof surface can be coated with snow and ice for continuous weeks.

Problems are not always induced by the elements, they can also manifest from physical abuse. Dropped tools from tradesmen, particularly around mechanical equipment, can puncture the membrane, creating an opening for moisture intrusion into the system. Equipment dragged across the roof can also damage the membrane. Areas of distress can be detected at roof entry points where flashing may be damaged by foot traffic. If these conditions are not repaired in a timely manner (or not at all) they can manifest into serious and expensive problems for the building owner. None of these conditions are typically covered by the manufacturer's warranty.

While some designers may select roof materials based on their warranty coverage, the designer should be conscious of building use and location as well as any warranty coverage. Warranties should not be viewed as "safety nets" that will protect the owner from all roof related issues. For instance, virtually all warranties provided by roof material manufacturers expressly state that the building owner is required to complete maintenance of the roof system throughout its service life. The absence of proper maintenance may be grounds to negate warranty coverage. Read the fine print of the warranty and clarify with the manufacturer what they consider to be maintenance items. It should be noted that most warranties cover only the roof system components (underlayment, insulation, membrane, flashings) and end at the flashing material.

Materials used for terminations (metal and sealant), intersections of different materials, and some of the accessories are not covered under the warranty. Periodic maintenance is a critical piece to achieving the expected service life of the roofing system. The life span of these materials is also far shorter than the roof system components covered under the warranty. Therefore, periodic maintenance often may be required for accessories and all other materials that interact with the roof system. For instance, open pitch pans (metal boxes applied around supports) typically need to be refilled every two to three years. The fill material dissipates over time, and movement from the supports creates openings. Roof coatings, depending on their grade, may require maintenance every three to five years.

Areas of maintenance can also be found at intersections of different building components or materials, particularly where sealants are applied. Sealants require periodic maintenance because they have an average service life span of five to seven years. These areas experience differential movement of the materials, and openings and splits commonly occur. Points such as separate elevations, adjoining walls, and joints at metal terminations and skylights are all maintenance items.

Roof Design for Maintenance

To effectively control roof maintenance, there must be an understanding of the design aspects of repair and reroofing specifications, which may ultimately impact maintenance requirements. This paper is intended to provide best practices to assist designers of no/low maintenance roof systems at each component.

The degree of maintenance required for any roof is often determined at the time of its construction, whether it be the original installation or at reroofing. The need for maintenance can be unwittingly "built in" to the original roof system by certain elements of the design. Some of these design elements can be corrected during repair or reroofing; others will continue to be constant maintenance items. It is necessary for those charged

with the design of roof systems to become familiar with the effect of maintenance requirements of the system and strive to design a low-maintenance system.

In new construction, a designer has more control over the building configuration, such as wall heights, perimeter treatments, and slope and drainage facilities, all of which can be designed in an optimum fashion. In addition, the designer will also have a larger selection of membrane systems to choose from, further giving them control over the design of the roof.

When existing construction requires reroofing, a designer is faced with modifying pre-existing conditions to maintain technically sound treatment approaches, a design task often more difficult than new construction design. After its original construction, a roof, in addition to aging and weathering, may undergo other changes. A new drain may be installed to improve drainage, a roof-mounted HVAC unit may need replacement, or entire areas may need repair or reroofing. The manner in which such activities are conducted may drastically impact maintenance. Such modifications are often attempted without design guidelines and by individuals not familiar with, or unconcerned with, the technical efficiency of their activity.

When designing a roof system, the emphasis begins at the roof deck and continues up through the membrane surfacing. Each component of the roof must be carefully integrated to ensure complete compatibility throughout the system. It is the roof designer's job to develop a system of many separate components that, once assembled, will serve as a single system. The designer should also provide design that eliminates extensive maintenance requirements. The roof system that is designed in this manner will provide a long waterproofing service life.

The typical roof system components are as follows:

- Underlayment (depends on deck type)
- Insulation System
- Membrane
- Surfacing
- Flashings
- Metal Terminations
- Accessories

<u>Insulation</u>

Insulation serves two primary functions in a roof system. It provides thermal resistance and a substrate for the roofing system. Insulation can also be used to create slope for positive drainage. All of these functions are critical to the success of the system.

The most important function of insulation is to provide thermal resistance. This is an economic asset to the building owner, as it prevents heat loss and reduces energy (heating and cooling) costs. Insulation's heat flow resistance is measured by its thermal resistance, which is known as R-value, and increases with the thickness of the insulation.

In addition to providing thermal resistance, insulation also reduces deck component temperatures, which reduces expansion and contraction. This is an important characteristic that can prevent premature roof failures due to membrane splits.

