

# **ADVANCING SUSTAINABLE ROOFING: LEED™ AND THE COMMERCIAL ROOFING INDUSTRY**

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## **INTRODUCTION**

In less than a decade since its inception, the U.S. Green Building Council (USGBC) is becoming a significant force in the construction industry. In addition to building a membership base of over 4000 firms and organizations across the United States and sponsoring its annual Greenbuild convention drawing thousands of attendees, the USGBC has achieved noteworthy success in the development and promotion of the LEED (Leadership in Energy and Environmental Design) Green Building Rating System™. Within less than six years following the formal introduction of this rating system, over 7000 architects and building designers have received LEED-sponsored accreditation and over 180 million square feet of new buildings in the United States have been registered with LEED. Given this impressive track record, the U. S. Green Building Council is well justified in calling LEED “a leading-edge system for designing, constructing, and certifying the world’s greenest and best buildings.”

This paper will explore the benefits and limitations of the LEED system, especially in relation to the commercial roofing industry. The paper will also identify the unique resources and perspectives that commercial roofing can contribute to both the LEED rating system and building sustainability. Finally, the paper will suggest actions that might be undertaken by the roofing industry to maximize the value of its unique perspective on long-term building sustainability and performance.

## **WHAT IS LEED?**

According to the USGBC, LEED is a “voluntary, consensus-based, market-driven national standard for developing high-performance, sustainable buildings.” LEED was created to:

- define “green building” by establishing a common standard of measurement
- promote integrated, whole-building design practices
- recognize environmental leadership in the building industry

- stimulate green competition
- raise consumer awareness of green building benefits
- transform the building market.

Instead of offering a complex and wordy formal definition of “green building”, LEED relies on a simple enumeration of its most-recognized characteristics. These key “green” characteristics include 1) a sustainable building site, 2) water efficiency, 3) energy conservation and atmospheric impact, 4) effective use of materials and resources, and 5) indoor environmental quality. By combining these key attributes into a single standard, LEED helps to promote a holistic approach to building design. And by developing a comprehensive rating and award system for these key attributes, LEED offers a stimulus for competitive responses to the challenge of green construction. And by promoting LEED as a recognizable concept, the system builds consumer awareness about green construction and, in the long run will transform the way buildings are designed, constructed and maintained. These three fundamental strategies – simple definition, competitive motivation, and brand awareness – appear to be propelling LEED along a path toward its final goal of transforming the building market.

## **ADVANTAGES OF LEED**

**Promoting the “Big-Picture.”** Because it offers a broad-based model addressing almost every element of building design and construction, LEED challenges the construction industry to consider a wide range of approaches to increase the overall sustainability of buildings. When applying LEED to a construction project, the building owner and designer must deal with many important environmental issues, including site impact, water and energy conservation, material use and recycling, and indoor environmental quality. By engaging them in such broad array of important issues, LEED rewards building owners and designers genuinely interested in increasing the sustainability of the built environment rather than minor tinkering with selected construction elements. This “big picture” approach to sustainability helps to lift the LEED message above the din of competing and sometimes contradictory claims regarding “green” construction products and practices.

**Keeping It Simple.** Compared to other current alternatives for assessing building sustainability, LEED offers a simple and understandable model that can be implemented by a wide variety of building owners and construction professionals. While other systems may require either complicated computer models or elaborate assessment infrastructures, LEED relies on a simple, consensus-based point system. First, LEED divides important environmental issues into five basic categories focusing on site considerations, water conservation, energy savings, material properties, indoor environment, as well as a sixth category for innovative practices. Each category offers a specific number of credits of one or more points, each tied to important concepts within the category. A building project that earns 26 points can become “LEED Certified”, while additional points can earn special Silver, Gold or Platinum status.

