Chapter 6: **Materials**

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Chapter 6

Materials

"Then I say the Earth belongs to each generation. During its course, fully and in its own right, no generation can contract debts greater than may be paid during the course of its own existence."

– Thomas Jefferson, 1789

Material Selection

The use of durable, attractive, and environmentally responsible building materials is a key element of any high-performance building effort. The use of natural and healthy materials contributes to the well-being of the occupants and to a feeling of connection with the bounty of the natural world.

Many construction materials have significant environmental impacts from pollutant releases, habitat destruction, and depletion of natural resources. This can occur during extraction and acquisition of raw materials, production and manufacturing processes, and transportation. In addition, some construction materials can harm human health by exposing workers and building occupants to toxic and hazardous substances. As a result, identification and selection of environmentally preferable materials for use in construction activities at LANL provide an opportunity to limit such environmental and human health impacts.

Selecting environmentally attractive materials with reduced environmental impacts is primarily achieved through the practice of resource conservation and selection of non-toxic materials. The resources used to manufacture construction materials affect the environment by depleting natural resources, using energy, and releasing pollutants to the land, water, and

Robb Williamson

Unfinished pressed fiberboard and the lack of interior finishes and fixtures reduce resource use and indoor air pollutants in the Chesapeake Bay Foundation's Phillip Merrill Environmental Center in Annapolis, Maryland.

atmosphere. Materials that contain irritating, odorous, hazardous, or toxic components adversely affect human health through out-gassing of volatile components or direct contact.

Ideally, materials choices would be made based on a rigorous assessment of environmental burdens throughout the entire of the product or material. This practice, known as *environmental life cycle assessment,* is rarely feasible for most building procurement decisions. It is possible, however, to use *life cycle thinking* to compare what is known about the environmental performance of products and make informed choices. Materials that

Craig Miller, DOE

Engineered wood products conserve wood and generate less waste.

Sample Characteristics of Environmentally Preferable (EP) Materials

Category	*Characteristic*
Material Cost	Relative cost to equivalent products that do not possess sustainable characteristics.
Life Cycle Cost Impact (LCI)	Relative impact on life cycle cost of building operations (not to be confused with environmental life cycle assessment, which measures environmental burdens, not financial impact).
Energy Efficiency (EE)	Construction materials that directly influence building energy use.
Water Efficiency (WE)	Construction materials that directly influence building water use.
Locally Manufactured (LM)	Construction materials that are manufactured within a defined radius (500 miles for the LEED Rating System) of Los Alamos, New Mexico. LANL strongly encourages the use of construction materials manufactured in northern New Mexico.
Material Reduction (MR)	Products or materials that serve a defined function using less material than is typically used.
Locally Derived Raw Materials (LRM)	Construction materials that are locally manufactured using raw materials obtained within a defined radius of Los Alamos, New Mexico. LANL strongly encourages the use of construction materials manufactured using raw materials derived from northern New Mexico.
Non-Toxic (NT)	Construction materials that release relatively low levels of emissions of odorous, irritating, toxic, or hazardous substances. Volatile organic compounds (VOCs), formaldehydes, and particulates and fibers are examples of substances emitted from construction materials that can adversely impact human health (allergens, carcinogens, irritants).
Recycled Content (RC)	Amount of reprocessed material contained within a construction product that originated from post-consumer use and/or post-industrial processes that would otherwise have been disposed of in a landfill.
Salvaged (S)	Construction materials that are reused as-is (or with minor refurbishing) without having undergone any type of reprocessing to change the intended use. This includes the reuse of existing building structures, equipment, and furnishings at LANL.
Rapidly Renewable (RR)	Construction materials that replenish themselves faster (within 10 years) than traditional extraction demand; and do not result in adverse environmental impacts.
Certified Wood (CW)	Construction materials manufactured all or in part from wood that has been certified to the standards of the Forest Stewardship Council as originating from a well-managed forest.

have a reduced environmental impact are known as environmentally preferable (EP) materials.

Environmentally preferable building materials have a reduced adverse effect on human health and the environment when compared with competing products for the same application. The selection of EP construction materials should always be based on functional performance, environmental performance, and economic costs. First costs and life cycle costs for building materials must be taken into consideration to ensure a balance between functional and environmental performance.

"We shall require a substantially new manner of thinking if mankind is to survive."

– Albert Einstein

Sustainable Design Evaluations for Materials and Resources

Material	Material cost	Life cycle cost impact	Energy efficiency	Water efficiency	Material reduction	Locally manufactured	Locally derived raw materials	Non-toxic	Recycled content	Rapidly renewable	Certified wood	Salvaged
Ceiling tiles	= +	–							●			
Carpet	=	=			●			●	●			
Fabrics (wall/furniture)	= +	= –						●	●			
Resilient flooring	= +	= –						●	●	●		
Interior/exterior paints	=	=						●	●			
Sealants and adhesives	=	=						●				
Steel	=	=			●				●			
Cement/concrete	=	=	●		●	●	●		●			
Insulation	=	–	●			●	○	●	●			
Bathroom partitions	=	=							●			
Wood products	= +	=			●			●		●	●	
Gypsum wallboard	=	=				●	●		●			●
Furniture	= +	=							●	●	●	
Brick/CMU	=	=				●	●					
Roofing	=	=	●						●			
Windows	+	–	●									
Doors	= +	–	●						●		●	
Ceramic tile	=	=						●		●	●	○
Insulating concrete forms	+	–	●						●			
Structural insulated panels	+	–	●						●			
Aerated autoclave concrete	+	–							●			
Exterior finishes						●	○					
Permeable paving	+	–		●					●			

○ Potentially applicable Material & Resource issue, research ongoing
● Applicable Material & Resource issue
(=) Equivalent, (–) Generally less expensive, or (+) Generally more expensive

Environmentally preferable construction materials may possess any one or more of the characteristics described previously, and they may possess these characteristics in varying degrees. A product may contain more or less recycled content, for example, or be better or worse in terms of indoor air emissions. The more EP characteristics a construction material possesses, and the greater the degree to which it possesses them, the better. Materials can also have environmental drawbacks, and these must be weighed against the EP characteristics when making a selection. Finally, the performance of a product must be assessed not only in the abstract, but also in the context of the specific application in the building.

