# Sustainability and roofing: its time has arrived

by Thomas W. Hutchinson, AIA, RRC

In spring 1995, a group of roofing professionals from around the world with expertise in roof system design, roofing forensics, material manufacturing and material research convened in Brussels, Belgium, to discuss an emerging idea within the roofing community—sustainability.

These roofing experts, who either are members of the CIB (International Council for Research and Innovation in Building Construction) Working Commission W.83 or RILEM (International Union of Testing and Research Laboratories for Materials and Structures) Technical Committee 166RMS, met as part of a five-year task group to determine the state-of-the-art design, application and maintenance of sustainable low-slope membrane roof systems. Their committee work was titled "Towards Sustainable Roofing."

The committee members believed there was a growing interest in sustainability and enlightened building owners and roof system designers were interested in adopting roof systems that fit within environmental parameters. On a universal model, the parameters vary among regions, countries and nations. The roofing industry's challenge is to translate this interest and good will into practical guidelines that lead to improvements in the long-term performance of roof systems—within a given financial budget.

## Background

The International Conference on Climate Change held in 1997 in Kyoto, Japan, challenged governments to improve their national environmental performances in terms of reducing pollution and energy demand. To work toward these desirable goals, the concept of "sustainable development" actively is being promoted in the contracting and property industries in some countries.

Although this is a worldwide issue, the United States currently has not signed the treaty. However, there may be a U.S. initiative at a future date.

It is unrealistic to believe any product or procedure will be adopted if it results in reduced performance. As an architect specializing in roof system design, I find my greatest challenge designing environmentally responsive low-slope roof systems is to exceed anticipated service lives.

## Defining the concept

During the initial committee meeting, it was discussed that in developed countries there was a growing concern about the protection of the environment during construction, as well as maintenance of roof systems, which has created an interest in design and application criteria that promote or limit harm to the environment. Practices that consider the life-cycle costs of roof systems and environmental effects often are called "sustainable." The committee members believed the trend toward sustainable roofing would continue to grow. Practices for sustainable roofing may vary among countries or regions.

The committee quickly realized that before addressing sustainability regarding roof systems and the environment, it needed to define the concept. Several organizations already had attempted to define it, and the committee wanted to consider all definitions.

In 1987, the Brundtland Report, titled "Our Common Future," was presented by Gro Harlem Brundtland, former prime minister of Norway, to the United Nations Commission on the Environment and Development. The report defined **principles of environmental sustainable development** as:

*The development that meets the needs of the present without compromising the ability of future generations to meet their own needs*

The report became the defining work with regard to sustainable development worldwide and provided the committee with the basis on which to pursue defining sustainability with regard to low-slope roof systems.

Attendees at the First International Conference on Sustainable Construction held in Tampa, Fla., Nov. 6-9, 1994, defined **sustainable construction** as:

*The creation and maintenance of a healthy built environment based on ecologically sound principles and resource efficiencies*

Realizing the importance of defining sustainable terminology, ASTM International issued ASTM E2114-01, "Standard Terminology for Sustainability Relative to the Performance of Buildings," in 2001. The standard defines 45 terms associated with sustainability.

Perhaps the best working definition of what I understand to be a sustainable roof system—and the definition the committee accepted provided key areas were addressed—was one used in the Proceedings of the Sustainable Low-Slope Roofing Workshop held at the Oak Ridge National Laboratory (ORNL) facility in Oak Ridge, Tenn., in October 1996. At the workshop, a **sustainable roof** was defined as:

Photos courtesy of Hutchinson Design Group Ltd., Barrington, Ill.

***These photos show the use of thermal insulation. Tapered insulation, in an effort to optimize thermal performance, can greatly reduce heating and cooling costs during the lifetime of this roof system and building. Benefits only will increase as energy costs continue to rise (the installation meets tenets 8, 9, 15 and 16).***

*A roof system that is designed, constructed, maintained, rehabilitated and demolished with an emphasis throughout its life cycle on using natural resources efficiently and preserving the global environment*

Translating this definition into the 19 languages of the committee members, as well as other languages, was almost unattainable and threatened to affect the committee's work worldwide. For example, in French, there is no word for "sustainability," and in developing countries that are struggling for conditions of safety and health, the concept of "life cycle" is quite foreign. However, it was interesting to learn that, in some of the poorest parts of the world, the use of indigenous materials, recycling and local labor has existed for centuries out of necessity.