Although the basic point system is very simple, LEED has integrated several features that add sophistication to the model without adding significant complexity. First, in recognition that certain environmental considerations should be “non-negotiable” in sustainable building design, all five primary LEED categories contain prerequisites that must be met before points can be earned. As an example, certain minimum standards of energy efficiency must be met before any energy savings credits may be earned. Secondly, because some environmental issues may have greater potential impact than others, the LEED point system is weighted toward many of these more salient concepts. As an example, up to 10 credits can be earned for a variety of overall energy-saving practices regardless of the energy source, while only one credit can be earned specifically for energy initiatives associated with “Green Power”.

**Fostering Competition.** Beyond its simplicity and ease of application, the LEED point system also appeals to the competitive nature of American society. Through its combination of an easy-to-understand point system and specific levels for attainment and recognition, LEED “...takes a complex, multifaceted problem ...and makes it a game, with clearly established rules and intricate strategies...” (“White Paper on Sustainability”, 2003, p. 8). In addition to helping simplify a complex and important task, LEED also offers building owners and designers an opportunity for tangible recognition for their efforts in advancing sustainability. By challenging designers to look at sustainability in an integrated and accumulative manner, LEED helps building teams benchmark where they want to go and devise strategies to reach those objectives.

**Building “Green” Awareness.** The simplicity of the LEED program also appears to help it build awareness about the importance of sustainable construction. Its simplicity makes it easy to understand, easy to specify and (relatively) easy to deliver. And the active promotion of LEED by the over 4000 members of the U.S. Green Building Council also appears to be building a special “brand” awareness about LEED itself. According to the editors of *Building Design & Construction*, “The LEED rating imbues projects with the equivalent of the Good Housekeeping seal of approval or a favorable review in Consumer Reports.” (“White Paper on Sustainability”, 2003, p. 11.)

**Transforming The Market.** The simplicity, the competitive nature, and the growing brand awareness of LEED all appear to be working together to permanently transform the way Americans perceive the built environment. As stated by Christopher Shaffner, a founding board member of the Green Roundtable:

“LEED is doing a wonderful job of getting people to look at the effects buildings have on the environment. It’s doing exactly what it is designed to do. It’s a force to be reckoned with. LEED isn’t perfect, and no one is saying it is. But it is a wonderful tool and it is motivating so many people. The U.S. Green Building Council has talked about transforming the marketplace, and that is exactly what LEED is doing.” (“Perspectives on Sustainable Design”, Nov. 2003.)

## LIMITATIONS OF LEED

**Limited Reach.** Although 140 million square feet of LEED-registered buildings may seem large to a uniformed observer, LEED projects represent a very small percentage of total building activity. According to a variety of industry sources, over one billion square feet of new non-residential buildings are commissioned every year. As a consequence, the 140 million square feet of LEED buildings registered since late 1998 represent little more than two percent of the over 6 billion square feet of buildings erected nationwide during the same period.

Many advocates of LEED would respond that the visibility of the program has influenced millions and millions of square feet of construction not officially registered with LEED. But even if it is assumed that the LEED system influences many construction projects beyond the official registration numbers, the impact of LEED on the commercial roofing industry remains very small. The reason is very simple: Over 70% of all commercial roofing installations involve the re-roofing of an existing building rather than the installation of a roof on a new building. Even if every new building erected in the United States were LEED-registered, over two-thirds of commercial roofing activity would not fit into the LEED mold<sup>1</sup>.

The current limited reach of LEED also can be seen in an apparent imbalance within the current inventory of LEED-registered building projects. Although governmental buildings account for less than 25% of all non-residential construction in the United States, over 50% of all LEED buildings registered to date have been submitted by Federal, state or local governments. And when projects submitted by institutional owners such as schools, hospitals, foundations and non-governmental organizations are added to the governmental buildings, very few LEED projects are left to represent the market-driven sectors of commercial and industrial construction.