The following internet Web sites identify manufacturers that offer products meeting one or more EP criteria for each material type:

- *www.epa.gov/cpg/database.htm*
- *www.epa.gov/nrgystar/purchasing/2d_products.html*
- *www.oikos.com*

This map shows cities within a 500-mile radius of Los Alamos, the recommended maximum distance for material transportation.

Recycled-Content Products

Under the Resource Conservation and Recovery Act (RCRA), EPA established the Affirmative Procurement (AP) Program to promote procurement of products with recycled content. Executive Order 13101 was issued to improve federal use of recycled content products and environmentally preferable products and services. EPA's Comprehensive Procurement Guidelines (CPG) identifies such products along with minimum recycled content requirements for federal agency procurement. Fifty-one such items are currently designated as EPA CPG compliant items with new products and categories added each year. The product categories currently include:

- Paper and Paper Products, including sanitary tissue, printing and writing paper, newsprint, paperboard and packaging, and paper office supplies (e.g., file folders, hanging files).
- Non-Paper Office Products, including binders, recycling and trash containers, plastic desktop accessories, plastic envelopes, trash bags, printer ribbons and toner cartridges, report covers, plastic file folders, and plastic clipboards.
- Construction Products, including insulation, carpet, cement and concrete, latex paint, floor tiles, patio blocks, shower and restroom dividers, structural fiberboard, and laminated paperboard.
- Transportation Products, including channelizers, delineators, parking stops, barricades, and cones.
- Landscaping Products, including garden and soaker hoses, mulch, edging, and compost.
- Miscellaneous Products, including pallets, mats, awards, and plaques.

Sustainable Building Materials

Ceiling Tile

Ceiling tiles are manufactured from a variety of different materials, including mineral fibers (mineral wool and cellulose fiber), fiberglass, gypsum, and polystyrene. Ceiling tiles are available with recycled content up to 95 percent. Slag wool from the steel industry, newspaper, glass, and sugar cane fiber are examples of recovered materials used in the manufacture of ceiling tiles. Ceiling tiles are also recyclable when replaced or discarded. Most major ceiling tile manufacturers have become environmentally conscious and resource-efficient through raw materials acquisition, manufacturing plant operations, and waste management.

Light reflectance is also an important part of a ceiling. The light reflectance (LR) characteristic of ceiling tiles enhances the efficiency of indirect lighting, which can reduce light requirements and energy costs. Highly reflective ceiling tiles have an LR of 0.85 or greater and should be specified with indirect, high-efficiency lighting, and can be incorporated as part of a daylighting strategy.

Recycled-content ceiling tiles are readily available at no increased cost. Additional first costs are incurred for high-LR ceiling tiles. However, the life cycle costs are lower when considering the operating cost savings associated with reduced lighting requirements for an indirect, high-efficiency lighting system.

Carpet

Nylon and polyester are common carpet fabrics. Such carpets have been identified under the CPG program to be available with recycled content of up to 100 percent for polyester and nylon carpet face fiber and up to 70 percent for nylon carpet backing. Carpet backing, such as vinyl, is also available with recycled content up to 100 percent. Reconditioned carpets are considered to be 100 percent recycled content. In addition, carpet cushion is available with recycled content ranging from 15 to 50 percent for bonded polyurethane, 40 percent for jute, 100 percent for synthetic fibers, and 60 to 90 percent for rubber. Some carpet manufacturers have buyback programs for used carpet. Most major carpet

LANL

LANL new construction uses a variety of regionally available building materials.

Recycled Content for Carpet

Carpet Components		*Recycled Content*
Carpet Face Fiber	Polyester	Up to 70%
	Nylon	Up to 100%
Carpet Backing	Vinyl	Up to 100%
	Nylon	Up to 70%
Carpet Cushion	Bonded Polyurethane	Up to 50%
	Jute	Up to 40%
	Synthetic Fibers	Up to 100%
	Rubber	Up to 90%

manufacturers are increasingly environmentally conscious regarding raw materials acquisition, operation of manufacturing plants, and waste management.

Carpet can be a detriment to indoor air quality. Once installed, carpets can trap pollutants from the air and from people's shoes, and they can be difficult to clean thoroughly. If they get wet, carpets with accumulated dirt can become a breeding grounds for mold. In addition, VOCs are released from the carpet, cushion, and adhesives, especially in the period immediately following installation. The Carpet and Rug Institute (CRI) has an indoor air quality (IAQ) test program that limits VOC emissions from carpet products. Carpet installed at LANL facilities should comply with the CRI IAQ test program.

Recycled content carpet complying with the CRI IAQ test program is readily available at no added cost.

Volatile Organic Compound (VOC)

Carpet Components	*VOC Limits*
Carpet	< 0.5 mg/m²/hr
Cushion	< 1.0 mg/m²/hr
Adhesive	< 10.0 mg/m²/hr

Fabrics (Wall/Furniture)

Fabric materials are common components of furniture (including partitions) and sound absorbing products. Major manufacturers of these products have recycled content fabric options available. IAQ issues associated with emissions from such fabric materials as well as installation requirements (such as use of adhesives) should be considered. Materials specifiers must always consider manufacturing location and transportation requirements. Cost for recycled content fabrics can vary, but in most cases will not impact cost.

C&A Floor Coverings

LANL specs recommend recycled-content carpeting.

