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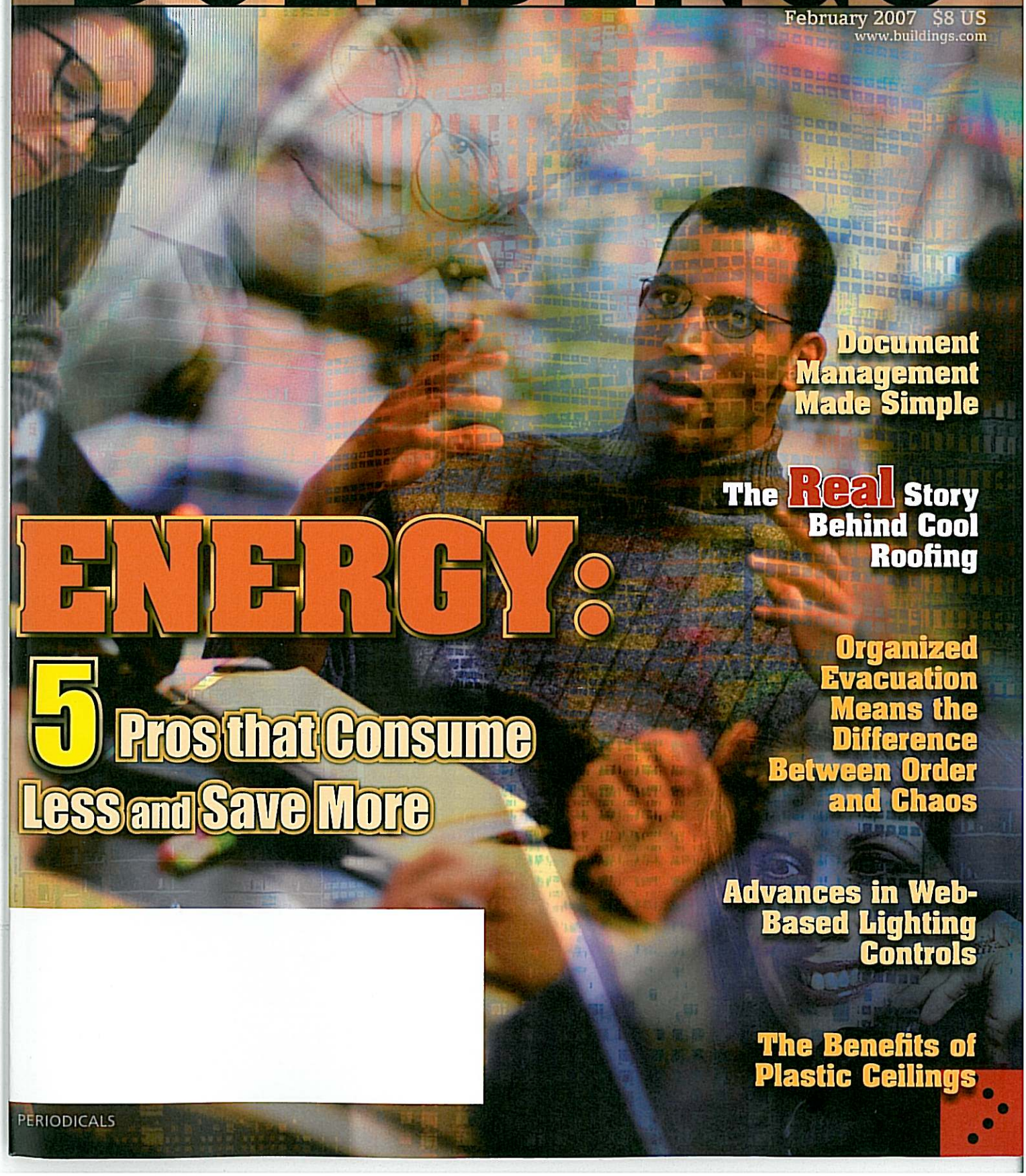

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Cool Roofing: A 10-Year Retrospective

By Thomas W. Hutchinson

In the mid-1980s, DuPont developed an energy calculator, which some manufacturers of light-colored membranes used as a marketing tool for their products. The high cost of light-colored membranes, though, was a substantial hindrance to widespread acceptance.