**Potential for Confusion.** For the roofing industry, the benefits of LEED's broad-based approach are offset to some degree by the difficulties encountered in identifying exactly what credits can be derived from roofing systems. Roofs serve a variety of functions within a building, shielding them from sun, wind and precipitation, insulating them from external temperature fluctuations, directing water run-off, and providing a working platform for important mechanical equipment. Because of this multiplicity of function, potential environmental benefits of roofs can be found in every LEED category. In addition to fundamental material features such as surface reflectivity, recyclability, and hazardous content, roofing materials can be critical to effective site development, water efficiency, energy consumption, and indoor environmental quality. As a result, "roofing credits" in LEED can be identified as part of at least a dozen different credit categories.

Given the increasing popularity of the LEED concept and the rating system's disjointed approach to roofing, the potential for confusion can be significant, especially for a building owner or designer wanting to apply the LEED concept to the billions of square feet of re-roofing projects installed annually. This confusion is frequently manifested when roofing contractors or manufacturers are asked whether their roofing products are "LEED-compliant." Unfortunately, the answer to this question is "Yes, no and maybe." "Yes", because some roofing products by virtue of a specific characteristic (such as

surface reflectivity) can gain a specific credit (in this case, for reducing solar heat absorption). “No”, because some roofing products offer environmental features (such as increased longevity) that aren’t currently measured by the LEED system. And “Maybe”, because some roofing products can contribute to LEED only if and when the products are correctly integrated into a larger design strategy addressing a specific LEED credit.

**Insufficient Emphasis on Durability.** Without a doubt the roofing industry’s greatest concern regarding the LEED program can be found in its apparent overemphasis on environmental benefit without an equal concern for the durability of the products employed to achieve this environmental benefit. As an example, a building owner or designer can achieve one LEED point for painting the building roof with a reflective coating even though the coating may last less than five years. At the same time no credit is available for the selection of a high-performance roofing system that may be designed and warranted to last 30 years or more. In a similar manner, a building owner can receive a LEED credit by selecting a highly-reflective roofing membrane such with less than 10 years of extensive field application while receiving no credit for the selection of a wide variety of roofing systems with 20 or 30 years or more of field experience involving literally billions of square feet of successful roof installations.

It is interesting to note that concerns about durability appear to be shared by the majority of construction professionals both within and outside the roofing industry. According to a recent *Building Design & Construction* survey of over 70,000 building designers and owners, the strongest opinion regarding sustainable construction was that building materials should be evaluated on the basis of life cycle cost, long-term durability, and maintenance, and not just environmental impact and energy savings (“White Paper on Sustainability”, 2003). In recognition of these concerns, the U.S. Green Building Council has initiated several programs to increase emphasis on material durability by introducing life cycle cost assessment (LCA) into the structure of LEED, so that the long-term performance of building components is given greater consideration. Unfortunately, there is little current consensus regarding what approaches to LCA provide the most reliable result, and the complexity of many LCA models may inevitably be incompatible with the simplicity of the LEED system.

**Stakeholder Imbalance.** Although LEED is called a “consensus-based” and “market-driven” standard, the membership list of the U. S. Green Building Council appears to bring this claim into question. Of the approximately 4800 members of USGBC as of August, 2004, over 68% represent a single sector of the construction community – namely design firms involved in the professional practice of architecture, engineering, landscape architecture, and interior design. With an additional 10% representing governmental bodies and non-profit organizations, only 22% of the membership is left to represent the vast “market” sector of commercial building owners, building contractors, material suppliers, and real estate developers. Part of this imbalance may be due to the USGBC’s policy regarding trade associations. Because its founding members feared that well-funded industry trade associations would unduly influence the direction of the green building movement, trade associations have not been allowed to join the USGBC. And because so many market sector organizations rely on trade associations to be their

“voice” in the public arena, the lack of participation by individual for-profit companies is understandable. It should be noted, however, that a special committee of USGBC is currently soliciting input from interested non-profit trade associations as well as current members in an effort to re-evaluate this position.

