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Re-Roofing: Options and Limitations

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New technologies, constraints, and building codes have created more choices — and limitations — when it is time to resolve the problem of a deteriorating roof. These many changes add up to a greater demand for informed decisions. Here is a guide to help owners, facility managers, design professionals, and contractors choose the right solutions for their re-roofing needs.

Workers install a cold-applied modified bitumen roof (MBR).

Repair vs. Replacement

The first decision is whether to replace the existing roof or extend its life through repair and maintenance. Sometimes, the answer is simple, when it is clear that further repair efforts are futile and the roof is no longer economical to maintain. But rarely is the answer that clear-cut. Usually, the process starts when an aging roof begins to display problems: surface deterioration, blisters, bare spots, visible splits in the membrane — and worse — roof leaks. Here, an investigation is warranted, using the following steps to evaluate the actual roof condition and make a reasoned decision on replacement or repair:

• Review the original drawings and specifications, if available.
• Visually inspect and evaluate the flashings and membrane.
• Inspect the roof surface for evidence of ponding water.
• Make roof probe cuts to verify construction techniques, determine the presence of water or hazardous materials within the roofing system, and evaluate attachment to the roof deck.
• Inspect the underside of the roof deck and framing.

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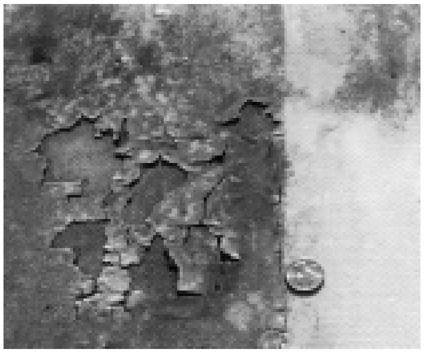
Recover vs. Tear-Off and Replacement

If this investigation points to roof replacement, another decision awaits: can the existing roof be recovered or should it be completely removed, down to the structural deck, and replaced?

Recovering offers a lower cost and a shorter project schedule than tear-off and replacement. Disposal of removed materials is simplified and therefore more economical. Maintaining a water-tight structure during re-roofing is much easier.

There are disadvantages, of course. Incompatibility between old and new roofing materials can cause major problems when recovering. For example, bitumens and some adhesives can melt polystyrene insulation if present in the existing roof. Fresh coal tar is incompatible with asphalt and most single-ply systems, while asphalt is also incompatible with some single-ply systems. Most of these problems can be solved by a divorcing layer of new insulation, but investigating and understanding the properties of the



Deterioration of the CSPE membrane is evident.

existing system is still critical to a successful re-roofing effort.

The best results, however, are gained from tear-off and replacement. This eliminates the danger of moisture trapped in old insulation, and allows for a thorough inspection of the roof deck, along with any needed repairs to rusted steel, spalled concrete, or other deterioration. Unlike recovering, incompatibility between old and new materials is not a concern, as all new materials are used. As with most building repair efforts, doing the job right may cost more up front, but will save plenty by extending the life of the roof and reducing the possibility of premature failure.

Ultimately, though, local building codes may dictate the decision. Most codes allow recovering of existing roofing only when the following conditions are met:

• The existing roof covering and insulation are not water-soaked;
• There are no more than one or two (varies by local code) existing roof coverings on the structure;
• The roof structure is capable of supporting the added dead load of the new covering;
• The roof deck is structurally sound;
• The existing covering is securely attached to the deck and can provide an adequate base for the new roof;
• Existing flashings are removed and replaced when the new roof is installed; and
• Fire retardancy requirements are maintained.

The Roof Deck as a Key to Design

An analysis of the structural deck should also be performed to help determine the best re-roofng options. The following are among the issues to be considered in this analysis:

• Can the deck support the weight of a ballasted roof system?
• What effect will mechanical fasteners have on the roof deck? Installing fasteners into a concrete deck, for example, may cause spalling during installation or may destroy the deck during removal for a future re-roofing project. As well, the fasteners may bend if they hit reinforcing steel during installation, or may hit electrical conduit buried in the concrete.
• If a lightweight fill exists above the structural deck, what length mechanical fasteners will be needed to grip the deck? Overly long fasteners may wobble and become loose over the deck's lifetime.
• Can the deck accept hot-mopped insulation or membrane? Cracks in planks or metal may allow bitumen to enter the building during installation. On decks vulnerable to thermal change, solid hot-mopping may increase the hazard of membrane cracking. On metal decks, hot-mopping may not provide adequate resistance to wind uplift.