Insulation also serves as a substrate and may increase the strength of the roof system. Insulation, especially applied over a metal deck, provides a firm base to which the membrane is to be adhered. The insulation should have the compressive strength to enable it to resist normal traffic loads and most weather elements. Insulation with a high compressive strength will help to prevent the breakdown of both the insulation and the membrane. It will also increase the membrane's resistance to punctures, which will lead to a longer service life of the system.

A best design practice for roofs that will experience heavy and/or consistent traffic is to specify an insulation high density cover board.

Roof insulation can also be used to create an artificial slope on a roof with the application of a tapered insulation system. Tapered insulation systems are primarily used on reroofing applications where the initial deck construction was not applied with sufficient slope. It can also be used on new construction where slope is not built into the structure. This should eliminate ponding water which occurs after a rainfall when proper slope is not present. Positive slope has a substantial impact on roof system longevity and maintenance requirements.

The proper design elements for insulation are as follows:

- Insulation must be kept dry; wet insulation should be removed and replaced,
- No more insulation shall be applied than can be covered the same day,
- Insulation boards shall be butted and aligned,
- Secure insulation to the substrate with fastening or adhesive patterns to meet the specific building requirements,
- Ensure that board joints are supported on metal decks, and
- When installing multiple layers of insulation all joints shall be staggered.

Membrane

The roof membrane is the waterproofing component of the roof system. Most designers base the roof system design on the selection of the membrane. The manufacturer, the warranty, and application methods are all determined during this design phase. If the designer is to provide the owner with a no/low-maintenance type roof system, the membrane selection must be completed by reviewing the potential site-specific requirements that may occur over the life span of the roof system. For instance, membrane selection will be different if the owner plans on staying in the facility over the life span (15 to 20+ years) of the roof as opposed to selling or vacating the building after a shorter duration.

Membrane selection is typically determined by building use and the required durability of the membrane. The designer should be aware of the anticipated level of traffic. Durable membranes are required on roofs that will experience heavy foot traffic; some large manufacturing facilities may require protection from motorized vehicles or carts, as opposed to buildings where roof access is minimal.

Some determining factors are types, sizes, and amount of required rooftop equipment because more equipment means more traffic and more potential problems (roof leaks). The other determining factor regarding rooftop equipment is future modification. Buildings with constant tenant change, such as offices, restaurants, and shops may require continual changes (additions and deletions) of rooftop equipment. This will have an impact on membrane maintenance, validation of the warranty, and life span of the system. Two ways to prevent roof-traffic damage include:

- **Walkway Pads.** The best design practice to eliminate concerns of traffic is to install walkway pads over the completed membrane surface. The walkway pads should be applied in all heavy-traffic areas, at entrances and ladders. They should also be applied around all serviceable mechanical units to guard against dropped tools. The grade of the pads should be determined based on the extent of traffic. In extreme cases, steel walkways are recommended instead of wooden walkways, which can deteriorate over time and may require maintenance to resolve safety concerns from trip hazards.

  On roof systems with heavy equipment or motorized traffic, the traffic area should include an overlayment that will protect the insulation.

- **Entry Points.** Entry points to the roof system typically experience heavier loads than other walkway locations. To eliminate membrane damage at these points, it is recommended that in addition to a coverboard, membrane protection such as concrete pavers be used.

Another building usage condition that has an effect on roof systems is **chemical output or debris**. Interior activity from restaurants or heavy industrial operations may discharge chemicals or byproduct debris on the roof membrane that will require maintenance/repair and/or replacement. Some membrane materials are better suited for these conditions. For instance, PVC membranes are better suited to reduce damage from greases and oils that will be discharged through vents on restaurants or kitchen areas. On warrantied systems, make certain that the manufacturer provides coverage for chemical and debris discharge present at the facility.

Roof systems that will experience continual output due to interior operations require permanent design requirements to eliminate membrane deterioration in these areas. There are two common methods of dealing with discharge. Application of a discharge containment accessory, available from a number of sources, that is applied around the exhaust vent is recommended. Filters used in these systems to collect contaminants require regular maintenance. The other type of application is to apply an additional layer of membrane to match the system in discharge areas. This creates a sacrificial layer that, if it deteriorates over time, will not contribute to roof leaks.

The key design elements for membranes are as follows:

- Comply with the manufacturer's requirements,
- Specify required adhesive application temperatures–most products on the market require ambient outside temperatures to be above 40 degrees °F,
- Specify adhesive coverage rates based on manufacturers requirements–too much or too little may lead to premature failures and/or loss of adhesion,
- Specify material be applied in an even application, and
- All roll materials shall be set in a straight line.