## **WHAT THE ROOFING INDUSTRY CAN OFFER**

**Increased Market Access and Opportunity.** As previously mentioned, because over 70% of all roofing projects are conducted on existing buildings not covered by the current LEED program, the roofing industry has access to almost three times the building opportunity as LEED, or over 3 million square feet of additional building surface area on an annual basis. Because of increasing public awareness about LEED and the green building movement, it is very probable that many building owners, when faced with the prospect of replacing an existing worn-out roof, might be very willing to consider incorporating sustainable products and methods into the re-roofing project. Given the likelihood of growing interest on the part of building owners, it is also highly probable that, if a “LEED-like” program for re-roofing were available, millions of square feet of buildings could benefit from improved roofing practices and many more building owners could participate in the rewards and recognition of LEED.

**Hard-Earned Experience in Material Durability.** When it comes to assessing the durability of building materials and systems, the roofing industry can offer a wealth of research and performance data. Because long-term material and workmanship warranties have become a standard feature of roofing systems for the past 30 years or more, extensive historical data bases have been assembled covering literally billions and billions of square feet of roofs. In addition, considerable research work has been conducted by materials manufactures, roofing consultants and roofing trade associations regarding the durability and performance of modern roofing materials.

Although it is difficult to generalize the results of the large body of roof performance research, one important principle appears to permeate the industry’s records. With few if any exceptions, innovations in roofing technology tend to experience a “learning curve” before the technology stabilizes and provides optimal performance. As an example, early versions of EPDM roofing system exhibited significant problems relating to field seams and perimeter attachments. But today, EPDM is considered to be one of the best performing roofing membranes available today (Bailey, Cash,& Davies, 2003, Trial, Robertson, & Gish, 2004 ), and some premium EPDM roofing systems now are available with comprehensive warranties up to 30 years. Similar examples of this performance learning curve can be cited for almost every other major roofing product, including fiberglass BUR, 2-ply modified bitumen, and PVC roofing membranes. And beyond these specific examples, numerous studies of historical warranty repair cost appear to support this principle (Hoff, 1997, Schneider & Keenan, 1997, Hoff 1998, Hoff 2003a).

The implications of such a learning curve on roof system sustainability may be very significant, especially since the current LEED program appears to favor a number of newer roofing technologies that may not yet offer optimal performance in regard to durability and sustainability. As mentioned previously in this article, LEED favors highly

reflective roofs as the sustainable choice even though many of these roofs use either temporary coatings or relatively new polymer technology to gain their supposed sustainability benefits. Although it would not be fair to label these technologies as “unproven”, based on the overwhelming evidences of historical performance data, it would be quite justifiable to assume these products still have a way to go in terms of their performance learning curves.

Unfortunately, the current LEED model makes little or no attempt to reconcile the need to meet new and emerging environmental needs with the preponderance of evidence pointing toward the slow development of any new roofing technology. In fact, it is interesting to note that the EPA Energy Star roofing standard, which is incorporated into the LEED credit system, only requires Energy Star roofing materials to provide a portion of their initial benefit for up to 3 years and provide a minimum overall durability warranty equal to “comparable” non-reflective products. Because some of these “comparable” products may offer as little as a 5 or 10 year warranty, many of these so-called sustainable products offer much less in terms of durability when compared to currently available roofing systems that now offer between 20 and 30 year performance warranties.

**Cooperative Industry Partnership.** Unlike the U.S. Green Building Council with its preponderance of membership representing only a limited segment of the overall construction community, the roofing industry enjoys greater balance in participation among all groups with a stake in the roofing process. Although our industry is not immune to conflict among key stakeholders such as contractors, consultants, owners, and manufacturers, we do enjoy a high level of participation from all stakeholder communities. And recent major industry initiatives such as the Roofing Summit and the Roofing Alliance for Progress appear to support the contention that our industry is becoming more consensus-oriented and inclusive in its approach to significant issues. In fact, a recent survey of attitudes among roofing contractors, roof consultants, roofing manufacturers, and building owners indicated surprisingly high levels of mutual respect and cooperation among these important stakeholder groups (Hoff, 2003b). Although the roofing industry is occasionally perceived as somewhat backward within the construction community, the organizational and communication structures we have developed may offer significant insights and opportunities to an organization such as USGBC, which appears to have limited success in reaching out to the “market-driven” sectors of our society.