By the mid-1990s, the concept of "cool roofing" was brought to the forefront of the building and roofing communities by organizations such as the Washington, D.C.-based U.S. Environmental Protection Agency (EPA). The idea of providing roofing materials that are sensitive to the environment (reducing the build-up of heat in urban areas, often referred to as "urban heat islands") and that also provide some energy savings is a laudable goal. Whether a single attribute of a roof system can be held responsible for such an audacious and altruistic goal is still debatable. Cool roofs have now been in place for nearly 10 years. This article takes a step back from the always-contentious debate about the real benefits of cool roofing and discusses what has been learned from the empirical experiences of the past decade.

PHOTOS COURTESY OF HUTCHINSON DESIGN GROUP

Recent studies by Oak Ridge National Laboratory (ORNL) have found that ballast (ASTM No. 4 minimum) and concrete pavers provide the same or greater benefits as cool roofs.

What is a cool roof?

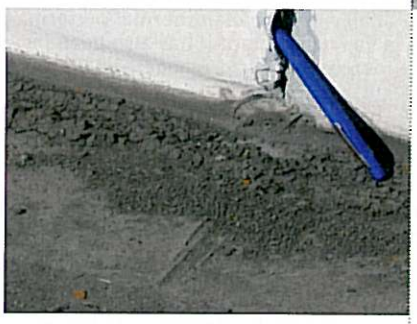
Not only is the building owner often confused by the plethora of marketing promises, roof-system designers and those involved in cool roofing are still at odds over the exact purpose or goal of cool roofing: energy conservation or reduction of the urban heat island? Most will agree that cool roofing relates to a roof-covering surface reflectivity and the ability of that material to release gained heat (its emissivity). The exact percentages of those parameters are defined differently by different organizations. For example, the EPA standard for cool roofs is a reflectivity of 0.65; the Atlanta-based American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) defines cool roofing as a roof membrane with a reflectance value of 0.70 and emissivity of 0.75, and only applies to geographical locations that have less than 3,500 heating degree days (HDD); the Washington, D.C.-based U.S. Green Building Council's (USGBC's) LEED for New Construction (LEED-NC) Version 2.1 defines cool roofing membranes as having a reflectance value of 0.90 and emissivity of 0.65. Increasing confusion is the USGBC's LEED-NC Version 2.2 edition, which has now gone to a solar reflectance index (SRI) value (a combination of the two). At the same time, there are other options available (such as roof gardens and ballasted roofs) that show performance equal to or better than a cool roof, but do not fit today's definitions.

One thing is clear: Without a clear idea about the goals of a cool roof, it's difficult to discern the definition of a cool roof. It should also be noted that the word "system" is rarely mentioned during cool-roof discussions. This is key; since roofs

Some cool roof membranes can promote biological growth (left); removal is necessary and often required by the manufacturer. Excessive discoloration will need to be washed away to maintain the expected benefits. White roofs often become soiled, decreasing their reflectivity and the potential for urban heat island reduction and energy savings (pictured below).

act as systems and are often fallible at their weakest links, concentration on only one attribute of any building system is incorrect, and focusing only on surface color in a roof system is also walking down the wrong path.

Unfortunately, those in a position to effect change have been misguided into believing that climatic and/or national energy conditions can be affected by cool roofing. Cities such as Chicago, and associations such as the USGBC, have initiated or lobbied for acceptance of their programs. These efforts have resulted in code mandates for cool roofing. Code mandates are often implemented by those with little knowledge of roofing and without any actual long-term performance requirement. For example, to meet the code in Chicago, all one has to do is coat a roof system to attain the required reflectance values at the time of installation and walk away. There is no consequence if the coating erodes away in a year or two, defeating the promoted purpose of the coating (and code).



ASHRAE 90.1 is now part of the Intl. Building Code, adopted by many municipalities, and has also been carried over into California's *Title 24*. The code mandates that, in a building undergoing a re-roof in which the insulation is not being disturbed, the roof *does not* need to be brought up to code in insulation R-value. In most cases, the existing roof will not meet code. Are "cool roofs" being used to cover an obvious error in the code, especially when one considers the direction that the cost of insulation is going?

