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Journal

Should You Replace Your Low-Slope Roof?

Understanding Recover and Replacement Options

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There are good reasons why low-slope roofing systems – where the slope is equal to or less than 2:12 – predominate in commercial roofing. For building owners, the advantages are many; easily accessible for maintenance and repairs, low-slope roofs readily accommodate rooftop equipment, are often less expensive to install and maintain, offer many cool and green roof options, and may be incorporated into outdoor terraces. Like all building systems, however, low-slope roofs have a finite lifespan. Once the roof shows signs of distress and failure, building owners are faced with the difficult decision of how best to proceed.

Installation of a replacement modified bitumen roof (MBR) assembly provides durable long-term protection for this cultural institution.

One solution that might seem simple enough is to recover the existing roof with one of the many reroofing products on the market. Recovering a roof tends to be less disruptive than replacing a roof and, for some owners, is therefore a logical starting point when the roof is nearing the end of its lifespan and warranty. However, buyer beware: recover projects have many potential pitfalls. So often do they go awry that many prudent design professionals will specify a roof recover only in limited situations where stringent criteria for the existing roof and detailing are met. In most cases, replacement with a new roof assembly is recommended.

Knowing which option is best for a given building and situation is essential, but that's only the beginning. From there, a successful roofing project hinges on thoroughly evaluating existing conditions, specifying the right system and installing it correctly, and providing appropriate integration with the rest of the building enclosure. A lot to think about, to be sure. Yet worthwhile for a long-lasting and reliable roofing solution.

Roof Recover Projects: Considerations

Existing roof systems most likely to be candidates for recover are those that have performed well to date and are just approaching the end of their warranty period. A recover should be viewed as means to prolong the life of an existing roof membrane and not as an equivalent to a new roof system. A recover material can also provide high

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solar reflectance, restore membrane mill thickness by providing a superficial top layer, or provide a new waterproof surface.

Roof Detailing and Water Infiltration

Before moving forward with a roof recover project, a licensed design professional should evaluate the general roof field condition, existing detailing, and roofing terminations, not only to confirm that the roof is a recover candidate, but also to determine the extent of preparation/repair work required prior to installation of the new coating or membrane. Roof recover products will not correct existing roof detailing failures and should not be leaned upon as a solution to roof water infiltration issues.

Visual inspection can identify trouble spots where existing detailing at areas like wall flashing, roof penetrations, and roof edges is not performing adequately and requires repair or replacement.

Infrared inspection, electronic field vector mapping, or other ***nondestructive testing*** are useful tools and should be considered as part of the design process. Nondestructive testing will aid in the identification of areas in the existing roof membrane and insulation compromised by water infiltration that may not be observable through visual inspection. Replacing compromised insulation, repairing existing membrane failures, and ensuring that roof terminations are watertight are important prerequisites for recovering a roof.

> "While it may seem straightforward to replace the roof system in kind, an analysis of current needs, new technologies, and new code requirements is advisable."

Building Code Requirements

Is a roof recover permitted under the prevailing code requirements? The 2015 *International Building Code* (IBC) excludes the following conditions from receiving recover systems:

1. "Where the existing roof or roof covering is water soaked or has deteriorated to the point that the existing roof or roof covering is not adequate as a base for additional roofing.
2. Where the existing roof covering is slate, clay, cement, or asbestos-cement tile.
3. Where the existing roof has two or more applications of any type of roof covering." (IBC 706.3)

Prior to installation of a recover system over an MBR assembly, loose granules in the existing cap sheet must be removed *(left)* or embedded in an asphalt flood coat *(right)*.

Drainage

The rate at which a roof system moves water to drains and the capacity of those drains to allow water passage are critical to roof performance. Ponding water increases the exposure of weak points in roofing and can exacerbate leaks. At its worst, ponding water can create loading concerns for the building roof structure.

Existing Membrane Condition

As membranes age and are exposed to weather and UV radiation over time, the material becomes brittle as it loses elasticity and sectional thickness. An important consideration for recover projects is that a warranty for the recover coating material does not encompass the performance of the existing membrane. The recover system will typically only be warranted for its own properties and ability to adhere to the substrate. While a recover coating or membrane may be marketed as a watertight system, it is highly advisable to repair the underlying membrane prior to the application of recover materials.

Roof Recover Projects: Options

Recover options come in a variety of chemical compositions and are applied as coatings or as membranes. Available systems provide varying degrees of tensile, impact, and ponding water resistance. Provided the existing low-slope roof system meets the criteria for membrane integrity, drainage, and building code requirements, recover systems may augment the existing roof assembly with various performance enhancements.