## **A FORWARD PLAN**

**Develop a Single Industry Strategy.** The real question for the roofing industry is not whether to participate in the growing green building movement, but what strategy should be employed to participate. As suggested by this paper, the LEED rating system contains a number of significant weaknesses, especially in relation to the needs of the roofing industry. LEED has little or no applicability to the hundreds of thousands of re-roofing projects contracted every year, and the LEED system can be very confusing if and when applied solely to a roofing project. And yet, LEED is rapidly becoming a recognized

brand name that more and more building owners and designers want to “hang their hat on.”

If the roofing industry elects a strategy to actively seek changes in the current LEED program or to advocate for a special “Roofing LEED” program, the industry must recognize that considerable time and effort will be required to gain a real voice in the LEED program. On the other hand, a strategy based on developing a roofing sustainability program separate from LEED will be at least as costly in time and effort, with an outcome perhaps less certain.

While it is not within the scope of this paper to endorse either strategy, it is worth suggesting that either a lack of strategy or a mixed approach trying to accomplish a little of both strategies will undoubtedly prove to be detrimental to the roofing industry. The growth and challenges presented by LEED call for industry-wide discussion regarding how we should address the issue of sustainability – both in terms of serving our customers and maintaining momentum for the advancement of good roofing practice.

**Tirelessly Advocate the Importance of Durability.** As an industry, we have spent far too much time and far too many dollars fixing past problems related to durability not to become an unflinching advocate for the utmost importance of durability in any green building initiative. Simply put, no building product should be considered truly sustainable unless it also meets or exceeds the desired durability of the building itself.

To buttress our resolve to become durability advocates, we should remember the 70,000 building designers and owners who (in a survey mentioned previously in this article) agreed wholeheartedly that building materials should be evaluated on the basis of long-term durability and not just transient environmental impact. Given the lessons our industry has learned (many the hard way), and given the apparent interest in life cycle cost and durability, we should do everything we can to transfer our experience to the larger construction community.

The “Guidelines for Designing Sustainable EPDM Roofing Systems”, currently under draft by Samir Ibrahim for the EPDM Roofing Association, offers an example of how durability and sustainability can be effectively linked together in a guideline format to educate and inform building designers and owners. This document (provided in Appendix I) draws on both the historical background of system performance as well as current state-of-the-art concepts to provide a comprehensive listing of key design concepts that can increase the durability and reliability of EPDM roofing systems. Guidelines such as this should be implemented for all major product segments of the roofing industry, using current trade associations for consensus and peer review.

**Use The “Tenets of Sustainable Roofing” as a Model.** Regardless of whether the roofing industry adopts a strategy to expand the LEED program or to develop an independent rating system for roofing, the Tenets of Sustainable Roofing as developed by the CIB / RILEM Environmental Task Group (Hutchinson, 2001) will serve as a useful

tool. The Tenets model uses a similar category-based approach as LEED, but only three basic categories are required:

1. Minimize the burden on the environment
2. Conserve energy
3. Extend roof lifespan

Unlike the current LEED model, the Tenets of Sustainable Roofing place a significant emphasis on the durability of materials. While none of the five basic categories of the LEED model address durability, the Tenets model dedicates one-third of its focus on durability and life cycle performance. And, with the exception of some elements of indoor environmental quality, the remaining two categories of the Tenets model fully cover all current LEED categories. In this regard, the Tenets model offers almost everything contained within LEED, with the added benefit of including durability as primary category. The Tenets model also contains 20 sub-categories (See Appendix II), many of which are strikingly similar to the sub-categories in LEED. In fact, a credit-based rating system for roofing could be developed using the 20 Tenets subcategories as easily as (or perhaps more easily than) the current LEED model.