"Sustainable roofs" is difficult to define, as well as implement and comprehend. Sustainable development supposes construction methods and their relationships with the environment, life-cycle analysis and environmental quality must be taken into account. Consequently, it is an all-encompassing concept that provides a stable framework for new design methods. What is meant here is that by considering the whole, a holistic view rather than a partial or incomplete view is taken.

In a true sense for each of the materials used in a roof system, the amount of energy required to extract, transport, manufacture, deliver, install and reuse/recycle roofing materials should be calculated. This concept, called "embodied energy," quickly can become extremely complex and overwhelming. The committee believed the design and construction community would not and could not embrace this type of analysis.

The committee reviewed the concerns and ideas of its members, reviewed research papers and published articles, and identified the following key areas where improvements could be made:

- Minimize the burden on the environment, being responsible stewards of Earth's resources
- Conserve energy, recognizing the importance of savings benefits and improving roof systems' thermal efficiency
- Extend roof system lifespans, realizing the worthiness of seeking long-term performance

## Tenets

***The proper application of a roof system, especially in detail areas such as this lap seam, will improve the chances of optimizing long-term roof system performance (meets tenets 13, 14 and 19).***

The committee believed if its work were to have an effect within the design, construction and roofing communities it had to give practical advice that easily was communicated, comprehended and attainable. The committee believed developing a one-page summary document that could be referenced by designers, roofing contractors and manufacturers would be most beneficial. Out of this idea arose the plan to use tenets (principles or doctrines held in common by members of an organization) to summarize definitive goals under each key area where improvements were needed.

In October 2000, the committee finalized a summary of what appears to be the best practices for sustainable low-slope membrane roofing based on published reports, technical papers and the experience/expertise of the members. Each tenet may appear to be simplistic or common sense; however, when they are considered as a whole, they make a considerable contribution to promoting sustainable roof system design, construction and maintenance. (See "The tenets of sustainability.")

## The roofing industry

As owners and designers raise issues about environmental concerns, the roofing industry has responded with a number of viable roof system design considerations. Following is a summary of these trends and concepts. Roof system designers wishing to incorporate these concepts are encouraged by the committee to investigate the concepts' appropriateness and potential for success. (For information about how roofing materials and products have been developed to support sustainable roof system design, see "Material trends and improvements.")

## CRRC and ENERGY STAR®

The Cool Roof Rating Council (CRRC) is a nonprofit organization whose mission is to provide a fair, accurate and creditable radiative performance rating system for roofing materials. The council provides ratings for various roof membranes with regard to reflectivity and emissivity values based on the appropriate ASTM test. Initial values and three-year values are provided.

It should be noted that before establishing a three-year value, ASTM tests E903, "Standard Test Method for Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres"; E408, "Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques"; E1918, "Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field"; C1549, "Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer"; and C1371, "Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers," allow a roof covering material to be washed prior to testing. I caution designers and contractors against accepting the same in-field values as those provided by CRRC. The values given are for comparison with other products, not a promise of in-field performance. ORNL has reported surface soiling can degrade the potential energy saving by as much as 50 percent.

ENERGY STAR is a program supported by the U.S. Environmental Protection Agency (EPA) and Department of Energy (DOE). Products bearing ENERGY STAR labels are said to be more energy-efficient than standard products. ENERGY STAR-labeled products include but are not limited to appliances; heating, ventilating and air-conditioning units; and lighting. With regard to roofing, low-slope products must have an initial solar reflectance of 0.65 or greater and aged reflectance value after three years of 0.50 or greater. Emittance is not considered. Products that meet these requirements without compromising product quality and performance qualify for the ENERGY STAR label. Manufacturers voluntarily sign an agreement with ENERGY STAR indicating compliance.

## Green roof systems

Although prevalent in Europe, green roof systems recently have made a presence in North America. There are two categories of green roof systems: intensive and extensive.