Roof Performance Criteria

Code and insurance requirements for fire resistance, wind uplift resistance, positive drainage, and energy conservation impose significant constraints and performance expectations that will also drive the design of the new roof.

Underwriters' Laboratories' fire resistance criteria, with its tests, listings, and classification of roofing systems, is used as a reference in many building codes. These classifications rate roofing systems on their resistance to fire exposure from both the outside and the inside of the building and on their contribution to fire spread within a building. Any deviation from the tested installation guides can mean loss of fire rating.

Wind uplift resistance is what keeps the roof on the building during a windstorm. (Uplift is counteracted in the field and at the perimeter of the roof.) Recently revised — and more stringent — code requirements for wind resistance are spelled out in the latest design standard, ASCE 7-95 "Minimum Design Loads for Buildings and Other Structures," whose recommendations have been adopted by most building codes. Underwriters' Laboratories and Factory Mutual also provide useful wind uplift test data, which has been adopted by some codes.

Positive drainage helps ensure the longevity and water-tightness of the new roof. Building codes detail the minimum slope design for roofs, along with requirements for overflow drains or scuppers to help prevent roof overloading under the weight of storm waters in the event roof drains become clogged.

The 1992 federal Energy Policy Act places significant emphasis on energy conservation in buildings. As a major element of the building envelope, the roof represents a great opportunity to increase the thermal efficiency of the structure. But before taking advantage of additional insulation, several factors must be considered: will increased snow loads exceed the design load of the roof framing? Will the additional height of the insulation affect flashing heights, requiring curbs and counter-flashing or gravel stops to be raised? And, as previously mentioned, will the length of any required fasteners pose a problem?

Roofing design must also address code requirements for seismic loads and rooftop guardrails, along with other considerations, such as pedestrian traffic and potential vandalism.

Owner/Occupant Concerns

While a re-roofing project is of limited duration, owner and occupant concerns during the project should play a large role in choosing the new roofing system. Occupants aren't concerned with the specific roofing system, of course, but rather with how its installation will affect them. When selecting a new system, be aware of the varying amounts of noise, dust, debris, odor, and fire hazards each system may produce during installation. Here are some specific issues to consider:

- Are the roofing products environmentally friendly? Mastics and adhesives can produce strong odors during installation, and must be formulated to meet current environmental requirements for Volatile Organic Compounds (VOCs). (VOCs react with ultraviolet light to produce ozone, which is believed to cause lung damage.) These, along with odors produced by asphalt products, are often objectionable to building occupants, who may perceive these as a health threat.
- If coal tar — a known carcinogen — is used, are proper OSHA work standards for use of this material being met in order to protect construction workers and building occupants?
- Are hazardous materials, such as asbestos, present in the roofing material being removed? Will asbestos-containing fireproofing materials inside the building be disturbed by the roofing work? How will hazardous material be disposed of?
- How will the building be kept water-tight during the renovation?

The owner's warranty requirements will also help determine the choice of roofing system. Length of warranties differs with various materials and installation methods. Typically, tear-off and replacement projects are eligible for longer warranties than recover projects.

Conclusion

A careful analysis of existing conditions, building codes, and owner requirements is imperative when selecting a replacement roof system. The goal is a highly durable, water-tight, and energy efficient system that can be installed with a minimum of disruption to building occupants. Despite the complexities of matching products and systems to a specific roofing situation, today's technologies can help owners and building professionals achieve the right solution. ■

A roof cut can help determine the make-up of the roofing system and its attachment to the deck, as well as determine the presence of moisture within the system.

The ponded water on this roof could add enough weight to cause collapse.

Old Favorites, New Technologies

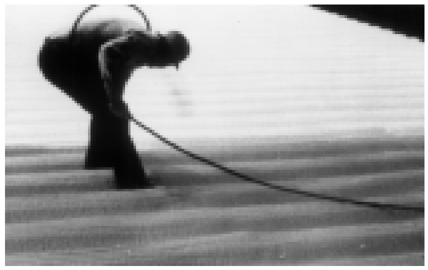
Paul C. Lanteri, AIA

Re-roofing systems for low-slope roofs fall into four major categories: built-up, modified bitumen, single-ply, and spray polyurethane foam. While the traditional building materials available for each of these systems offer consistency and proven performance, there are many new and innovative materials on the market that are worth a further look. Choosing from among the many products and systems becomes a matching game to determine which best fits the greatest number of requirements, including code, budget, aesthetics, maintenance, and occupants' needs. Here is a look at these four roofing categories and some recent technological advances that are improving on the tried-and-true.