If the roofing industry decides to develop and advance an independent rating program for roofing, the Tenets of Sustainable roofing could provide the same broad-based but simple approach that has made LEED so popular. Or if the roofing industry decides to work within LEED to develop a “Roofing LEED” program, the Tenets can serve as a simple and effective reminder about the importance of durability.

**NOTES:**

1. It should be noted that the USGBC has initiated a new LEED program for existing buildings, but the program is designed to address major building renovations, which drive a very small portion of the 3 billion-plus square feet of re-roofing applied annually in the United States.

## REFERENCES:

- Bailey, D. M., Cash, C. G., & Davies, A. G. (2003). Service life tests for roofing membranes. In W. Rossiter & T. Wallace (Eds.), *Roofing Research and Standards Development (5th Ed.)*. West Conshohocken, PA: ASTM International
- Hoff, J. L. (1997). Historical warranty repair cost as a measure of long-term roof system performance. *Proceedings of the Fourth International Symposium on Roofing Technology*. National Roofing Contractors Association: Rosemont, IL.
- Hoff, J. L. (1998). EPDM re-roofing versus re-cover: A comparison of historical maintenance cost. *RCI Interface*, July.
- Hoff, J. L. (2003a). EPDM roof system performance: An update of historical warranty service costs. *RCI Interface*, September.
- Hoff, J. L. (2003b). Exploring industry expectations. *Professional Roofing*, March.
- Hutchinson, T. W. (2001). Designing environmentally responsive low-slope roof systems. *RCI Interface*, November.
- Perspectives on sustainable design (2003). *Environmental Design + Construction*, November.
- Schneider, K. G. & Keenan, A. S. (1997). A documented historical performance of roofing assemblies in the United States 1975-1996. *Proceedings of the Fourth International Symposium on Roofing Technology*, National Roofing Contractors Association: Rosemont, IL.
- Trial, T., Robertson, R., & Gish, B. (2004). EPDM roof membranes: long-term performance revisited. EPDM Roofing Association. Available at [http://www.epdmroofs.org/press/news\\_stories/2004/7\\_26\\_04.shtml](http://www.epdmroofs.org/press/news_stories/2004/7_26_04.shtml)
- White paper on sustainability (2003). A supplement to *Building Design & Construction*, November.

## **APPENDIX I: DESIGN GUIDELINES FOR SUSTAINABLE EPDM ROOF SYSTEMS**

(An EPDM Roofing Association Draft prepared by Samir Ibrahim, September, 2003)

**General Guidelines.** Although the length of warranty may be a directional indicator of roof system durability, the length of warranty should never drive the design of sustainable roofs. Rather, effective design should be based strictly on established performance principles. Regardless of the type of EPDM assembly (ballasted, adhered or mechanically fastened), the following guidelines are recommended as minimum standards to increase the roof expectancy, reduce the risk of incidental problems and reduce costs associated with periodic maintenance.

1. When configuring R-value, meet ASHRA 90.1 or local codes, whichever is more stringent. Insulation boards should always be installed in 2 layers with joints staggered to optimize energy performance. Because the addition of insulation in excess of minimum code requirements frequently offers a long-term cost payback, special consideration should always be given to exceeding minimum R-value standards.
2. All roof assemblies should be designed to resist wind forces in a geographic area. For adhered and mechanically fastened EPDM assemblies, follow ASCE 7 standards for anticipated wind loads and the required fastening density. Ballasted systems must be configured in accordance with ANSI/SPRI RP-4 to determine proper gravel size and wind resistance. As with R-value, special consideration should always be given to exceeding minimum wind uplift requirements in order to increase system robustness and reduce the potential for wind damage.
3. Perimeter edging is the first line of defense protecting the roofing systems from a blow off. Perimeter wood nailers must be secured following FM (Factory Mutual) Loss Prevention Data Bulletin 1-49. Securement of metal edging should be in accordance with ANSI/SPRI ES-1, a national standard for edge systems. Special consideration should be given to pre-engineered snap-on edging or anchor bar fascia systems that offer higher wind resistance and are known for their reusability.
4. Require International Building Code standards when configuring roof slope. Positive drainage must always be provided and roof drains should be located in areas where maximum deck deflection is anticipated. Areas of potential ponding should be mitigated with the use of tapered crickets or saddles. Field membrane seams should always be shingled with all “T” joints overlaid. Field seams that may be located in areas where incidental ponding may occur should also be overlaid with Pressure-Sensitive Flashing.