Acrylic: Cost-effective, reflective, and easy to install, acrylic coatings are water-based single-component compounds that arrive on site ready to apply. However, they are not suited for ponding water or cold weather

application and will lose thickness more quickly than alternatives over time.

Silicone: For a material that can withstand ponding water and weather wearing, silicone coatings offer a more durable option than acrylics. A multicomponent, moisture-cure material, silicone requires specialized application equipment. Other shortcomings include a tendency to hold dirt and a low tensile/puncture strength. Note that silicone coatings are available in high- and low-solid options, which will need to be taken into consideration when determining the number of applications and the target thickness of the coating.

Polyurethane: With superior strength, tensile, reflective, and durability properties, polyurethane is a versatile choice. On the downside, it can be challenging to install, often requiring multiple coats, and it is known for producing a strong odor during application.

Reinforced liquid resin: Additional recover membrane options include polyurethane-methacrylate (PUMA) and polymethyl-methacrylate (PMMA) systems, which are two-component, catalyst-cure membranes that can include a fleece reinforcement. While providing superior performance in most categories, they require on-site field mixing and come at a cost premium. These systems may include additional measures like the installation of a new roof base sheet to meet manufacturer warranty requirements.

Bitumen-based cap sheets: Like single-ply roof membranes, modified bitumen roof (MBR) membranes can receive liquid-applied recover systems, but they are also candidates for installation of new bitumen-based cap sheets. A consideration for MBR systems is whether the existing cap sheet has a granular surface. Loose granules

(continued on next page)

At the End: Edge Metal, Copings, Counterflashing, and Termination Bars

Whether for an existing roof or a new roof design, termination of the waterproofing is of the utmost importance because that is the most common location, by far, where water infiltration issues arise.

Roof membrane terminations occur at adjacent building walls, roof edges, and penetrations.

What to look for in a roof termination:

Height: Eight inches above the field membrane is an industry standard and often a starting point. Flash rain events, roof overburden, and poor roof slope create conditions where water accumulates around low roof terminations, leading to infiltration.

Clamp rings secure the membrane around circular penetrations.

Mechanical fastening: Metal termination bars, cleats, and clamping rings are common tools to hold the edge of the membrane physically, or "mechanically," in place. Termination sealants are used to further seal the membrane edge. In the case of termination bars and cleats, the design must include appropriate fasteners, and the substrate needs to provide sufficient pull-out resistance.

Counterflashing: Metal counterflashing, most commonly aluminum or stainless steel, shields the edge of the membrane from UV radiation, water infiltration, and wear by lapping over the membrane flashing. The metal is far more resistant to deterioration from exposure than the pliable membrane material, and it protects the vulnerable roof edge from contact damage.

Transition: Continuous air barriers are required by code for new construction. Providing laps between wall and roof membranes, in conjunction with through-wall flashings, meets this code requirement and helps to prevent energy loss and condensation risk caused by air infiltration. ■

Metal counterflashing protects the upturned membrane edge at parapet walls.

Parapet copings prevent water infiltration that can migrate under the roof membrane.

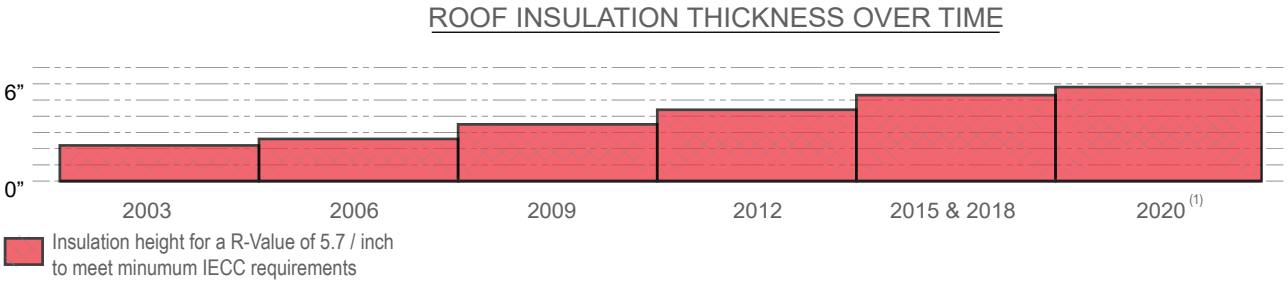
Energy Code and Roof Insulation Timeline

Insulation makes up a large component of new roofing – literally.