Bituminous Built-Up Roofing

Bituminous built-up roofing (BUR) is a continuous, semi-flexible membrane composed of multiple plies of reinforcing felts laid in shingle fashion and assembled in place between layers of bitumen. The system is then covered with mineral surface cap sheets, aggregate set in an asphalt flood coat, or a smooth surface coating which can be mopped, sprayed, rolled, or brushed on.

The reinforcing felts are porous by design, allowing moisture to percolate up through the felts during installation to help reduce blistering and ridging of the roofing membrane. Inorganic reinforcing felts (glass fiber mats) are usually a better choice than organic felts (cotton or cellulose-based), as the glass fiber mats will not absorb water. Inorganic felts are stronger than organic felts in resisting lateral and longitudinal stress,



A worker applies silicone coating to a urethane foam roofing system.

resulting in fewer splits in the completed membrane assembly.

The bitumen used between the felts acts as a bonding agent for the felts as well as the waterproofing membrane. The bitumen can be either asphalt or coal tar. Coal tar has a lower softening temperature than most asphalt bitumens and will flow more readily after installation. These attributes make coal tar suitable only for level or near-level roof slopes, as even sunlight can warm the tar enough to soften it. This ease of flow, however, does allow coal tar to self-heal small fractures and punctures that may occur over time. Coal tar is also more UV- and water-resistant than asphalt bitumen and will hold up under ponded water. Asphalt, however, is more economical and is available in grades with higher softening points than coal tar, making it better suited for steep-sloped roofs.

Other options include modified asphalts and coal tars, where the bitumen is altered through heating, and the addition of rubbers and plastics increase elasticity and resistance to water penetration. These products offer a higher softening point than conventional BUR bitumen, making both appropriate for use on flashings and steeper-slope roofing. Cold-applied built-up roofing is another product innovation, developed for use where project conditions preclude the use of hot bitumen. Cold BURs use asphalt cutbacks or elastomeric adhesives as the bonding and waterproofing agent, combined with either asphalt-coated felts or synthetic felts (such as those manufactured with polyester).

Modified Bitumen Roofing

In modified bitumen roofing (MBR) systems, the membrane is actually layers of modified asphalt or coal tar which waterproof a reinforcing material, a combination that is essentially a manufactured built-up roof. The roofing system consists of a base sheet and a cap sheet, which can be torched, hot-mopped, cold-applied, self-adhered, or mechanically attached to the insulation or roof deck. This two-layer system greatly increases the membrane's strength and water-resistance. Cap sheets are available in coated and uncoated versions. Coatings include mineral granules, slate chips, and metal surfacings which increase the membrane's weatherability and UV-resistance. MBRs easily accommodate the stress of building movement, endure foot traffic, and provide fire resistance for the roof surface.

In asphalt-based MBR systems, the modifier is either APP (atactic polypropylene), a thermoplastic material, or SBS (styrene-butadiene-styrene), a synthetic rubber modifier. APP is typically torch-applied, and offers great flexibility at high and low temperatures and excellent ultraviolet resistance. SBS asphalts are usually hot-mopped, and provide greatly enhanced elasticity.

The reinforcing material used in MBRs is polyester, glass fiber, or a combination of the two. Polyester can stretch and flex with the roof, and has good tear-, puncture-, and impact-resistance. Glass fiber offers tensile strength, fire resistance, UV-resistance, greater resistance to shrinkage during torching or asphalt application, and a lower cost.

Single-Ply Roofing

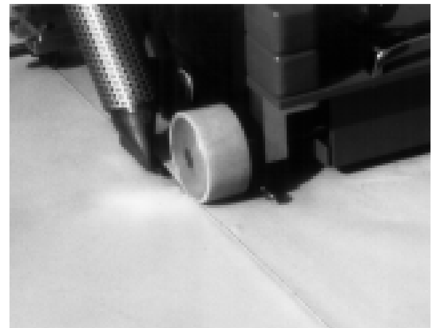
Single-ply, flexible roofing membranes are divided into three broad categories: elastomerics, thermoplastics, and rubberized asphalts.