<u>Surfacing</u>

The use of surfacing materials has changed significantly in the past decade. The old Built-up Roof Systems used aggregate to shield the bitumen from ultraviolet exposure that would cause damage to the bitumen surface. Surfacing materials are now used to provide energy savings and comfort to building occupants. The most prevalent surfacing material is a light-colored coating material that reflects the sun's heat from entering the interior of the building. In some areas, coating materials are now required on roof membrane systems and must meet reflectivity and emissivity regulations.
(Note: some light-colored membranes have the inherent ability to meet reflectivity and emissivity requirements without the use of surfacing materials.)

Properly applied coating materials can extend the service life of a membrane. However, similar to all materials, there are higher-grade and lower-grade coatings. The designer should evaluate the coating material and choose one that best suits the requirements of the building.

Coatings are not maintenance-free materials. Over time they will degrade and require repair and/or replacement. Rapid deterioration occurs from heavy levels of airborne pollutants, extensive ponding of water, chemicals, and debris. The designer should inform the coating manufacturer if these conditions are prevalent at the building and discuss design options, such as use of primers, specific coating material to apply in these areas, and required coverage rates. Most coating manufacturers offer material warranties that range from two to ten years. Extended labor and performance warranties may also be available.

It should be noted that for reroof applications a moisture analysis of the existing roof system will be required. Coating materials should not be applied over moisture-laden systems because they do not thoroughly cure and are susceptible to premature failure through blistering, peeling, and displacement.

The designer should comply with the manufacturer's application rates and ambient temperature constraints. The application rate and temperature have a direct impact on the performance of the coating. The theory that "more is better" does not apply in these applications. Too much material will slow down the curing rate of the coating material and could lead to runoff if precipitation occurs prior to complete cure.

Drainage

A common cause of roof deterioration is from improperly designed drainage. Treatments that do not allow for rapid runoff of water will result in ponded conditions, which accelerate deterioration of the membrane or coating in the ponded areas. Improper drainage that leads to the continual presence ponding of water 48 to 72 hours after a rainfall may also affect the roof warranty coverage.

The designer must design the drainage system in accordance with applicable code and design requirements. The following are some items to be considered:

- Determine if using primary (interior drains) or secondary (exterior, i.e., gutter, scupper) drainage is necessary.
- Ensure adequate deck slope, per IBC code the minimum slope is ¼" per foot.
- Place drains at mid-span (low points).
    - For best results, drains should be installed to meet local codes as a minimum. Individual building construction may require more than the code minimum.
    - In geographically complex buildings at least one drain is required in each area.
- Position more drains as required in areas where excessive penetrations impede flow.
    - Drains should be installed per code requirements for building locations, but additional drains may be required where excessive penetrations impede flow.
- Taper the roof system to drain.
    - Water should be off the roof in 48 to 72 hours after a rainfall.

If the deck slope is not sufficient, then artificial slope will be required. This is common on reroof applications that were originally designed for BUR systems and/or systems where the deck has settled over the years.

Drainage design for low/no maintenance should include:

- Slope to drain structural design.
- Full tapered insulation system, and/or
- Tapered insulation saddles (or crickets) at drains and the back side of curbs.

Tapered insulation increases insulation thickness and may not be practical in areas where flashing heights are at a minimum. In some cases new drains can be installed at the ponded areas to increase water flow off the roof. This can only be accomplished if there is access to the interior area for installation of new pipes.

These elements will help to reduce ponding water but some annual maintenance may still be required. The absence of ponding water will minimize debris collected on the roof; however, roof debris may still form from overhanging trees, chemicals, or byproduct discharge and debris. All of these contaminants could plug the roof drains and impede water flow. In severe instances, impeded water can back up and infiltrate the building. Therefore, all roof drains should be inspected (and cleaned) an average of two times a year to make certain there are no clogged drains. Inspections should take place in the spring to evaluate the effects of the winter and in the fall to prepare for the winter.

Flashings, Metal Terminations and Accessories

Industry statistics indicate that the vast majority of roof leaks occur at flashings, metal terminations, and accessories. Improper design, poor workmanship, and need of maintenance are all contributing factors to active roof leaks in these areas. In addition, the materials applied in these areas may have life spans that are shorter than other roof system components, and these materials are typically not covered in the manufacturer's roof system warranty. These conditions are often unique to each building and the designer should place more emphasis in the design of these components by selecting no/low maintenance materials and details. However, designers often build maintenance requirements into these locations rather than designing them out.

Properly draining roofing systems, redundant flashing details, and minimizing penetrations are all design items that can eliminate dependency on products that are not designed to last as long as the roof system components.