The minimum resistance to heat flow, or R-value, of roof insulation installed is dictated by building code. If the code requirement for insulation seems to continually change, that is because it does: with each successive edition of the *International Energy Conservation Code* (IECC), the minimum required roof insulation R-value – and, therefore, minimum insulation thickness – has increased.

Who provides the building code? Established in 1994, the International Code Council (ICC) brought together independent building officials and code administration organizations to establish unified national model construction codes. The ICC model codes are then adopted by state and municipal governments, which may choose to edit or augment the code to suit local needs and priorities.

What is an R-value? A measure of an insulating material's resistance to conductive heat flow, R-value expresses thermal resistance as a function of time, area, temperature difference, and heat (h·ft2·°F /BTU). The higher the R-value, the more resistant that material is to heat transfer and, therefore, the better its insulating performance. Polyisocyanurate, a common roof insulation material, has a typical long-term thermal resistance (LTTR), a time-weighted average R-value, of 5.7 per inch. To achieve the R-30 minimum required by the current edition of the IECC for Climate Zone 4, for example, would require more than five inches of polyisocyanurate insulation. ■



1. Insulation height for NYC ECC minimum R-Value of 33ci

(continued from page 3)

are not suitable as a substrate for coatings or new cap sheets and will need to be embedded or removed prior to installation of recover systems.

The characteristics of the new coating material and manufacturer warranty requirements will also need to be accounted for in preparation of the existing roof substrate.

Roof Replacement: Considerations

Compared with a recover project, roof replacement generally entails greater expense and effort but ultimately yields a higher-preforming system and added value. A full roof assembly replacement goes beyond the waterproofing membrane and includes considerations for insulation, fire classification, wind uplift, and structural roof deck/diaphragm performance. Since modern building code requirements are much more stringent than those in effect 20 or even 10 years ago, design professionals must address a range of design considerations when planning a roof replacement project.

Structural Diaphragm Analysis

As wind load is applied to the walls, the load is carried to vertical elements, such as wall braces, shear walls, or steel frames, which comprise the building's ***lateral force resisting system.*** A horizontal roof deck that collects and distributes these lateral forces is considered a ***diaphragm.***

Depending on the governing code, a roof replacement project may require that a licensed engineer perform an analysis of the roof structural diaphragm and the roof-to-wall connections, as specified in the IBC. If deficiencies are found, repair or structural augmentation will be required.

Wind Uplift Resistance

As wind moves over a roof surface, it creates uplift forces that pull on the roof overburden and membrane. The magnitude of those forces can be substantial and is a function of the building height, surroundings/exposure, and geographic location. Building codes stipulate the minimum wind loads designers use to calculate required uplift resistance for the roof's membrane, ballast, and edge metal, all of which are subject to wind forces and may become displaced or damaged if poorly chosen or installed.

Membrane attachment: To protect against wind uplift, low-slope roof systems are attached with adhesive or metal roof fasteners. Single-ply membrane adhesive is applied in continuous beads, and the spacing between lines of beads has been tested and certified by the manufacturer to provide a set value of uplift resistance. For mechanical attachment, the spacing of fasteners and type of structural substrate directly correlates to lab-tested uplift resistance performance data.

Ballast: Whether it be loose stone, pavers, or interlocking extensive green roof treys, ballast is installed as a top layer to provide the weight needed hold down roof insulation in an ***inverted/protected roof membrane assembly (IRMA or PRMA).*** Building codes include requirements for when, where, and what type of ballast may be used, considering the building height, location, and wind speed. In some instances, the use of loose-laid stone ballast is not permitted by code.

Edge securement: Edge securement, which includes termination bars, metal roof edging, and parapet copings, is used to terminate, anchor, and protect the edge of the roof membrane. The method of attachment, the building substrate material, and the gauge of the metal directly impacts the edge securement's ability to resist wind uplift forces and remain in place. Per the IBC, manufactured products are to be tested for resistance in accordance with test methods RE-1, RE-2, and RE-3 of ANSI/SPRI ES-1, "Test Standard for Edge Systems Used with Low-Slope Roofing Systems."

Fire Classification

The building code requires that roof systems provide a level of performance when it comes to resisting the spread and penetration of fire. The minimum acceptable roof assembly fire classification depends on the type of building construction and is designated as A, B, or C, where A is the highest performing system.

Note that rooftop-mounted photovoltaic (solar) panel systems are also required to be tested, listed, and identified with a fire classification in accordance with UL 1703, "Standard for Flat-Plate Photovoltaic Modules and Panels."