Elastomerics EPDM (ethylene propylene diene terpolymer) is the primary elastomeric used today. Its advantages include lower cost, ease of installation without the use of open flame or heat, and the ability to be installed during any dry weather condition. Its flexibility allows the membrane to stretch and recover from the normal stresses of installation, thermal change, or building movement.

EPDM's weak point is at the seams, which can fail if the membrane splices are improperly cleaned or contaminated with dust or debris during installation. Liquid adhesives have been the preferred choice until recently, when manufacturing improvements in seam tapes have dramatically increased their use. One manufacturer recently introduced a talc-free, pre-cleaned membrane that eliminates time-consuming splice cleaning, in turn reducing the risk of seam failure.

Another innovation in EPDM roofing is the factory-lamination of a non-woven polyester fleece backing to the membrane. In these installations, the membrane is fully adhered to the substrate with hot asphalt or a two-component urethane spray adhesive. The flexibility of substrates to which it adheres makes it especially suitable for recover applications.

Thermoplastics The thermoplastics category includes CSPE (chlorosulfanated polyethylene), PVC (polyvinyl chloride) and TPO (thermoplastic olefin). Their primary advantage over EPDM roofing is the use of heat-welded seams, which reduces the risk of seam failure often found in EPDM systems. But heat welding is a specialized installation technique which must be precisely performed. Even the slightest deviation in temperature, power supply, or installation rate will create a non-uniform weld that can lead to open seams.



Heat-welding of a PVC membrane.

CSPE is a reinforced synthetic rubber membrane whose qualities include high resistance to weathering, chemicals, and pollutants. This membrane cannot be installed at low ambient temperatures, however, and is difficult to repair after weathering.

PVC, an early entrant in the single-ply membrane market, offers seams which can be either heat- or solvent-welded. The plasticizers used to keep the PVC membrane flexible can migrate over time, causing the membrane to become brittle and crack. A relatively new EPDM coating for aging PVC membranes offers the promise of extended life for these deteriorating membranes. Older PVC membranes have actually experienced catastrophic failure in some cases, with the membrane shattering throughout the entire roof area. Reinforcing the membrane will eliminate this phenomenon.

TPO, one of the more recent product innovations, uses a catalyst technology

Workers apply built-up roofing (BUR) over fastened insulation.

in lieu of plasticizers to keep the membrane flexible. The membrane is reinforced with fiberglass that has been fused between two layers of TPO, giving it stability and increased resistance to the shrinkage and elongation caused by thermal change. Other advantages include color stability, resistance to ultraviolet damage, and resistance to grease and chemical contamination. Re-welding older membranes — a problem with CSPE membranes — can be accomplished if surface oxidation is first sanded or chemically cleaned.

Rubberized asphalt membranes These membranes can be liquid-applied or self-adhered directly to a concrete deck. The self-adhering quality prevents leaks from traveling laterally along the deck, a major problem with loose-laid ballasted systems and adhered systems which have insulation between the deck and membrane.

Rubberized asphalt is highly vulnerable to UV damage, and can be used only where a protected membrane system configuration (consisting of insulation and ballast above the membrane) is possible. Because the membrane is applied directly to the concrete deck, repair, surface preparation, and priming are more critical than with systems applied above roofing insulation.

Spray Polyurethane Foam Roofing

Spray polyurethane foam (SPF) systems are two-part roofing systems consisting of a rigid, closed-cell sprayed-in-place polyurethane base and a protective coating made of silicone, neoprene, urethane, Hypalon™, or vinyls. Recent improvements include granule and aggregate surfaces as part of the protective coating for aesthetic considerations and to improve the system's impact resistance.

SPF systems are self-flashing, a key
(continued on page 8)

The Facility Manager's Surfboard: **Roofing**

For more information related to the topics discussed in this issue, you can visit the following locations on the World Wide Web.

A. The Roofing Experts

www.riei.org
Roofing Industry Educational Institute: A good, impartial source of information.

www.roofonline.org
National Roofing Contractors Association: Publishes excellent reference material.

www.smacna.org
Sheet Metal and Air-Conditioning Contractors National Association: Publishes sheet metal details that are critical to a water-tight roof.

B. Other Experts Relevant to Roofing

www.nibs.org
National Institute of Building Sciences: Special areas of expertise are asbestos and metric construction.

www.csinet.org
Construction Specifications Institute: Special areas of expertise are specifications, building technology, and retrofit/repair strategies.

www.asce.org
American Society of Civil Engineers: Publishes roof live-load design calculations (formerly published by ANSI).

www.astm.org/dsearch.htm
American Society of Testing and Materials: This "search for standards" site is a source for material standards and test methods that are important to quality control in roofing.