Sustainability: The Greater Good

The essence of sustainability is long-term performance. The CIB W083/RILEM 166-MRS Joint Committee on Roofing Materials and Systems, an international group of experts in roofing material and design, has completed its work on "Towards Sustainable Roofing," offering tenets of sustainable, low-slope roofing (of which the consideration of roof color is only one parameter). The full report is available at **(http://irc.nrc-cnrc.gc.ca/pubs/bsi/2005/docs/karen.pdf)**. The tenets are categorized under three keys areas of improvements: 1) minimizing the burden on the environment using the earth's resources responsibly, 2) conserving energy by improving the thermal efficiency of roofs, and 3) extending roof lifespan by improving long-term performance. No roof system is expected to implement *all* of the tenets in its design and construction, but these tenets will help roof-system designers consider real thermal performance (by recognizing that thermal insulation can greatly reduce the heating and/or cooling costs over the lifetime of a building) and regional climatic and geographical factors that could affect the performance of the roof system. It's also important to employ designers, suppliers, and contractors who are adequately trained and have the appropriate skills to provide you with the proper roof system for your needs and budget.

Observations from the Field

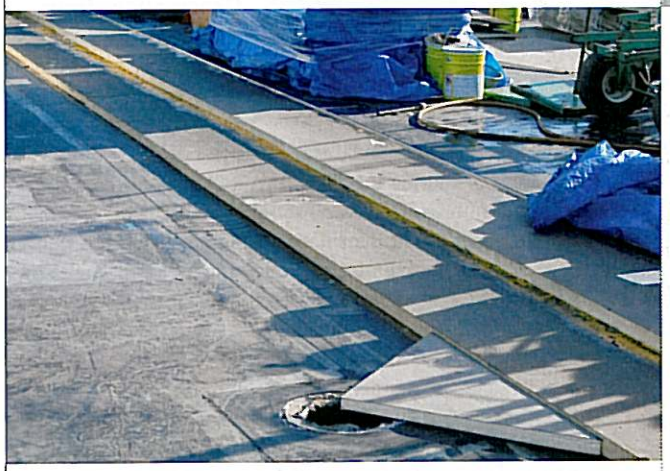
There is an underlying principle in the roofing industry which emphasizes that time in the field is the true test of a new product. The same can be said for the implementation of new concepts. Cool-roofing membranes have now been in place for the better part of 10 years. What information and knowledge has been gained from these installations? Following is a summary of observations made personally, reported in technical articles published at various symposia and conferences, and from follow-up research by respected institutes such as the Oak Ridge, TN-based Oak Ridge National Laboratory (ORNL).

- The cool-roofing issue has made building owner/facility management professionals, the roofing industry, and the design community more aware of the environment.
- Geographic location of a building and regional climatic conditions play heavy roles in achieving any benefit with cool roofing.
- Building type (e.g. warehouses; high-rise, high-performance buildings; etc.) influences the effects of cool roofing.
- While it is almost always suggested that a building's cooling load and its potential for peak load should govern design, the U.S. Department of Energy (DOE) recently reported that it is actually the *heating load* that governs. The DOE has suggested that buildings should be designed for heating conditions.
- Cool-roofing systems appear to provide the most benefit in low-performance buildings, such as warehouses, where mechanical cooling is nonexistent and little thermal insulation is offered, providing some relief to tenants and occupants during the summer months.
- Light-colored roof surfaces soil. ORNL research has found that light-colored roof systems lose between 35 and 50 percent of their reflectivity during the first 3 years of operation.
- The promise of potential energy savings differs greatly from that which is actually achieved.
- Only so much can be done with roof materials to meet the various cool-roofing parameters and code mandates before they become too costly.
- While cleaning cool roofs may be a necessary evil, it's expensive and is almost never considered in the initial roof-system cost.
- Any negative results associated with cleaning a roof membrane are not covered under a membrane warranty.
- Highly reflective roofs may negatively affect adjacent building materials, building occupants, and/or overhead users, such as pilots.
- Cool-roof membranes functioning as roof coverings have

continued

been performing well, but system design has been failing in some climates. For example, a roof system featuring a single layer of mechanically fastened insulation with a mechanically fastened roof system can result in moisture drive and lead to condensation forming on the underside of the roof membrane. Several building types in Chicago – both new construction and roof replacement – are showing the results of this lack of consideration for full-system design and have saturated insulation below perfectly good roof coverings. And, while the roof warranty promises to fix a leak, it does not cover this type of roof failure.

