Rapidly Renewable Materials and LEED

By Tim Toburen and Will Spates

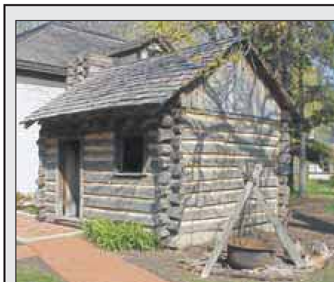
The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council, provides standards for environmentally sustainable construction. They are increasingly popular.

Recently, criticism of LEED has surfaced. Experts question whether evidence supports the claim that LEED-certified buildings use 25% to 30% less energy than similar non-LEED buildings. See "Is LEED Misleading? A Hard Look at 'Green Buildings'" in the September issue of *Connections*.

At the core of criticism is the structure of the LEED system. Buildings earn "points" for meeting LEED criteria on how they handle a wide variety of environmental issues. With enough points, the building qualifies as LEED Certified. Additional points may earn Silver, Gold or Platinum certifications. Most points are for design; for projected, not actual, results.

Buildings, however, are not agglomerations of design features—they are systems. A change in components affects performance of other components, often unpredictably. Point systems tend to incentivize designers to make changes to acquire a point, without necessarily working through how such a change may affect the building's performance.

Will Spates, one of the authors of this article, spent much of 2008 working through the LEED NC (New Construction) AP (Accredited Professional) track. He noticed ways in which actions taken to qualify for LEED points may interfere with the goals promoted by LEED. In this article, we limit the discussion to ways in which use of Rapidly Renewable Materi-



Reconstruction of typical early log cabin. Courtesy Arlington Heights Historical Museum.

Stick frame multi-story construction in Austin, TX. Note plywood (engineered wood) sheathing.

Visible building wrap and back of stucco after OSB disintegrated. Cause: low volume window leak. IET photo.

Rapidly renewable materials in use. Linoleum and bamboo flooring in IET's office.

als could potentially have negative impacts on Indoor Environmental Quality (a major LEED category).

The authors agree with the goals of the LEED program. Our concerns are regarding implementation of the program, in particular that it may encourage using materials that are not good choices for meeting those goals.

To illustrate these concerns, let's look back at the history of building materials in the United States.

"Greener" Building Materials and American History

Until recently, "green" just wasn't an issue. While American builders and manufacturers have a long history of shifting from materials that are more destructive to the environment (from today's environmental perspective) to those that are less destructive, this was for economic rather than environmental reasons. The results were the same.

Principles of green building have been applied by American builders and suppliers for well over a century:

- Use timber more efficiently. Less of the tree becomes waste.
- Replace logged forests with fast-growing trees, allowing a shorter harvest cycle and thus more lumber harvested in a given period. Another application of this principle involves building with methods using smaller sections of lumber, permitting younger trees to be harvested, shortening the regrowth cycle.
- Develop uses for by-products of the manufacturing process. Waste products are recycled into usable building materials (engineered wood products).

The most common building type in newly-settled areas was the log cabin. It used a lot of wood per cubic foot of space enclosed, but in an odd way it was a form of recycling. Trees were being cut down anyway to clear land. There was no market for most of the lumber. Trees not turned into housing would have been burned.

The log cabin was considered a rather low-status form of housing. As areas became prosperous, the inhabitants proclaimed it by building up-scale housing. These were generally multi-story homes of post-and-beam construction, with exterior walls of stone, brick or clapboard. These buildings were extremely durable, as many of them, built 200 to 300 years ago, are still around, often in excellent condition. They used less wood than log cabins, but massive posts and beams, often of hardwood, require large timbers and thus a long harvest cycle.

Starting about 1830, a uniquely American style of light construction developed, balloon frame or stick construction. Instead of large timbers connected with mortise and tenon joinery, stick frame walls used light frame members nailed together. Stiffness was provided by exterior wall sheathing.

Balloon framing often used less wood than older construction methods. More importantly from a green perspective, frame members could be cut from much smaller, more rapidly replaceable trees.

In the late 1800s and early 1900s, engineered wood products began to be available. These products break wood down into pieces, then reassemble it with adhesives into sheets, boards and other products. This allows more efficient use of resources, including waste from milling and wood from timber that does not produce usable dimensional lumber. Engineered wood leans green.