5. Use wider splice tapes. Seam durability and long-term performance could be enhanced and the benefits of wider seams will outweigh the marginal increase in cost of the initial installation. Special consideration should also be given to providing a redundant tape overlay at all roof seams or at roof areas with increased risks or consequences of moisture penetration.
6. Elevate rooftop-mounted equipment to facilitate ease of installation and reduce potential reroofing costs. Provide walkways and other traffic protection around and to all equipment requiring periodic maintenance.

**Ballasted EPDM Systems.** Since their introduction in the mid 60's, ballasted systems have been perceived as a low-cost economical roofing alternative. While many of these systems continue to perform successfully, some early installations experienced membrane bridging, crazing of Neoprene flashing and inconsistencies in splice performance. As evidenced by the Hoff (1997) study on life cycle analysis based on repair costs, these early problems were virtually eliminated since the mid 80's. According to the Trial, Robertson & Gish (2004) study on EPDM long-term performance, samples with 18 to 23 years of field exposure showed the material physical properties still exceeded current ASTM standards with this inherent characteristic and the technological advances introduced in the mid '80's and early 90's with the introduction of non-penetrating securement methods, cured EPDM membrane for flashing and the use of Butyl splicing cements and tapes. EPDM Ballasted assemblies make logical candidates for a roof alternative with economical advantages. In addition to the general guidelines, the following criteria can be used to further improve sustainability of ballasted assemblies:

1. Configure appropriate sheet sizes so all field seams are located in elevated areas where ponding is unlikely to occur.
2. Increase membrane thickness specified to a minimum of 60 mils to enhance the long-term membrane puncture resistance.
3. Incorporate interlocking rubber pavers minimum ½" thick in heavily traveled areas or use concrete pavers elevated on pedestals to prevent membrane grinding and improve paver freeze-thaw resistance.
4. Develop a comprehensive roof plan that includes roof slopes, deck flute direction and steel deck end lap locations. The drawing should also include locations of all field seams and roof penetrations. This document will become an effective navigation tool when tracing a roof leak, minimizing disturbance of large areas and reducing repair maintenance costs.

**Adhered EPDM Systems.** Adhered roofing assemblies are perceived as the most versatile, easy to maintain roofs. Their superior wind performance make them a logical choice in many geographic locations throughout the North American market. While these systems are exposed to the highest levels of UV and ozone, the inherent ozone resistance of EPDM caused these assemblies to increase in popularity as a sustainable

long-term performer. Their material long-term performance has been documented in the Trial (2003) study previously mentioned.

With the increased focus on sustainable designs, a roofing designer may take additional steps to ensure long-term performance beyond manufacturer's warranties.

1. Reduce thermal bridging by adhering the top layer of insulation to a mechanically fastened base layer.
2. Select underlayments known for their durability. Increase compressive strength on polyiso when used as an underlayment to nominal 25 psi.
3. Specify membrane with thicknesses greater than 60-mil (72 or 90-mil) to increase puncture and hail resistance.
4. In coastal areas or locations where high wind is a common occurrence, special underlayments with FM ratings of 1-150 or higher should be specified.
5. When possible, select adhesives with low VOC emissions and increase sheet sizes to reduce the number of field seams and in turn the amount of primers/tapes.