LANL, including construction contractors for LANL, are required to purchase products with recycled content, as long as recycled content versions of the products meet the applicable performance specifications, are available at a competitive price, and are available within a timeframe that doesn't delay schedules. Descriptions of CPG products and recycled content requirements are available at ***www.epa.gov/epaoswer/non-hw/procure/index.htm.***

Resilient Flooring (Linoleum, Cork, Bamboo)

Common types of resilient flooring materials include vinyl composition tile (VCT), vinyl (PVC) tile and sheet, rubber tile and sheet, linoleum tile and sheet, and cork tile and planks. The CPG program requires 90 to 100 percent recycled content for rubber flooring. Vinyl and PVC plastic can be recycled for use in the manufacturing of vinyl flooring. Similarly, recycled rubber and tires can be used to manufacture rubber flooring. Natural linoleum is made from cork, linseed oil, wood flour, and pine rosin. Cork used in linoleum and cork tile/planks is sustainably harvested from the bark of cork oak.

Similar to carpet floor coverings, IAQ is a sustainability issue for resilient flooring. Emissions associated with the flooring material selected as well as the adhesives used for installation are potential contributors to poor IAQ. Low or no-VOC adhesives should be used for all resilient flooring installation. Vinyl-based resilient flooring (VCT and PVC) should generally be avoided due to the use of hazardous and toxic substances in the production process. Off-gassing from rubber flooring as well as odors from linseed oil in linoleum may cause problems for chemically sensitive people. Light reflectance is another IAQ issue that should be considered when selecting resilient flooring to ensure adequate performance as part of the lighting (and daylighting) design efforts.

While recycled-content resilient flooring is readily available, cost varies widely depending on the resilient flooring material selected. Consider maintenance issues when selecting resilient flooring materials. Those requiring frequent maintenance or harsh chemicals for cleaning, waxing, and stripping should be avoided. The majority of cork and linoleum flooring is produced in Europe, resulting in significant transportation impacts.

Forbo Industries

Natural linoleum is a low-VOC flooring.

Robb Williamson

Bamboo is a rapidly renewable substitute for hardwood.

Interior/Exterior Paints

Latex paints are available with recycled content. Reprocessed latex paints in white, off-white, and pastel colors are available with up to 20 percent recycled content. Reprocessed latex paints in gray, brown, earth tones, and other dark colors are available with up to 99 percent recycled content. Consolidated latex paint (no color designation) composed of 100 percent recycled content is available for use as an undercoat or for exterior applications where color is not of concern.

Paint is a potential contributor to poor IAQ. Regardless of the types of paints used, VOC emissions from paints should be minimized. Green Seal (GS), an independent nonprofit organization that certifies products following the ISO 14024 environmental labeling standards, has developed a standard (GS-11: Paints) to limit VOC emissions and prohibit the use of specific toxic chemicals in paints. Interior and exterior paints used at LANL should comply with the GS standard. Although not all paints meet the GS standard, all major paint manufacturers produce GS-compliant paints (though very few of them are certified by Green Seal).

PPG Architectural Finishes, Inc

Low and zero-VOC paints protect indoor air quality.

VOC Limits for Paint

Paint Applications		*VOC Content Limit** *(grams of VOC per liter)*
Interior Coatings (GS-11)	Flat	< 150
	Non-Flat	< 50
Exterior Coatings (GS-11)	Flat	< 200
	Non-Flat	< 100
Anti-Corrosive (GS-03)	Gloss	< 250
	Semi-Gloss	< 250
	Flat	< 250

Source: California South Coast Air Quality District

*Excluding water and tinting added at the point of sale.

There is little or no cost increase associated with GS-compliant paints. Although recycled-content paints are available, inventories vary with the quantities being recycled. Recycled paints are typically less expensive than new "virgin" paints.

Sealants and Adhesives

IAQ considerations are the most important sustainability characteristics associated with sealants and adhesives. These products can contain toxic chemicals that are released during construction as well as during building occupancy. Due to air quality laws enacted in the state of California, all major sealant and adhesive manufacturers now offer products that limit VOC emissions and prohibit the use of specific toxic chemicals. Green Seal has also developed a standard (GS-36: Commercial Adhesives) to limit VOC emissions and prohibit the use of specific toxic chemicals. California- and/or GS-compliant adhesives should be required for construction at LANL.

No-VOC and low-VOC sealants and adhesives are readily available and are becoming the industry standard. As a result, such non-emitting or low-emitting sealants and adhesives can be used at no additional cost.

VOC Limits for Sealants

Sealant Applications	*VOC Content Limit** *(grams of VOC per liter)*
Architectural	250
Roadways	250
Single-Ply Roof Material Installation/Repair	450
Non-Membrane Roof Installation/Repair	300
Other	420
Sealant Primer Applications	***VOC Content Limit**** *(grams of VOC per liter)*
Architectural – Nonporous	250
Architectural – Porous	775
Other	750

Source: California Bay Area Air Quality Management District

*Water; acetone; parachlorobenzotrifluoride (PCBTF); cyclic, branched or linear, fully methylated siloznes (VMS); and difluoroethane (HFC-152a) are not considered part of the product.

VOC Limits for Adhesives

Adhesive Applications	*VOC Content Limit** (grams of VOC per liter)
Architectural	
Indoor carpet	50
Carpet pad	50
Outdoor carpet	150
Wood flooring	100
Rubber flooring	60
Subfloor	50
Ceramic tile	65
VCT and asphalt tile	50
Dry wall and panel	50
Cove base	50
Multipurpose construction	70
Structural glazing	100
Single-ply roof membrane	250
Specialty	
PVC welding	285
CPVC welding	270
ABS welding	400
Plastic cement welding	250
Adhesive primer for plastic	250
Contact adhesive	80
Special purpose contact adhesive	250
Adhesive for traffic marking tape	150
Structural wood member adhesive	140
Sheet-applied rubber lining operations	850
Substrate-Specific	
Metal to metal	30
Plastic foams	50
Porous material (except wood)	50
Wood	30
Fiberglass	80

*Water; acetone; parachlorobenzotrifluoride (PCBTF); cyclic, branched or linear, fully methylated siloznes (VMS); and difluoroethane (HFC-152a) are not considered part of the product.