One of the first engineered wood products was plywood. The use of laminated wood sheets goes back thousands of years, but modern softwood plywood for construction purposes began to be produced around 1900. It gradually became dominant in exterior wall sheathing, roof decking, subfloors and other uses. Plywood is produced by peeling wide sheets from logs on a rotary lathe, then laminating the sheets together, alternating grain direction. Plywood is more consistently strong than dimensional lumber. It creates much less waste than cutting logs into lumber. It can be made from tree types unsuited for lumber.

By-products of the milling process, such as chips, sawdust and wood fibers, were turned into other engineered wood products: particle board, medium density fiberboard (MDF), waferboard, etc. They eventually gained acceptance for many furniture and interior construction uses. Paper and the many building materials made from it, including drywall, insulation facing, etc. are made from wood fibers.

Another green strategy used scarce, costly hardwoods as veneers over engineered wood products for flooring and furniture.

In the late 1970s, oriented strand board (OSB) began to replace plywood. OSB is greener than plywood, since strands rather than sheets of wood can be made into panels. It has replaced plywood for many structural applications.

Problems with engineered wood

Most problems with engineered wood products have been caused by moisture, in the form of both liquid water and water vapor (humidity). Engineered wood products generally absorbed moisture more rapidly than solid lumber and then quickly delaminated, disintegrated or lost structural integrity. They were more susceptible to mold growth and decay. The more thoroughly wood is broken down before reassembly, the more negatively it reacts to water. Particle board (sawdust) and paper-based products (wood fibers) are the least resistant, while plywood (sheets) is more resistant.

Manufacturers dealt with the moisture-sensitive nature of these products by specifying them for interior use only, assuming that interior materials would not become wet or be exposed to

*See **Materials,** page 32*

Materials, *from page 31*

excessive humidity for the life of the building. Indoor environmental professionals know this assumption is often overly optimistic.

Moisture resistance of engineered wood products often varies significantly with the type of wood used. For example, aspen plywood and OSB are much more susceptible to moisture and mold growth than the same products made from Douglas fir, even though they function identically if dry. This is related to the characteristics of these woods. Dead standing aspen trees quickly absorb water and decay. By contrast, dead fir trees may remain standing for decades.

Adhesives were the second major cause of problems. Early plywood used adhesives which were moisture-soluble, delaminating rapidly when wet. Some later adhesive types used in engineered wood products off-gassed formaldehyde, potentially creating elevated levels of this toxic gas in the building. Excessive humidity sometimes interacted chemically with adhesives to produce even higher levels of offgassing.

In the United States today, most plywood is made with adhesives that are waterproof and off-gas little formaldehyde. In the presence of moisture, modern plywood behaves much like solid lumber. Delamination is uncommon.

Most other engineered wood types continue to have serious problems when exposed to moisture. Particle board, for example, loses structural integrity almost instantly, then quickly begins to support mold growth.

OSB does not absorb moisture as quickly as plywood, but once moisture is absorbed it is released much more slowly. Small volume envelope leaks that might cause structurally insignificant damage to plywood sheathing may cause significant failure of OSB sheathing, especially in humid climates. The authors, based in Florida, have seen numerous sheathing installations where the OSB has completely disintegrated from minor window or envelope leaks, to the point that when drywall was removed we were looking directly at the back side of the building wrap or stucco. The OSB wasn't there anymore.

In fairness to OSB, when used appropriately it is an excellent product. Moisture intrusion causing this damage has usually been caused by the failure of other building components to perform properly.

LEED Rapidly Renewable Materials

Rapidly renewable materials qualifying for LEED points are from plants typically harvested within a ten-year or shorter cycle. Examples include bamboo, wool, cotton, agrifiber (wheat straw and other agricultural by-products), linoleum, strawboard and cork. These natural resources are extensively modified, usually by combining natural fibers with a wide variety of bonding materials, including adhesives of many types, cement and plastics. Characteristics of the end product vary widely with fiber types, how the fibers are processed, the bonding material used, and other factors.

Some of these products, such as linoleum and cork flooring, have been used in the United States for decades, although perhaps they've been out of fashion for a while. Their performance is well documented. Others, including many agrifiber products, are quite new, at least to the American market, and their performance under installed conditions is not fully known.

The history of engineered wood products has application to possible issues that may develop as new types of rapidly renewable materials come to market. Most are composites, usually composed of two basic components: natural fibers and a bonding material that holds the fibers together. Both components, as well as the methods by which the components are assembled, influence the characteristics of the final product.