**Mechanically Attached EPDM Systems.** In addition to their lightweight, mechanically fastened assemblies are known for their economical advantages and quick installation. Since the mid 80's they have been preferred in many new and recover projects. Some of the early installations exhibited fastener back-out due to the low fastening density used and wind loading. Since that time, numerous improvements have been made and today's systems are far more able to withstand greater wind forces. Listed below are criteria by which sustainability in a mechanically fastened system can be secured.

1. Specify reinforced 60-mil and 72-mil membrane to increase fatigue and puncture resistance.
2. Specify an assembly meeting FM 1-90 or better.
3. Specify buttress thread design to enhance back-out resistance.
4. Consider the use of an air barrier on projects subject to excessive positive pressure.
5. Limit use of non-reinforced membrane to projects of low elevations and limited positive pressure (those with an air barrier or existing roof to remain).
6. An engineered system approach should be adopted when designing a large roofing facility to adjust sheet width and fastening density throughout the roof.

Closer to the perimeter, narrower sheets with a heavier fastening density will accommodate the higher wind loading in these areas. Wider membrane with lesser fastening density could be utilized in the field of the roof where wind loading is less severe.

**Special Considerations for Re-Roofing.** While performance and functionality should always be the determining factor in the replacement of an old roof, many roofs are replaced due to other factors (i.e., change in ownership, budgetary considerations, renovations and construction cycles or changes in building usage, etc.).

Removing all existing components was always a preferred approach, however, this practice has been re-examined over the past few years. A more sustainable approach has slowly emerged influencing the selection of a suitable alternative. There are key issues that must be examined when considering a sustainable approach in a reproofing project. Reusability, recycling and lower emission of VOCs (volatile organic compounds) are evaluated to determine balance between an environmentally friendly roof system and optimum performance. Key issues of sustainable considerations include:

1. Examine existing insulation for evidence of moisture to avoid total removal. Additional insulation can be added to comply or exceed local standards and enhance energy performance.
2. Evaluate conditions of the existing roof to determine its reusability as an air barrier.
3. Determine a suitable option for a low VOC assembly that can adequately function in the presence of an air barrier (i.e., utilization of a mechanically fastened system in lieu of an adhered assembly).
4. Re-use various components (i.e., edging, walkways, ballast if present) to reduce disposal.
5. Look for alternative ways to utilize roofing components. Suggest alternate ways to use components that may not be utilized as part of the new roofing assembly (i.e., ballast used as landscaping).
6. Remove old and unused equipment to reduce adhesive usage for unnecessary flashing and lessen the potential for future problems.
7. When feasible, consider attachment of the new roofing assembly to the existing roofing membrane after evaluating moisture content.

Restoration of existing EPDM roofs should always be evaluated prior to determining whether the existing roof is removed or recovered. Restoration could offer many economical and environmental advantages when considering today's technology.

**APPENDIX II:  
THE TENETS OF SUSTAINABLE ROOFING**

(CIB / RILEM Joint Committee on Roofing Materials and Systems – Environmental Task Group, October, 2000)

**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 can be reused or recycled.
6. Promote the use of “green roofs” supporting vegetation, especially on city center roofs.
7. Consider roof designs that ease the sorting and salvage of materials at the end of the life of the roof.

**CONSERVE ENERGY**

8. Optimize the real thermal performance, recognizing that thermal insulation can greatly reduce heating or cooling costs over the lifetime of a building.
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 the roof surface color and texture with regard to climate and the effect on energy and roof system performance.

**EXTEND ROOF LIFESPAN**

13. Employ designers, suppliers, contractors, tradespeople and facility managers who are adequately trained and have appropriate skills.
14. Adopt a responsible approach to design, recognizing the value of the robust and durable roof.
15. Recognize the importance of a properly supported structure.
16. Provide effective drainage to avoid ponding.
17. Minimize the number of penetrations through the roof.
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. Adopt preventative maintenance, with periodic inspections and timely repairs.