Steel

All steel manufactured in the United States contains recycled content. Recycled content varies based on the type of furnace used for processing. Steel from a Basic Oxygen Furnace (BOF) contains approximately 30 percent recycled content on average. Steel from an Electric Arc Furnace (EAF) contains nearly 100 percent recycled content. Structural shapes (such as I-beams) are typically manufactured using the EAF, while historically, other steel products such as plates, sheets, and tubing components have been manufactured using the BOF. As EAF plants get more sophisticated, however, more and more profiles are available from those facilities. Although local manufacturers of structural steel may be difficult to identify, local fabricators of structural steel are readily available.

Pennsylvania Department of Environmental Protection

The headquarters of the Pennsylvania Department of Environmental Protection was constructed from sustainable resources, such as wheatstraw, cork, recycled glass, and steel.

Structures should be designed to use the least amount of steel adequate to do the job. At a minimum, steel surfaces generally require a protective primer coat to prevent rust and corrosion. Depending on the visibility of the particular material, paint may also be applied. Such coatings have potential to degrade air quality by emitting toxic VOCs. No- or low-VOC paints and primers should be applied to steel surfaces when such coatings are required. In addition, application of paints and primers at the manufacturing facility is always preferable due to better process emission controls.

No additional costs are associated with recycled-content steel products due to the inherent recycling in all U.S. steel manufacturing processes. Although some products manufactured using foreign steel may actually be less expensive, the recycled content in foreign steel may be unknown. Foreign steel products are not recommended due to the environmental cost associated with energy and natural resources expended for transportation.

Cement/Concrete

The manufacturing of cement has significant environmental impacts, including energy consumption, natural resource depletion, and greenhouse-gas emissions. The manufacturing of cement is the most significant contributor to these emissions. The amount of cement used in concrete can be reduced by replacing a portion of the cement with coal fly ash and/or ground granulated blast furnace (GGBF) slag. The level of fly ash in concrete typically ranges from 15 to 35 percent of total cementitious material, but can reach 70 percent for use in massive walls, girders, road bases, and dams. The level of GGBF slag usually ranges from 25 to 50 percent. The amount of fly ash and/or GGBF slag used in cement or concrete constitutes the recycled content. Cement and concrete containing such additives should be readily available at no increased cost. An additional EP feature of concrete is its potential to contribute to energy efficiency by providing thermal mass to a building envelope that slows heat transfer. Fly ash often contains elevated concentrations of natural radioisotopes. Radioanalytic laboratories should evaluate the potential impact of the residual radioactivity.

Sheila Hayter

Coal fly ash is a byproduct of coal burning at electric utility plants, while slag is a byproduct of iron blast furnaces. Both can replace cement in concrete. The walls of this building are constructed with concrete made from coal fly ash and insulated with an Exterior Insulating Finishing System (EIFS). The additional thermal mass provided by the insulated concrete walls combined with the other passive solar design features reduce the annual energy costs by more than 60%.

Insulation

Insulation is a critical component of an energy-efficient building. Energy (or thermal) performance associated with insulation is based on the thickness needed to achieve a specified or desired thermal resistance (such as R-19 walls and R-30 roof). In addition to the energy (or thermal) characteristics of insulation, recycled content and toxicity (to both human health and the environment) of insulation must be considered. Although some manufacturers now offer formaldehyde-free fiberglass insulation, phenol formaldehyde is widely used to bond the fibers in fiberglass batts. In addition to formaldehyde concerns, airborne fiberglass particulates are considered an inhalation irritant. Such fibers can become airborne when installing insulation, and if allowed to enter the HVAC system can be distributed throughout a building. However, insulation manufacturers can control the release of particulate fibers by encapsulating the batts in a thin plastic film.

The optimal amount of insulation in the building envelope should be determined based on computer models of the building's overall thermal performance (see Chapter 5). Insulation containing recycled-content material is readily available from all major insulation manufacturers at no increased cost. Formaldehyde-free fiberglass insulation, however, is relatively new, and not universally available.

Bob Hendron

CPG-Required Recycled Content Levels for Building Insulation

Insulation Type	*Recycled Content*
Rock Wool	At least 75%
Fiberglass	At least 25%
Cellulose	At least 75%
Plastic Rigid Foam (polyisocyanurate and polyurethane)	At least 10%

Bathroom Partitions

Restroom and shower partitions/dividers are constructed primarily of steel or plastic, although partitions/dividers can also be made of wood or marble. Such partitions/dividers are available with recycled contents ranging from 20 to 100 percent for plastic and from 30 to 100 percent for steel. Steel partitions/dividers are typically painted to prevent rust or corrosion. Factory-applied paint should always be required to minimize VOC emissions following installation.

No cost increase is incurred by using restroom and shower partitions/dividers constructed of recycled-content plastic or steel when compared to non-recycled-content plastic and steel. It should be noted that recycled-content steel does not include stainless steel. Partitions/dividers constructed of stainless steel, or marble, are significantly more expensive than painted steel or plastic.

Wood Products

Wood is a versatile construction material that can be used for both structural and non-structural applications. However, due to degradation from exposure to sun and weather and the corresponding maintenance required, wood is not recommended for exterior surface finishes.