Energy Performance

Energy codes demand increasingly stringent roof energy conservation performance, augmenting requirements for insulation thickness, solar heat reflectance, and thermal emittance with each new iteration of the code. For this reason, replacement of the existing roof assembly with the same system is often impossible. Building owners should be aware of new requirements and their impact on roof replacement options.

Solar reflectance and thermal emittance: The 2015 International Energy Conservation Code (IECC) requires that roofs above cooled conditioned spaces in climate zones 1, 2, and 3 meet specified standards for solar reflectance, emittance, and Solar Reflectance Index (SRI).

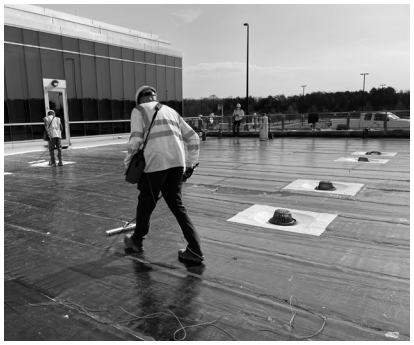
Two-component reinforced liquid resin recover systems, such as PMMA, cost more and require on-site mixing *(left)* but provide a seamless solution for complex roof areas *(right).*

Recoating an existing roof that isn't watertight won't solve moisture problems.

Insulation thickness: Current energy conservation building codes include minimum thermal resistance (R-Value) or thermal transmittance (U-Factor) requirements. The R-value method is most common, and current codes requires values ranging from R-2 to R-30, depending on location. An R-30 requirement can correlate to an equivalent of more than five inches of rigid insulation, depending on the type specified. Where the existing roof deck is flat and tapered insulation is used to create the required slope to drains, insulation depth can be significantly more than five inches in some areas of the roof. If existing building elements, such as low parapet walls or penthouse thresholds, were designed for a roof system with two inches of insulation, these components will need to be modified to accommodate the new finished roof level. In some instances, such as the preservation of historic elements, building code exemptions may be sought to allow for a reduced insulation thickness.

Drains

Analysis of existing drains to confirm their location and sizing to appropriately accommodate rainfall is



Electric leak detection is a non-invasive way to pinpoint breaches in the membrane.

a recommendation for pre-design. Replacement of drains, and addition of new drains, when necessary, requires access to the underside of the roof deck. Suspended or finished ceiling must be removed and reinstalled accordingly.

Roof Replacement: Options

While it may seem straightforward to replace the roof system in kind, an analysis of current needs, new technologies, and new code requirements is advisable. When selecting an appropriate roof assembly, a design professional will consider roof usage, environmental factors, and budget, among other design criteria.

Roof Terraces

Roof systems that serve as supplementary spaces for tenant activities, such as amenity spaces or green roofs, will require a robust assembly that provides protection for the membrane and a surface for foot traffic. This system will likely be an IRMA or PRMA, with insulation and overburden installed on top of the membrane. Since the membrane is not easily accessible once the assembly is installed, a quality, resilient system is recommended. Membranes appropriate for roof terraces include multi-ply bitumen, hot-applied rubberized, and reinforced liquid resin.

Green Roofs

Intensive vegetated ("green") roof assemblies create an environment where water is consistently introduced to the overburden and where root systems can prod lap seams between membrane sheets. The heavy overburden creates a logistical and financial burden if leaks occur. These concerns can be mitigated through the use of a seamless membrane application, such as liquid-applied resin and hot-applied rubberized systems.

Unoccupied Roofs

Roofs that serve solely as a waterproof cap to the building and perhaps a home for mechanical equipment provide an opportunity for the use of the largest variety of membranes. Multi-ply bitumen systems, hot-applied rubberized systems, and reinforced liquid resin systems provide superior performance, but less expensive options may provide near-equal outcomes. Traditional or exposed membrane assemblies allow for budget-friendly single-ply systems such as ethylene propylene diene terpolymer (EPDM), polyvinyl chloride (PVC) and thermoplastic polyolefin (TPO) membranes.

Building owners and managers should be aware, however, that manufacturers provide single-ply membranes in different thicknesses. Over time, foot traffic, water flow, ultraviolet radiation, and exposure to the elements will erode the surface of the membrane. Simply speaking, the thicker the membrane is, the longer it lasts. However, this maxim does not take into consideration the roof installation and detailing, the performance of which rely on educated design and quality workmanship.

Environmental Considerations

There are scenarios where environmental factors may dictate the use of a particular membrane type. For example, chronic exposure to pollution and exhaust demands a membrane with suitable chemical properties, which will not prematurely deteriorate when subjected to the extreme environment. Caustic deposits, such as fats from kitchen vents or fuel from airplanes, require the use of membranes with a composition proven resilient to such exposure. An example of a membrane typically resistant to fats and oils is a polyvinyl chloride (PVC) or ketone ethylene ester (KEE) membrane.