Intensive systems are more substantial green roof systems, incorporating trees and bushes in a growth medium up to 1 foot (0.3 m). Substantial roof decks and structures are required. Extensive green roof systems are much less of a structural burden, incorporating plants with shallow roots to about 2 1/2 inches (63.5 mm) deep. Technologies have been developed so even lightweight roof decks can support extensive roof gardens. The greatest environmental benefits can be obtained from intensive systems and include reducing rainwater runoff, often to less than 50 percent of typical percentages; reducing pressure on ground-level drainage systems; and providing longer roof system service lives because of the inherent protection of roof membranes from ultraviolet (UV) radiation, hail, wind and foot traffic.

## Roof surface reflectivity

Recent studies have found temperature excursions occur on sunny days because of heat-absorbing properties of the built environment—buildings, roofs, walls, roads,
parking lots, etc.

***This fully adhered 90-mil- (0.09-inch- [1.5-mm-]) thick EPDM roof system was designed with long-term performance as a key goal. By achieving a highly thermal-efficient, robust and durable roof system, the building owner is taking the long-term view, which is the most important concept in***

ORNL and the Lawrence Berkeley National Laboratories, Berkeley, Calif., hypothesize that a small reduction in heat gain will result in substantial energy consumption savings. In cases where roof surfaces are black and heat-absorbing, the concept of reflectivity has been proposed as a way to reduce urban heat temperatures.

***sustainability*. (This installation meets tenets 4, 8, 9, 10, 12, 13, 14, 15, 16, 18, 19 and 21.)**

Reflectivity is defined as a roof surface's ability to reflect solar energy. The greater a roof surface's ability to reflect, the cooler the roof surface, which could result in lower air-conditioning demands but also can increase the need for heating in environments such as Chicago.

However, reflectivity will decline over time because of UV radiation; surface soiling from atmospheric pollution and microscopic growths; acid rain; moisture intrusion into roof systems; wind; hail; and the temperature cycling that occurs on all roof systems because of climatic changes.

Physical changes in the properties of a roof membrane or coating also can decrease reflectivity. ORNL has published studies indicating white roof systems lose between 30 percent to 50 percent of their reflectance with a corresponding decrease in energy efficiency within the first three years after being installed. EPA and DOE have become involved and developed the ENERGY STAR program, and CRRC has developed a rating system for white roof membranes. Membrane color is one parameter for sustainability and needs to be made within the whole concept of a building system.

## Using solar energy

Photovoltaic panels, which convert sunlight energy to electricity without consuming fuel or creating pollution, no longer are tacked-on appendages begging to be concealed. There are photovoltaic materials available for virtually all surfaces of a building envelope, such as photovoltaic shingles and metal standing-seam panels. As an enduring symbol of environmental responsibility, more and more building owners are willing to pay an additional 1 percent or 2 percent of buildings' total construction cost for photovoltaic roofing materials. In some instances, excess solar energy is "sold" back to utility companies.

## The future

We all must realize our planet is vulnerable. As we continue in the 21st century, the ideals of sustainable architecture and being environmentally responsive will manifest themselves via government mandates, building codes and owner desires. Obtaining sustainable, environmentally responsive roof systems can be achieved by becoming educated about the possibilities and using a straightforward approach in adapting the tenets of sustainable roofing where possible. Materials, products and construction techniques will continue to evolve, and with them, the tenets of sustainable roofing and concept of designing for the long term will grow.

Those who take an active role in this endeavor and embrace the concepts of sustainable roofing will be ready for future environmental challenges.

The committee's work on the topic of sustainability is finished, and a copy of the full report is available to CIB members atwww.cibworld.nl/pages/begin/Pub271.html. The committee's next task involves new product introduction into the marketplace.

*Tom Hutchinson is principal of Hutchinson Design Group Ltd., Barrington, Ill. He is a CIB member and secretary of CIB W.83.*

---

## The tenets of sustainability

### Minimize the burden on the environment

1. Use products made from raw materials whose extraction is least damaging to the environment.
2. Adopt systems and working practices that minimize waste.
3. Avoid products that result in hazardous waste.
4. Recognize regional climatic and geographical factors.
5. Where logical, use products that could be reused or recycled.
6. Promote the use of "green roof systems" supporting vegetation, especially on city roofs.
7. Consider roof system designs that ease the sorting and salvage of materials at the end of the life of a roof system.