Wood may be salvaged, certified, and low in toxicity. Wood products are often composed of wood composites, fibers, or chips. Particleboard and medium-density fiberboard are often made using shavings from milling operations, but these are not considered a "recycled" material as they have not historically been landfilled. Wood chips or particles that are adhered together using a bonding resin may emit toxic substances, most notably formaldehydes. Wood finishes such as paints, stains, and varnishes are also potential sources of toxic emissions. However, non-toxic finishes such as water-based paints and stains, as well as curing processes that accelerate the emission of any volatile toxins, are readily available.

The cost of wood construction materials can vary depending on market demand and availability. Wood products (or components) that are certified as originating from sustainably managed forests will generally add to initial costs. To ensure Forest-Stewardship-Council-compliant certification, the invoices from the supplier must include a chain-of-custody certificate number. The availability of salvaged wood is dependent on supply and generally adds to up-front cost. Many wood product manufacturers are replacing formaldehyde-based bonding resins with non-toxic substitutes. Cost impacts for such non-formaldehyde wood products can vary.

Robb Williamson

The Chesapeake Bay Foundation's Phillip Merill Environmental Center in Annapolis, Maryland, made plentiful use of salvaged and recycled-content wood.

Gypsum Wallboard

Drywall is generally composed of 92 percent gypsum and 7 percent paper, with the remaining 1 percent being a combination of impurities in the gypsum rock and additives. The primary component of drywall, gypsum, can be obtained from natural resources or synthetically produced from byproducts of power plant operations. The synthetic gypsum represents a 100-percent post-industrial recycled-content product. Gypsum wallboard composed of synthetic gypsum and recycled-content paper facing and backing is available at no cost increase; however, synthetic gypsum wallboard is not currently manufactured within 500 miles of Los Alamos.

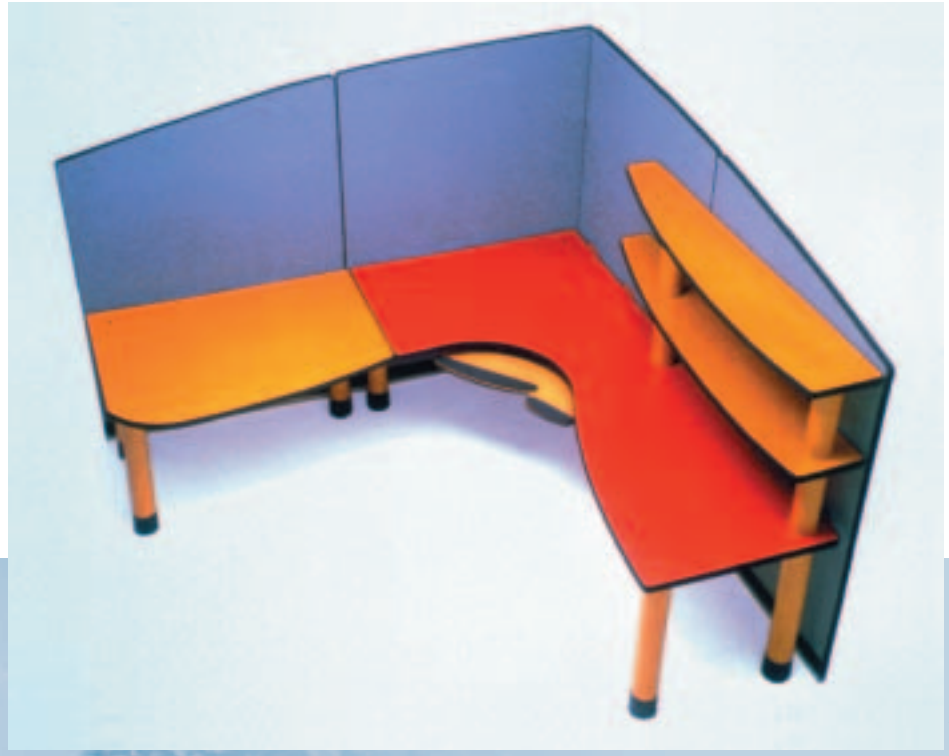
We are 'doomed to achieve sustainability' one way or another, at some level of comfort or discomfort, by choice or by nature's decisive hand.

– *Alan Atkisson, author of* Believing Cassandra

Furniture

Furniture is typically constructed using a combination of different materials (steel, wood, plastic, adhesives, fabric, etc.), and offers many sustainability opportunities. Recycled-content materials can be used for a variety of furniture components. Wood components in furniture can be derived from rapidly renewable or sustainably certified sources. Furniture is also available as a salvaged material that is refurbished for reuse. An important EP characteristic of furniture involves VOC emissions. The potential for emissions from furniture can result from fabric material, adhesives, finishes on wood and metal components, and formaldehyde in wood components.

Furniture costs are highly variable depending on style, ergonomic characteristics, functional requirements, and other optional features that may be required. The impact of EP characteristics on furniture costs is also variable.



Studio eg

Ecowork office furniture is made from 98% recycled materials.

Brick/Concrete Masonry Units (CMU)

Brick provides thermal mass that adds to energy efficiency by slowing heat transfer through the wall. Brick is also very durable, requiring essentially no maintenance because it never needs to be painted and never rots, fades, warps, burns, dents, tears, or becomes brittle. Salvaged brick may be available depending on local vendor supplies. New brick can be matched to salvaged brick as necessary. Although brick containing recycled content has not been identified, locally manufactured brick is available.

Brick wall construction is generally less expensive (both first cost and life cycle cost) than pre-cast concrete panel, metal panel, and exterior insulation finish system walls. Salvaged brick can actually cost more than new brick due to the labor required to refurbish used brick for resale. CMUs or concrete block are less expensive than brick and may be available with recycled content. CMUs with finished faces can provide both the structure and either the interior or exterior surface of a wall, thereby replacing whole layers of additional material. For energy efficiency and comfort, it is best to locate the CMU on the inside and insulation on the outside of the wall (e.g., CMU with an exterior finish insulating system [EFIS], see p. 141).