- Single-layer applications of insulation result in heat loss through joints (insulation shrinks). The Rosemont, IL-based National Roofing Contractors Association (NRCA) reports that heat/cooling loss through the joints of single layers of insulation are between 8 and 10 percent, negating any potential savings due to a cool-roof membrane. (Consider using a minimum of two layers of insulation with offset joints.)
- Mechanically fastened insulation provides as much as a 3-percent heat loss through fasteners, as reported by the NRCA.
- Mechanically attached roof systems don't often incorporate a cover board over the insulation substrate. One major concern is that fasteners exposed to the underside of the membrane are subject to foot traffic and potential penetration through the membrane over time. Foot traffic and construction work (both during and after the roof installation) can crush the insulation, resulting in the roof membrane being placed in an unsupported condition and fastener heads pressing up on the membrane, causing a condition that is conducive to damaging the roof membrane.
- Most mechanically attached roof systems (many of which are cool-roofing systems) have not considered the effects of air permeability on the performance of the roof systems.
- ORNL has recently found that the use of ballast (ASTM No. 4 or larger) gravel and/or concrete pavers provide the same energy-saving benefit as a maintained cool-roof membrane, is self-cleaning, and can provide a more aesthetic appearance than a soiled, light-colored membrane.
- The use of reduced amounts of insulation below cool-roof membranes is shortsighted and does not take into effect the long-term historical rise in the cost of energy nor the effects of temperature extremes, such as sustained periods of cold or heat.
- Roof-membrane manufacturers do not guarantee that their membranes will remain white.



Cool roofs tend to be most beneficial on buildings that are unconditioned and/or have low thermal values (above). Multiple layers of thermal insulation are extremely important in achieving expected thermal performance (left). Pictured here, a vapor/air retarder has also been installed to further enhance roof-system performance. The life expectancy of this roof is 30-plus years.

- Some white-colored roof membranes actually promote rooftop biological growth.
- The effects of a cool-roof membrane in regard to potential energy savings are negated when thermal insulation values of approximately R-24 are utilized in the system's design.
- Many of the decisions being made at federal, state, and local levels that affect the roofing industry are being made by those with little knowledge of roof-system design or the effects of building components on the roof, and have no liability as to the outcome of their decisions.

What You Need to Know to Make Good Long-Term Decisions

With all of the various roofing options, sales pitches, voluminous published information, code requirements, and the growing desire to be environmentally conscious, what is the building owner/facility manager to do? The role and expectation of the building owner and facility manager has changed greatly over the past 2 decades. Fiscal responsibility is the reality. Do you select the short-term, low initial cost or provide funding for a long-term solution? All buildings are different; building-owner expectations and building uses differ as well, as do geographic locations and climatic conditions. Following are some guidelines to assist you in selecting the roof system that is best for both current *and* long-term needs.

Define expectations. The purpose and expectation of the roof system need to be clear. Parameters such as expected roof service life need to be defined, whether that be 10, 20, or 30 years (or more). What will the roof be utilized for besides protection from the exterior environment? Will it serve as a security barrier or house the movement of mechanical machines across the roof? What type of foot traffic can be expected? One of the greatest detriments to all roof systems is unabated or monitored HVAC equipment. What is the building's current and anticipated long-term use? Certainly, a facility that houses dry goods and doesn't require much cooling and/or heating has differing thermal insulating requirements than an office or educational building, where interior climate is a concern and often affects productivity.