Flashings

The flashing component is the most vulnerable part of any roof system because it is at the point where the horizontal roof deck and vertical surface join. It is also the intersection of two different materials, such as parapet walls. Flashings are also vulnerable because they are applied around all roof penetrations, such as skylights, mechanical equipment, exhaust vents, expansion joints, and other areas where the membrane is terminated and interrupted. The primary purpose of the flashing component is to seal the membrane at all edges.

The flashing material should have a life expectancy that meets or exceeds that of the membrane. This is an important characteristic because the flashing generally has to perform under more-severe conditions. In addition, the flashing material should be compatible with all adjoining materials and must have the capability and durability to last the lifetime of the roof system.

It is well documented that most roof leaks occur at flashing locations. The designer can eliminate most of these problems by following industry-recommended best practices. Flashings should be provided with a minimum eight-inch height if possible, or otherwise detailed in a manner that keeps the top edge of the flashing out of the water line. Flashing installed at less than eight inches may place the flashing in the water line, inviting problems. Further, flashings that are inadequately attached at their top edge (due to lack of nailing) may slump below their counter flashing, allowing for direct access of water into the building.

Comply with the manufacturer's flashing requirements for material and application requirements. Flashing materials must be from the roof membrane manufacturer, especially when they are used for repair/maintenance activities. Using a different manufacturer's materials may affect the warranty and could create more long-term problems for the system.

Implementing the following design elements at the different types of flashing conditions can help create a no/low maintenance system:

- **Parapet Walls, Expansion Joints and Area Dividers:** Extend flashing material over the top of the horizontal substrate and down the outside face, under the sheet metal capping, to protect interior elements from water that enters from sheet metal openings (joints, ends etc.) over time. Without added flashing material water could enter into the building.

- **Counterflashings:** Sheet metal counterflashings can be applied as a termination to vertical flashings and are typically applied over the flashing material at walls and curbs. A termination bar (1/8" x 1") is typically secured near the top of the flashing material to hold it in place and eliminate slippage. Counterflashings serve as rain shields and provide additional protection to the top of the flashing material. There are two primary types of counterflashing application: surface-mounted and integral.

  Surface-mounted counterflashings are fastened to the vertical substrate above the top of the flashing material. A bead of sealant is applied over the top of the counterflashing and may be the sole line of defense against water entry. Because sealant materials require continual maintenance/repair, this type of attachment is not always recommended. In order for this application to be most effective, always terminate and seal the top of the roofing flashing. This gives two lines of defense against water intrusion to the roofing flashing.

Integral wall counterflashings are set into a reglet joint that is cut into the wall, masonry, stucco or metal, and uses the groove to secure the metal within the wall assembly. These types of attachments provide long-term weatherproofing performance because the counterflashing is sealed within the joint. Sealant may be applied at the top of the counterflashing in some cases. However, unlike the surface-mounted application, the sealant is the secondary line of defense and may not be recommended. This type of application provides low/no maintenance throughout the life of the system and is highly recommended.

Best Design Practice. When possible, the reduction of rooftop equipment is beneficial to the long-term success of a roof system. Fewer penetrations equal lower probability of leaks and help to create no/low maintenance. On re-roof applications it is recommended that all abandoned equipment be removed. The cost of new decking in the abandoned area is usually offset by the elimination of the application of the required curb flashing.

- **Perimeter Flashings.** The most common type of wind-uplift damage occurs at raised edges, or perimeter flashings. The IBC Code now requires that all metal applied at the perimeter of the building be certified by ANSI/SPRI ES-1. Fastening of the perimeter metal must be in compliance ASCE wind-uplift calculations.

  The perimeter edge metal shall extend over the base flashing and act as a shield over the flashing joints. There should be a separation layer between the edge metal and the membrane to provide added waterproofing protection and to prevent splits from differential movement between the metal and the membrane. This condition is most prevalent in colder climates where splits occur at these locations.

  The edge metal is an important element at this component because it adds to the waterproofing of the system by covering the flashing joints, acts as a termination of the membrane, serves as a rain shield, and provides a surface for anchorage of the fascia metal.

- **Top of Flashing Material.** Apply a termination bar (1/8” x 1”) at the top of the flashing material to eliminate flashing slumping and displacement. Additional waterproofing can be achieved at flashings by sealing the top of the flashing material and termination bar. For modified bitumen systems this can be completed by applying a multi-course layer of fabric and roof cement. For single-ply applications this is achieved by applying a water cutoff sealant.