Roofing

Dark, non-reflective roofing surfaces create heat island effects by absorbing energy from the sun and radiating it as heat. This "black body" effect causes ambient temperatures to rise, which increases cooling requirements in the summer, requires larger HVAC equipment, and increases building energy consumption. A roof system with light colors can reflect heat instead of absorbing it, reducing HVAC equipment and energy use. The U.S. Environmental Protection Agency's ENERGY STAR program has established solar reflectance and thermal emissivity requirements for roofs. Product manufacturers must comply with these requirements to

LANL

CMU construction for the LANL Emergency Operations Center provides a durable exterior wall. A second CMU interior wall provides mass to improve interior thermal comfort.

LANL

ENERGY STAR-compliant roof materials include metal and are applicable to both low-slope and steep-slope roof configurations.

receive an ENERGY STAR label. ENERGY STAR-compliant roof systems are required for all new LANL facilities as part of the overall energy-efficiency strategy for the project.

Depending on the roofing system selected, there is potential for roofing materials to contain recycled content and low-emitting materials. ENERGY STAR-compliant roof construction does not increase building cost. The roofing materials required to comply with ENERGY STAR provisions are becoming standard in the industry.

Windows

Windows are a critical component for an energy-efficient building. Not only do windows affect the thermal performance of a building (in the same manner as insulation), they provide natural daylight, reducing the electric lighting requirements of a building.

High-performance windows should be considered for all new LANL facilities as part of the overall energy-efficiency strategy for the project. See Chapter 4 for details on optimizing the energy performance of windows and glazing systems. Select frame materials that have recycled content, are durable, and are compatible with the LANL climate and weather characteristics (to conserve resources and reduce maintenance). High-performance windows used for LANL facilities should be constructed at a local window fabricator that uses insulating glass units from a major glass manufacturer. High-performance windows cost more than standard windows. However, reduced lighting requirements and superior thermal efficiency can recover any cost increase in a relatively short period of time. In addition, high-performance windows lead to improved occupant comfort

Ecologically conscious design is less about what the individual knows or thinks he knows, and more about approaching the design with a totally new consciousness and the willingness to rely on the collaborative energy of all of the participants.

– Bob Berkebile, Founding Chair, AIA's Committee on the Environment

Robb Williamson

High-performance windows increase thermal resistance, reduce solar heat gain (for internal-load-dominated buildings), and provide daylighting.

Doors

Exterior doors (and frames) should be constructed of recycled-content steel and contain insulating core material that does not contribute to ozone depletion. Rigid foam plastics and fiberglass are typically used as insulating cores. In the case of foam plastics, expanded polystyrene (EPS) is preferable to extruded polystyrene and polyurethane. Fiberglass core materials should also contain recycled content. Finishes on steel doors should be applied at the factory (where process emission controls are in place) and consist of a no- or low-VOC paint that is cured (or baked) to eliminate VOC emissions after installation. Weather-stripping along the top, jambs, and bottom sweeps will minimize air infiltration around exterior doors.

Interior doors do not separate conditioned space from unconditioned space and do not require good thermal performance characteristics. Interior doors are typically constructed of wood products (veneers, core materials, rails, and styles) and synthetic wood products (plastics). Steel frames are also commonly used for interior doors for durability and reduced maintenance. Interior doors provide an opportunity for using recycled-content material (plastics and steel) and certified wood (as applicable), and in some cases salvaged materials (complete doors or components). Urea formaldehyde is a commonly used binding agent in wood door construction that should be avoided in favor of significantly less volatile binders such as phenol formaldehyde. Factory-applied finishing is preferred to site-applied finishing based on control of VOC emissions.

The costs for EP interior and exterior doors may be higher than for conventional doors. However, such cost increases are dependent on the sustainable features specified. For example, no- and low-VOC finishing techniques are readily available for both wood and steel at no additional cost; however, certified wood components will generally increase cost. Non-ozone-depleting insulation material such as expanded polystyrene does not increase cost relative to other door insulation materials; although highly insulated doors (low-temperature applications) cost more than non-insulated or marginally insulated doors (moderate-temperature applications). Additional first costs are generally offset by reduced operating costs.

U.S. Forest Service

Select certified wood or salvaged doors when using wood doors.

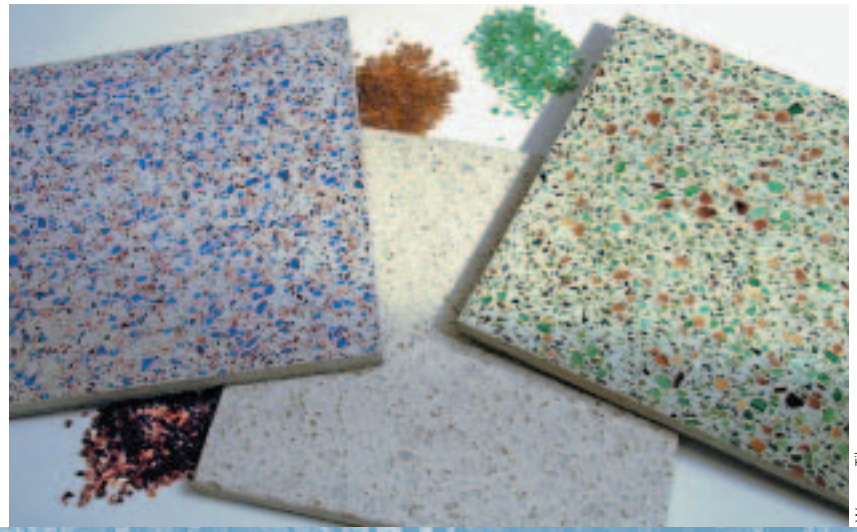
Ceramic Tile

Ceramic tile is durable and low-maintenance. Up to 100 percent recycled content is available in ceramic tile. Glass and feldspar mine wastes are the primary materials of the recycled content. Reuse of salvaged ceramic tile may also be an option. Although ceramic tile is an inert material, to prevent adverse air quality impacts, the adhesives used for tile placement should be non-toxic and/or non-VOC-emitting. Tile cost varies depending on the characteristics and features selected. No additional cost results from recycled-content material or non-toxic adhesives.