Budget

Price points for roof membranes vary by manufacturer and system. Generally, single-ply membranes are comparatively low-cost systems with basic labor demands for installation. Multi-ply systems provide added redundancy, something always sought after in waterproofing, and typically price higher than single-ply systems. Liquid-applied resin and hot-applied rubberized systems are commonly the highest priced assemblies, requiring onsite material preparation and labor-intensive installation, but providing a seamless waterproofing membrane.

Best Post-Installation Practices

Following installation of the recover or replacement roof assembly, manufacturer maintenance guidelines should be provided to facility managers and ownership by the installers.

Low curbs and thresholds pose a challenge when insulation height must be augmented.

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representative projects

Roof Recover and Replacement

While it might seem cost-effective to recover an existing roof and eke out a few more years of service, the hard truth is that by the time a recover is considered, the roof probably merits full replacement. Our design professionals evaluate critical conditions, such as compromised insulation, faulty detailing, condensation, insufficient attachment, thermal bridging, and new code requirements before making recommendations. We also consider supply chain and availability to address immediate roofing needs as well as long-term serviceability.

Hoffmann Architects' experience with roof assessment, rehabilitation, and replacement includes:

Mount Holyoke College Kendall Field House
South Hadley, Massachusetts
Roof Replacement with Adhered MBR Assembly to Receive Solar Array

1350 Eye Street NW Office Building
Washington, District of Columbia
Roof Replacement with Rehabilitation and Reuse of Existing Ballast and Pavers

York Correctional Institution
Niantic, Connecticut
Roof Membrane Replacement with Retention of Dry, Intact Insulation

Brookfield Place, 200 Liberty Street
New York, New York
Roof Replacement for Conversion to Occupied Terrace

Masonic Hall, 71 West 23rd Street, New York, New York, *Roof Recover System Investigation and Roof Replacement.*

Eastern Connecticut State University Burnap and Crandall Halls
Willimantic, Connecticut
Roof Condition Assessment, Replacement of Water-Saturated Assembly

Collins Aerospace, Air Labs
Windsor Locks, Connecticut
Roof Replacement to Accommodate New Rooftop Apparatus

Columbia University Chrystie Field House, Baker Athletic Complex
New York, New York
Replacement of Traditional Recover Roof with IRMA

Bluestone Data Center
Shelton, Connecticut
Roof Failure Investigation and Replacement

Deerfield Academy, West Gymnasium
Deerfield, Massachusetts
Replacement of Mechanically Fastened Roof System with Adhered Assembly

Heritage Center I
Annadale, Virginia
Roof Replacement, Drainage Rehabilitation

General Electric Manufacturing Facility
Bridgeport, Connecticut
Campus-Wide Roof Replacements

CityCenterDC
Washington, District of Columbia
Green Roof Waterproofing Rehabilitation

University of Connecticut, Boiler Plant
Storrs, Connecticut
Assessment of Existing Spray Foam Roof Recover System

Town of Fairfield Public Schools
Fairfield, Connecticut
Water Infiltration Investigation and Repairs at Recovered Roof Assemblies

One East River Place
New York, New York
Replacement of Stone-Ballasted Roof with MBR and Liquid Resin Systems

Smithsonian Institution, National Air and Space Museum, Udvar-Hazy Center, Chantilly, Virginia, *Exterior Envelope Restoration and Roof Repair / Recoating.*

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Installers apply spray adhesive for a single-ply assembly during a roof replacement project.

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This literature will include information regarding the timing of routine inspections, what to look for during roof evaluations, general care and upkeep recommendations, and directions for notifying the manufacturer of issues. Maintenance guidelines will vary by manufacturer and membrane.

Typical roof inspection items include signs of stress (e.g. wrinkles, blisters), evidence of mechanical abuse (e.g. punctures, cuts), unusual wear due to excessive foot traffic, and evidence of damage caused by chemical attack or other adverse reaction to substances discharged on the roof.

Maintenance recommendations may include keeping the roof free of debris that may result in damage, cleaning the membrane with low-pressure water and/or soft-bristle brooms, and maintaining clear drains and scuppers. An established maintenance routine will prolong the life of the roofing system and help identify leaks promptly.

It is not an understatement to say that a building's roofing system is vital to its enjoyable use and longevity. Selecting an appropriate roof system and diligently maintaining the roof will ultimately reduce issues and increase the return on investment. ■

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