- **Flashing Seams.** The most common maintenance requirement at flashings is at flashing seams. Openings and splits in seams occur from weathering and building movement. On modified bitumen roofs, apply manufacturer-approved material over the seams; applied in adhesive, heat-welded or self-adhered. Applying coating at flashing seams and/or entire flashing surface to prevent UV degradation is recommended. On single-ply systems apply manufacturer-approved material over the seams especially at changes in direction for extra protection.

- **Sheet Metal.** Sheet metal components are exposed to the elements more often than flashing materials. These are typically the first line of defense in a flashing system. The type of material applied has a significant impact on their performance and maintenance requirements. It is recommended that the designer specifies a high-grade metal finish, such as Kynar 500/Hylar 5000, or a stainless steel that prevents corrosion and finish deterioration for no/low maintenance.

- **Sheet Metal Fastening.** Improper fastening of perimeter sheet metal can create continual roof problems. Depending on the fastening frequency and pattern, this may allow for movement of the sheet metal,

which can fracture the membrane materials under sheet metal, providing potential for leakage and ongoing maintenance. Perimeter sheet metal should be fastened in a pattern and frequency that will restrain this movement.

Insufficient fastening could also contribute to wind damage and/or blow off. Fastening of the edge metal must be in compliance with ASCE wind-uplift calculations. Fasteners with corrosion resistant coatings should be specified because they provide longer service life over the commodity-grade zinc-coated fasteners.

- **Metal Joints.** The most common seal on metal joints (parapet coping, counterflashings, expansion joint covers, etc.) is a bead of sealant. Due to weathering and continual expansion/contraction of the metal, these sealant joints often fail within five to seven years and become the source of moisture infiltration. To eliminate continual maintenance at these locations the designer should specify a sealant tape application. The sealant tape is self-adhered for easy application and most manufacturers provide these materials in widths used for this purpose. On copings always continue the roofing membranes up and over the parapet walls as a primary waterproofing.

Accessories

Roof accessories are materials and products for various penetrations such as vents, pitch pans, equipment supports, skylights, roof hatches, etc. They are integral to the waterproofing of the system; however, they are typically not covered by the warranty. In the past these types of products and assemblies were fabricated in the field with metal and/or membrane with roof cement and sealants. These application methods typically required a fair amount of maintenance, but recent advancements in design and material technology have decreased the level of maintenance needed at these penetrations.

- Pitch Pans. Pitch pans are typically used to flash a penetration through the roof, and often require continual maintenance. Pitch pans lose their fill material with time; in addition, the material will often harden and shrink away from the penetration, allowing potential for water entry. To provide low/no maintenance design, a sheet metal cone/umbrella (cover) should be fabricated and applied over the pitch pan. This will aid the dissipation of fill material as well as protect from UV exposure and provide added waterproofing.

- Prefabricated Roof Accessories. There is now a plethora of manufacturers that have developed prefabricated roof accessories for all types of penetrations that can be used with most roof membrane systems. This eliminates the use of field-fabricated materials and, when used, decreases the need for maintenance in these areas.

Roof Maintenance Materials

In the past decade roof material manufacturers have made a concentrated effort to provide a full range of maintenance materials that complement their roof systems. The most significant advancement is liquid membrane flashing systems. These materials can be used in the application of the system or as maintenance materials that are used to extend the service life of the existing system. Liquid membrane flashing systems are flexible flashing materials that are specifically designed to work with a variety of bituminous roofing systems. These materials can be used as weatherproofing on a wide range of flashing details. They typically consist of a two-part system containing a polyester reinforcing scrim and a flashing liquid of various products. These systems are ideal for maintenance applications because they are liquid applied and offer superior bonding and durability properties for a long-term service life.

These materials can easily be applied in any flashing location. Their main application benefits are that the primer dries rapidly - allowing the application process to move quickly – and the material can be mixed in the original container or in two-component cartridges that mixes during the dispensing process. The material cures in all temperatures and forms a seamless barrier that provides exceptional strength and flexibility.

These materials can be used with all bituminous systems and hybrid systems for use on new and re-roof projects, metal roofing, paver systems and historic preservation and restoration.

The main attributes of these materials are as follows:

- Low permeability,
- Wide application temperature range,
- Low cost per penetration,
- Minimal odor release,
- Great tensile strength,
- Enhanced workability, and
- Great crack bridging capabilities.

The designer should consult with the manufacturer to ensure that the correct materials are used and that they are applied in accordance with the manufacturers' specific requirements.

It is the designer's desire to design a roof system for long-term performance**.** Maintenance elements should be considered in unison with the original roof system design. If no/low maintenance elements are encompassed in the original design, the building owner can manage the roof system with relative ease and expect a long-term solution for the protection of their asset.