Insulating Concrete Forms (ICF)

The thermal efficiency of ICF construction is attributable to the insulation properties of the form material, temperature stability from the thermal mass of concrete, and reduced air infiltration. ICF walls can have thermal resistance (or R-value) of approximately R-15. Both the insulation material of the forms and the concrete used in ICF construction could contain recycled-content material, as noted previously in the discussions on insulation and cement/concrete materials. The potential for toxic emissions from ICF walls is low based on the materials used for construction. Expanded polystyrene is the most common insulation material used in ICF construction, and along with concrete, these materials generally have no emissions.

The relative cost for ICF construction is nearly equivalent to poured concrete or concrete block construction. ICF construction is marginally more expensive when compared to wood or steel-frame construction. However, the energy savings resulting from ICF construction may result in a lower overall life cycle cost compared to conventional wall construction techniques.



Wausau Tile

These terrazzo tiles, 60 percent recycled glass by weight, are stronger and more water-resistant than most stone-based terrazzo tile.

Craig Miller, DOE

ICF construction provides superior energy efficiency (high R-value, low air infiltration, and high thermal mass), and is strong and durable.

Structural Insulated Panels (SIP)

Facing materials in SIP construction are commonly drywall and structural wood sheathing (such as plywood and oriented strand board). These facing materials could contain certified wood, although no SIP manufacturers offer certified wood facings as a standard product. Similar to ICFs, the foam insulation used as core center should be EPS (which is most commonly used) to eliminate potential contributions to ozone depletion. Structural wood sheathing and adhesives used in the construction of SIPs have the potential to release toxic emissions, such as formaldehyde and VOCs.

The cost for SIP construction is equivalent to poured concrete or concrete block, and marginally higher than conventional frame and insulation package construction. However, life cycle considerations indicate reduced overall costs due to the substantially increased energy efficiency over conventional construction techniques.

Michael Bacchler

SIPs can be faced with wood sheathing made from certified wood.

Aerated Autoclave Concrete (AAC)

AAC is considered a highly sustainable building material. Features of AAC include low energy and raw material consumption during manufacturing, good thermal performance, structural-use capabilities, non-toxicity, and durability. AAC can be used as an insulating and structural material, reducing the overall construction materials needed. AAC is considered to be fairly friable and must be protected from weather by an exterior finish or coating. Any number of interior finishes can cover the interior surface. AAC was incorporated throughout the Metropolis Center (MC) facility recently completed at LANL.

The first cost for AAC construction is marginally higher compared to conventional concrete construction techniques. However, the use of AAC in place of structural steel at the MC facility resulted in savings of approximately $2.5 million. life cycle energy savings may also offset initial cost increases.

Exterior Finishes

In addition to aesthetics, exterior finishes prevent water and air infiltration. The moisture barrier provided by an exterior finish protects the interior wall materials, such as wood, steel, and insulation, from degradation caused by contact with water. Newer manufactured sidings have been engineered to require far less maintenance than traditional wood.

Toxicity is generally not a concern for exterior finish materials (with the exception of painted surfaces). To be durable and withstand the effects of sun and weather, the material will likely be inert. Recycled-content materials that are locally manufactured (and preferably locally harvested) should be considered. High-maintenance materials (such as wood) should be avoided to reduce repair, replacement, and upkeep costs (such as repainting). Brick, concrete, stucco, steel, aluminum, and fiber-cement offer superior longevity. These materials resist cracking and other deterioration. Only the exterior finishes known to be applicable to the LANL climate and weather characteristics should be considered.

Exterior Insulation Finishing Systems (EIFS) refers to a specific category of exterior finishes. EIFSs are multi-layered exterior wall systems consisting of the following components: insulation board secured to the exterior wall surface with a specially formulated adhesive and/or mechanical attachment; a durable, water-resistant base coat applied on top of the insulation and reinforced with fiber glass mesh; and a durable finish coat. By applying insulation outside the structure, EIFS reduces air infiltration and reduces energy consumption. Traditional "between-the-studs" insulation leaves thermal breaks caused by gaps where heat and cold pass more freely between the outdoors and the interior conditioned space. EIFS can reduce air infiltration by as much as 55 percent compared to standard brick or wood construction. Experienced, skilled applicators are required for proper installation.

Cost comparisons for the different exterior finish options will primarily be determined during the design phase based on functional and architectural considerations.

Jim Schäfer

The siding on the Cambria Office Building in Harrisburg, Pennsylvania, is made from untreated hemlock. It will gray with age to match the area's century-old barns.

Permeable Paving

Permeable (or porous) paving can be used to control surface water runoff by allowing stormwater to infiltrate the soil and return to the watershed (see Chapter 7). Permeable paving includes methods for using porous materials in locations that would otherwise be covered with impermeable materials (parking areas, walkways, and patio areas). These methods and materials include:

- ***Permeable pavers*** – Paving stones placed in an interlocking fashion over pedestrian surfaces (such as walkways and patios).
- ***Gravel/crusher fines*** – Loose aggregate material used to cover pedestrian surfaces.
- ***Open cell pavers*** – Concrete or plastic grids with voids that are filled with a reinforced vegetative turf or an aggregate material (sand, gravel, crusher fines). These are applicable to limited-vehicle-use areas.
- ***Porous asphalt (bituminous concrete)*** – A porous asphalt layer constructed with "open-graded" aggregate (small fines removed), which leaves voids between the large particles unfilled by smaller fine particles. An open-graded stone base holds water until it filters through into the underlying soil. This is applicable to general-vehicle-use areas.
- ***Porous concrete*** – A concrete mix without the fine aggregate, and with special additives for strength.