- Characteristics of source materials are likely to have a significant effect on those of the end product, just as aspen plywood and OSB differ significantly from the same products made of Douglas fir. Agrifibers, such as wheat straw, decay quickly in the natural environment. When converted into building materials, they may retain some of these characteristics, which may cause problems in use.
- Apparently identical products made from slightly different materials may have quite different characteristics. Different species of bamboo, for instance, may potentially affect the performance of products made from then as much as different species of wood affect those of engineered wood products.
- The choice between particular adhesives or bonding materials may create products with considerably different and perhaps detrimental qualities, just as adhesives historically used in engineered wood products contributed to delamination or off-gassed of toxic chemicals.
- The same natural fibers and bonding materials processed in somewhat different ways may have quite different characteristics, as identical wood and adhesives processed into OSB and plywood are quite different in their moisture and microbial resistance.

Most critically, we think modern building practice, including the LEED program, pays far too little attention to the potential effects on materials of moisture and humidity levels likely to be present at some point during the life of the building. Most building interiors, especially those in humid climates, can be expected to suffer water damage from weather or plumbing leaks and/or be exposed to extended periods of elevated humidity. The use of materials that are unusually susceptible to moisture or microbial growth for interior purposes, on the theory that they will never be exposed to water or excessive humidity, is not a good building practice.

*See **Materials**, page 39*

Materials, *from page 32*

Durability must be considered in the evaluation process if the principles of sustainable construction are to be properly implemented.

Products made from non-traditional materials will not necessarily have problems of these types. Innovative companies will hopefully develop ways of using these resources that avoid the mistakes of the past.

Our recommendations to those specifying rapidly renewable materials for LEED certification purposes are:

- Use materials such as cork that are inherently moisture and mold resistant.
- Use materials such as linoleum with a good performance history. This gives the designer an idea of how the product will perform over time.
- Obtain as much information as possible from the manufacturer about the material's performance. Its moisture resistance rating should address not only how quickly it absorbs water from momentary contact, but also the effects of extended contact with water and elevated humidity. What are the effects on structural integrity? How easily or quickly does the material support microbial growth in damp environments? If such information is not available, it may be an indication that the product has not been tested for such easily anticipated problems.
- Most of the problems likely to develop with rapidly renewable materials, as with engineered wood products, will be moisture-related. Recently-developed technology allows more effective prevention of damage from moisture intrusion and humidity. For instance, wireless sensors are available that can be permanently installed inside walls in locations where moisture problems are likely and automatically alert building staff when moisture conditions exceed preset parameters. Some can automatically turn off water pressure to areas when there is a possible leak. Reasonably priced moisture/humidity sensors built into materials may soon be available, perhaps using RFID technology.
- The owner's manual for a home or commercial building should stress preventing moisture intrusion and excessive humidity, as well as provide tools and resources for doing so.

We believe the LEED program should pay much more attention to moisture intrusion and humidity control than it has to date. In most areas these issues are by far the most common reasons for deterioration of the building and its environmental quality. Buildings in which materials must be removed and replaced prematurely are hardly examples of sustainable construction.

With forethought, we can avoid with rapidly renewable materials some of the problems caused by engineered wood products. Getting too caught up in the enthusiasm of a popular movement does not help in thinking through how these products are likely to interact with the indoor environment over time. In particular, moisture and humidity control and their potential effects on material durability and the building's environmental quality should be considered in building design and maintenance if a building is to be truly green.

Note: For those interested in pursuing this subject in more detail, we have posted links on our website to sources of the information used in compiling this article. See www.ietbuildinghealth.com

Timothy D. Toburen is an Indoor Environmental Consultant for Indoor Environmental Technologies, based in Clearwater, Florida. He has worked in the restoration, remediation and environmental consulting industries for over 35 years, serving on the committees that produced both the IICRC S520-2003 Mold Remediation and S500-2006 Water Damage Restoration standards. He can be reached by e-mail at ttoburen@ietbuildinghealth.com or by phone at (727) 446-7717.

Will Spates is President of Indoor Environmental Technologies, based in Clearwater, Florida. He has over 20 years of experience in the environmental consulting industry. He can be reached by e-mail at wspates@ietbuildinghealth.com or by phone at (727) 446-7717.

INDEX TO ADVERTISERS