C. U.S. Government Sites Relevant to Roofing

www.nist.gov
National Institute of Standards and Technology (formerly the National Bureau of Standards): This site provides information on roof longevity, fire resistance, energy conservation, and more.

www.epa.gov
U.S. Environmental Protection Agency: Special topics are asbestos and hazardous waste disposal.

www.osha.gov
U.S. Occupational Safety and Health Administration: Special topics are asbestos, lead paint, fall protection, and other worksite safety issues.

D. Academic Sources

www.lhl.lib.mo.us
Linda Hall Library of Science, Engineering, and Technology

arc.cmu.edu/cbpd/index.html
Center for Building Performance and Diagnostics, Carnegie-Mellon University

www.arch.uiuc.edu/brc
Building Research Council, School of Architecture, University of Illinois

E. Gateways to Further Information

www.facilitiesnet.com
Site sponsored by *Building Operating Management* magazine, offering many useful links to other sites.

Compiled by Alan P. Eddy, Technical Information Specialist ■

REPRESENTATIVE PROJECTS

Roof Rehabilitation

Hoffmann Architects specializes in the rehabilitation of building exteriors. A substantial portion of the firm's work is in the diagnosis and resolution of roofing problems. This work includes investigative studies and full architectural services for the repair and replacement of membranes, insulation, decks, flashings, and parapets.

A typical re-roofing project begins with an investigative analysis to determine the underlying causes of a deterioration problem. The firm's professional architects and engineers conduct site studies, take test probes and roof cuts for laboratory analysis, and analyze the structural integrity of the roof system. A thorough program of repair or replacement is developed, using the investigative data, along with occupancy needs during construction, budget, building life expectancy, code requirements, and other issues. The firm prepares detailed plans and specifications for competitive bidding. Contract administrators and on-site project representatives track the progress and quality of construction.

Among Hoffmann Architects' recent roof rehabilitation projects are the following:

General Electric
Corporate Headquarters
Fairfield, Connecticut
(General Electric Company)

Nine West Group Inc.
Corporate Headquarters
White Plains, New York
(Trammell Crow Company)

Pfizer, Inc. World Headquarters in New York, New York.

New York Hilton and Towers
New York, New York
(New York Hilton and Towers)

Fairfield Central Office
Fairfield, Connecticut
(Southern New England Telephone)

Pfizer, Inc.
Brooklyn, New York
(Pfizer, Inc.)

Time Life Building
1271 Avenue of the Americas
New York, New York
(Rockefeller Center Management Corporation)

United Jewish Appeal - Federation of Jewish Philanthropies of New York, Inc.
New York, New York
(United Jewish Appeal - Federation of Jewish Philanthropies of New York, Inc.)

1166 Avenue of the Americas
New York, New York
(Marsh & McLennan Companies, Inc.)

Lockwood Mathews Mansion Museum
Norwalk, Connecticut
(Lockwood Mathews Mansion Museum)

P.S. 329
Brooklyn, New York
(New York City School Construction Authority)

J.H.S. 303
Brooklyn, New York
(New York City School Construction Authority) ■

IBM Corporation, Building 12, in Poughkeepsie, New York.

Adhesive is applied to a lap splice in an EPDM membrane.

benefit. The foam is applied to form a transition from vertical to horizontal surfaces, which often precludes the need for pipe flashings, lead boots, and other metal flashings. Positive slope to drains is achieved by a tapered installation of the foam. Other recent improvements include new installation equipment for easier application and a better mix of the components. For environmental considerations, the blowing agents used to spray the foam have been changed to a chemical which causes far less ozone depletion than original formulations.

Conclusion

New products and systems in the marketplace promise increased efficiency and quality. Caution, however, is the key word when assessing these new offerings. Be sure they have been thoroughly tested and have been successfully performing for a minimum of five years in a climate comparable to that of the proposed project. With new products as well as familiar ones, select from a manufacturer who will be supportive if the product does not perform as intended. ■

JOURNAL is a publication of Hoffmann Architects, specialists in the rehabilitation of building exteriors. The firm's work includes investigative and rehabilitative architecture/engineering services for the analysis and resolution of problems within roofs, facades, glazing, and structural systems of existing buildings, plazas/terraces, and parking garages.

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