### Conserve energy

8. Optimize the real thermal performance of roof systems, recognizing thermal insulation can greatly reduce heating or cooling costs during the lifetime of a building.
9. Keep insulation dry to maintain thermal performance and the durability of a roof system.
10. Use local labor, materials and services when practical to reduce transportation.
11. Recognize embodied energy values are a useful measure for comparing alternative constructions.
12. Consider the roof surface color and texture with regard to climate and the effect on energy and roof system performance.

### Extend roof system life span

13. Employ designers, suppliers, contractors, tradespeople and facility managers who adequately are trained and have appropriate skills.
14. Adopt a responsible approach to design, recognizing the value of a robust and durable roof system.
15. Recognize the importance of a properly supported structure.
16. Provide effective drainage to avoid ponding.
17. Minimize the number of penetrations through a roof system.
18. Ensure that high maintenance items are accessible for repair or replacement.
19. Monitor roofing works in progress, and take corrective action as necessary.
20. Control access onto completed roof systems to reduce punctures and other damage by providing defined walkways and temporary protection.
21. Adopt preventative maintenance with periodic inspections and timely repairs.

## Material trends and improvements

Roofing material manufacturers slowly have responded to the green roofing movement by developing materials and products that support sustainable roof system design. Government mandates are responsible for much of the push toward development, but more clients/building owners are requesting designs that respect the environment during material manufacturing, installation and performance.

Following is an overview of some major material developments in recent years.

### Insulation

The Montreal Protocol, which banned the production and importation of HCFC-141b by the end of 2002, has had a major effect on the polyisocyanurate insulation industry. Reformulations always are challenging, especially when products with years of satisfactory performance must be altered. The conversion of all U.S. insulation manufacturing facilities from HCFC-141b to pentane-blown polyisocyanurates now are complete.

Expanded polystyrene (EPS) and extruded polystyrene (XPS) insulations offer environmental benefits that need to be considered when making insulation selections. During its manufacturing process, EPS emits no chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs) into the atmosphere. EPS also is recyclable. XPS has an extremely low absorption rate and, as such, lends itself to reuse even after decades of in-place use, consequently saving money, conserving insulation and minimizing contributions to waste sites.

### Adhesives

Foam adhesives have gained popularity, and their use has increased dramatically in recent years. Two-component polyurethane spray foam adhesives contain no HCFCs, and there are no U.S. Environmental Protection Agency (EPA) restrictions on using them in congested areas.

Cold-process adhesives used with bituminous products now can be formulated for use in extreme environmental conditions, and volatile organic compound emission mandates require the use of the most environmentally benign product possible.

The requirements of achieving a successful adhesive seam have changed little. Clean surfaces, positive bonding and mating of materials still are required. What have changed are the products used to achieve a bond. Splice primers now are formulated without isocyanate; liquid adhesives are being replaced with tapes; and flashing materials are being manufactured with tape adhesives laminated to flashings.

### Wood blocking

An integral part of almost all roof systems is the use of wood blocking. Wood that is pressure-treated to enhance protection against rot, decay and termite attacks generally is recommended by roof system designers and contractors. Traditionally, CCA-treated wood, which contained arsenic and chromium (EPA-classified hazardous chemicals), was used. There now are alternatives available. Wood treated with ACQ,® a new copper plus quat preservative system, provides the same level of protection as CCA preservatives without the arsenic and chromium. Worker safety is a prime benefit of using ACQ, and disposal of the ACQ system into ordinary waste sites is acceptable.

### Asphalt

Odor probably is the most troubling attribute of working with asphalt, particularly when working on sensitive facilities, such as hospitals, schools and restaurants. Low-fuming, no-waste packaged asphalt now is available. Asphalt is packaged in containers that do not require removal and melt without affecting performance, thus reducing waste. Formulations that include a polymer that creates odor-trapping skim layers now create a more comfortable environment in the vicinity of a kettle.

### Reinforcements

A number of roofing felt and modified bitumen manufacturers now are manufacturing reinforcing mats made from reprocessed polyester, as well as recycling and reducing waste to benefit the environment.

### White membranes and coatings

The manufacture of additional types of white membranes and coatings in response to cool roof concepts and the ENERGY STAR® Roof Products Program has increased greatly during the past five years. Led by the introduction of TPO membranes, these materials have a variety of formulations, and designers are cautioned to research each product thoroughly for its appropriateness in particular designs.