Consider hiring a roof consultant. Defining project goals is often difficult. Bringing a knowledgeable roof consultant on board early in the process can help you define and budget

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Concrete pavers and gravel ballast meet Chicago Energy Conservation Code requirements and do not require any care or cleaning to maintain.

for your goals. A registered roof consultant (RRC) (a nationwide list of RRCs can be obtained from RCI-The Institute of Roofing, Waterproofing, & Building Envelope Professionals at **[www.rci-online.org]**) will be able to provide the appropriate roof investigation and make roof-system recommendations, detailing advantages and disadvantages of various systems for your consideration. As a cautionary note, most states require that a licensed design professional (architect or engineer) provide the necessary design oversight and stamping of drawings for permit. This is not often the case with roofing contractors or roof-membrane manufacturers providing design services that may not be in compliance with state law.

View roofs as systems. All building components need to be considered in the design of the roof system. Replacement roof systems that do not take the building's internal function, adjacent masonry walls, and HVAC concerns into consideration may result in unsatisfied tenants.

Make the roof robust. Roofs are used – intentionally or unintentionally – in a variety of ways and for a variety of purposes. Traversed by maintenance staff, window washers, painters, glazers, and other professionals, the traffic is detrimental to the roof's condition. Consideration of a sound and stout substrate and protective walkway pads that allow water to migrate below them will assist in the protection of the roof surface.

Consider the benefit of sustainability. Achieving sustainable roof systems – ones that will provide long-term performance – (defined here as roof systems that are designed and installed to provide at least 25 years of service) is possible, but requires that a number of parameters be given consideration (not just roof color). There is no single parameter panacea, and selecting a roof covering based solely on color is no exception.

Take the location into consideration. Full consideration of local climatic conditions and their effect on the roof system's ability to meet expectations of the roof-system designer is needed.

Keep expectations realistic. Unrealistic expectations as to what your roof can provide will only result in a lack of trust between the designer, contractor, and owner. There are no shortcuts to achieving performance.

Consider the value of thermal insulation. Consider for a moment that when replacing your roof, the decisions you make affect you for 10, 20, or 30 (or more) years. The cost of thermal insulation is a relatively minor expense compared to the lifetime costs of a roof system that works 24/7. One layer of insulation *does not* provide the same thermal value as two layers equaling the same thickness because considerable thermal value is lost through the joints of only one layer of insulation. Using multiple layers of insulation is more than a recommendation – it's a mandate for any roof system from which you desire long-term performance. Additionally, consider the value of a vapor/air barrier. Air leakage is one of the greatest sources of heat loss and moisture migration. Incorporating a vapor/air barrier will often enhance both roof-surface performance and energy savings.

Provide proactive maintenance. All roof systems, regardless of their physical make-up, require maintenance; most (if not all) roof-system warranties require it. Designing the roof to make maintenance easier and safer will help you achieve long-term performance from your roof. Items such as rooftop hatches; quality, protective walkways; safety line davits; and water spigots and electrical outlets to assist in rooftop cleaning (if required) are a few essential design considerations.

Enhance building-code requirements. Building codes provide a minimum standard of care and, as such, are at the low end of performance. If you're hoping to achieve a sustainable roof, enhance its thermal insulation, wind uplift, and hail performance.

Explore alternatives. The following alternatives to cool-roofing options exist:

1. **Ballast.** The use of self-cleaning ballast (ASTM No. 4 at minimum) and/or concrete pavers is an energy-saving solution.
2. **Coatings.** Quality coating can provide a potential solution to owners of existing roofs needing service-life enhancement and provide the benefits of a lighter-colored surface.
3. **Solar and wind power.** These technologies are rapidly changing; keeping abreast of these developments is recommended for the sophisticated building owner or facility manager.
4. **Garden roofs.** Garden roofs provide a measure of protection to the roof surface, much like ballast, and may provide a certain amount of aesthetic value. Unless the overburden is quite substantial, the amount of water retention may be negligible. The cost of roof gardens, though, is still relatively high.

Planning for the Future

There is no panacea for all roofing conditions. Each roof is a unique, individual element of the building environment. The choices you make will be tested by time. Environmentally sensitive and sustainable roof systems are obtainable and include a number of parameter considerations (the least of which is color). The next time a roof-replacement opportunity arises, give consideration to designing for sustainability. Why accept a 10-year roof-system design when a 20- or 30-year life can be achieved? By making use of today's knowledgeable designers and appropriate materials and technology – while recognizing the importance of building use and geographical location – savings in energy, natural resources, landfill waste, and long-term satisfaction can be attained.

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