DESIGNING SUSTAINABLE ROOF SYSTEMS

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ABSTRACT
Enlightened building owners and roof system designers are interested in adopting roofing systems using environmental parameters. In many countries a generation has grown up in a culture sympathetic and supportive to "green" issues. Many colleges and universities include environmental studies as part of normal course work. 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.

INTRODUCTION

The 1997 Kyoto International Conference on Climate Change challenged governments to improve their environmental performance by reducing pollution and energy demand. To work towards these desirable goals, the concept of "sustainable development" is being actively promoted in the contractor and property industries in some countries.

The roofing industry's challenge is translating this interest and good will into practical guidelines, which will lead to improvement in the incorporation of environmentally respectful procedures and products in roof system design. No product or procedure that results in reduced performance will be adopted. An architect specializing in roof system design has the greatest challenge designing environmentally responsive low-slope systems that exceed an anticipated service life.

DEFINING THE CONCEPT

Before beginning any discussion of roof systems and the environment, the terms need to be defined. Roof systems are the sum of all their parts; likewise, so are environmental concerns. Therefore, environmental issues should be considered as part of a more holistic approach—that of sustainability.

In regard to roof systems, several conceptual definitions have been proposed. Perhaps the best working definition of **sustainable roof** is one used in the *Proceedings of the Sustainable Low-Slope Roofing Workshop*, held at the Oak Ridge National Laboratory in the USA in October 1996:

> A roofing 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.

Difficult to comprehend, the definitions are also difficult to implement. Their value lies in their far-reaching scope. Sustainable development supposes that construction methods and their relationship with the environment, life cycle analysis, and environmental quality must all be taken into account. Consequently, it is an all-encompassing concept that provides a stable framework for new design methods using the 'long view'.

Life cycle analysis involves examining each step in the life of matter: from raw material extraction or processing; through production; packaging; transportation; design; installation; service life; reuse; recover or tear-off; and ultimately disposal. This is typically illustrated in a 'Cradle to Grave' model.

TENETS OF SUSTAINABILITY

Environmental studies and debates have laudable goals, but designers and contractors seek basic advice in sustainable development. Working since 1995, the CIBW.83/RILEM166RMS Committee (Tom Hutchinson, Legat Architects, USA; Keith Roberts, Roberts Consulting, United Kingdom; co-chairs) has identified three areas for improvement.

- **Minimize the burden on the environment** by responsible use of the earth's resources.
- **Conserve Energy** by improving thermal efficiency of roofs.
- **Extend Roof Lifespan** by improving long-term performance.

In October 2000 the task group finalized 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. The following summary will be of practical use for designers, manufacturers, and contractors alike. Appearing to be simplistic, when considered as a whole, the tenets make a considerable contribution to promoting sustainable roof system design, construction, and maintenance of membrane roof systems.

Tenets of Sustainable Roofing

Minimize the Environmental Burden

1. Use products made from raw materials whose extraction is the least environmentally damaging.
2. Adopt systems and working practices that minimize wastage.
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 roofs' supporting vegetation.
7. Consider roof designs that ease the sorting and salvage of materials at the end of the roof's useful life .

Conserve Energy

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

their affect on energy and roof system performance.

Extend Roof Lifespan

13. Employ adequately trained designers, suppliers, contractors, trades people, and facility managers with appropriate skills.
14. Adopt a responsible approach to design, recognizing the value of a robust, durable roof.
15. Recognize the importance of a properly supported structure.
16. Provide pond-avoiding drainage.
17. Minimize roof penetrations.
18. Ensure that high maintenance items are accessible for repair or replacement.
19. Monitor roofing works in progress, taking necessary corrective action.
20. Provide defined walkways and temporary protection to control access onto completed roof to reduce puncture and other damage.
21. Adopt preventative maintenance, with periodic inspections and timely repairs.

ROOF SYSTEM DESIGN EXAMPLE

When designing roof systems, the greatest environmental good results from taking the long-term view, designing roof systems that have extended service lives. Single-ply roofs' average life is less than 12 years; it is less for BUR roof, discounting roofs designed for 10-year lives. It is felt that these service life averages are unacceptable. Following is a case study of a project that used the tenets of sustainable roofing to achieve a service life greater than 20 years. Maintenance is important to achieve these extended service lives, but maintenance will not be discussed here.

Case Study:
Project: Highland Park High School
Science Classroom Addition
Highland Park, IL

Goals: 1. 29-year roof life, minimum
2. Achieve energy conservation
3. Where economical, be environmentally responsive

ROOF SYSTEM DESIGN SOLUTION

Component	Justification	Tenet of Sustain-able Roofing
Moisture Protection Design Team	Team of professionals educated in moisture protection	13, 14
Steel Structure, structurally sloped	Locally fabricated, knowledgeable local installers, positive slope guaranteed	10, 13, 15, 16
Metal Roof Deck (Exposed)	Locally manufactured, installation familiarity	10, 13
5/8" Dens-Deck in foam adhesive	No penetrations through roof deck desired, foam adhesive allows for ease of installation	14
2 Layers of 2", 1 layer 1½" polyisocyanate set in foam adhesive, R = 5.67/in, 20 psi min.	R30 achieve, non HCFC product, locally produced. 20psi min. offers a greater degree of stability than normal	8, 9, 10, 14
½" high density wood fiber board set in hot asphalt	Offers separation between membrane and polyiso-cyanate (outgassing); provides firm substrate underfoot	14
60 mil reinforced EPDM fully	Extensive successful experience of contractors	

adhered *isocyanate-free primers *tape adhesive use where practical *all seams to be overlaid with cover strip	and designers, north facing slope Use of environmental obtrusive materials No VOC's Provides redundancy	10, 13, 14, 12 3 3 14
Limited Penetrations	Minimize the possibility of default in flooring	17
ACQ Pressured Wood Blocking	Rot and decay resistant treatment, environmentally safe	3, 14
Heavy-gauge aluminum coping, fascias, and counterflashings	Provides superior wind uplift resistance, nice aesthetic look	4, 14
Preapproved roofing contractors	Optimize probability of success	10, 13
Monitor installation	Optimize probability of success	19
Control Access on completed roof	Optimize probability of success	20
Review with owner the maintenance requirements	Optimize probability of success	13, 14, 21

While not every tenet was fulfilled, many were, and that is the intent of the list.

CONCLUSION

Our planet's vulnerability is real. Entering the Twenty-first Century, sustainable architectural ideals and environmental responsiveness will manifest themselves via government mandate, codes, and owner desires. Environmentally responsive roof systems are achievable utilizing the tenets of sustainability. As materials, products, and construction techniques evolve, so will the tenets of sustainable roofing and the concept of long term design. Those taking an active role in this endeavor, embracing concepts of sustainable roofing, will be ready for the Twenty-first Century's environmental challenges.