Permeable paving is not intended to replace standard impervious paving, but to limit the use of impermeable paving to heavy traffic areas. The availability of recycled content, salvaged materials, and locally manufactured products depends on the specific techniques implemented. Impacts from snow removal and control (salting) may affect durability.

Permeable paving surfaces generally cost more than conventional impervious surfaces. However, life cycle savings include reduced cost for stormwater management facilities and equipment and reduced operation and maintenance for infrastructure repairs. Permeable paving can potentially eliminate the need for stormwater collection drains, subsurface piping, and discharge structures.

LANL

Limiting the use of impermeable paving helps control runoff and protects the watershed.

System Integration Issues

Materials are in every physical aspect of a building. Therefore, the integration of material considerations into all components of building systems is a necessity. The following integration issues relate to material considerations:

- Low-energy building design involves integration of building envelope materials (insulation, windows, doors, and structural mass components) into the overall thermal load. Material characteristics should be included in the energy simulations (see Chapter 4).
- Indoor environmental quality involves integration with materials considerations to ensure workers and occupants are not subject to odorous, irritating, toxic, or hazardous substances and emissions.
- Daylighting design involves integration with materials considerations for windows as well as reflectance characteristics of interior finishes (such as ceiling tiles and paint).
- Stormwater design involves integration with materials considerations for perviousness of exterior surface structures (sidewalks, roadways, and parking lots) to promote infiltration into the ground surface.
- Roofing design involves integration with materials considerations to achieve ENERGY STAR compliance for reflectance and emissivity.
- Operation and maintenance requirements must be considered when selecting materials to ensure future sustainability when cleaning, repair, and replacement are required.

Robb Williamson

	Standard Practice/	*Better*	*High Performance*
Materials Reduction	◯ Typical material use	◯ Alternate low-mass, low volume materials	◯ Materials that serve multiple functions, and allow for omission of layers
Locally Manufactured	◯ 10% of building materials	◯ 20% of building materials	◯ 30% of building materials
Locally Derived Raw Materials	◯ 5% of building materials	◯ 10% of building materials	◯ 15% of building materials
Non-Toxic	◯ CRI-compliant	◯ CRI-compliant carpet and GS-compliant paint	◯ CRI-compliant carpet, GS-compliant paint, California AQMD-compliant adhesives and sealants
Recycled Content	◯ Meet EPA Comprehensive Procurement Guideline requirements	◯ 10% of building materials by weighted average	◯ 20% of building materials by weighted average
Salvaged – Material	◯ None	◯ 5% of building materials	◯ 10% of building materials
Salvaged – Building Reuse (if applicable)	◯ Maintain 75% of existing building structure and shell	◯ Maintain 100% of existing building and shell	◯ Maintain 100% of existing structure and shell AND 50% of non-shell (walls, floor coverings, ceiling systems)
Rapidly Renewable	◯ None	◯ 5% of building materials	◯ 10% of building materials
Certified Wood	◯ None	◯ 50% of wood-based materials	◯ 75% of wood-based materials

Additional Resources

ENERGY STAR – A voluntary labeling program sponsored by the U.S. EPA and DOE designed to identify and promote energy-efficient products, ***www.energystar.gov***

Federal Energy Management Program (FEMP) – FEMP is a U.S. DOE program that promotes water and energy efficiency. FEMP issues "Product Energy-Efficiency Recommendations" for products, ***www.eren.doe.gov/femp/***

Environmentally Preferable Purchasing (EPP) – EPP is a U.S. EPA program that encourages and assists in the purchasing of environmentally preferable products and services, ***www.epa.gov/opptintr/epp/***

Comprehensive Procurement Guidelines (CPG) – CPG is a U.S. EPA program established to promote the use of recycled products by designating products and establishing recycled-content recommendations, ***www.epa.gov/cpg/***

A Guide to Implementing Executive Order 13101, ***www.eren.doe.gov/femp/resources/greengov intro/html***

Resource Conservation and Recovery Act Online, ***www.epa.gov/rcraonline***

GreenSpec – A product directory listing building products selected by the publishers of Environmental Building News, ***www.greenspec.com***

GREENGUARD™ – A certification and labeling program for low-emitting interior products and building materials, ***www.greenguard.org***

Carpet and Rug Institute – Manages a testing program that verifies adherence to minimum standards for pollution emissions from carpets, cushions, and adhesives, ***www.carpet-rug.org***

WaterWiser – A resource for water-efficient products, ***www.waterwiser.org***

Green Seal – A nonprofit organization that develops consensus standards for environmentally preferable materials and products, ***www.greenseal.org***

OIKOS Green Building Source – A resource for construction products, materials, and techniques that promote sustainable design and construction, ***www.oikos.com***

Certified Forest Products Council – Provides a database of wood products certified to the standards of the international Forest Stewardship Council, ***www.certifiedwood.org***

Architectural Record/Green Architect – Provides a guide to green building products and materials, ***www.archrecord.com/green/green/asp***

"Rule 1168 Adhesive and Sealant Applications." California South Coast Air Quality District, September 15, 2000.

"Regulation 8, Organic Compounds, Rule 51, Adhesive and Sealant Products." California Bay Area Air Quality Management District, May 2, 2001.

"Anti-Corrosive Paints," Second Edition. GC-03, January 7, 1997. "Paints," First Edition. GS-11, May 20, 1993. "Commercial Adhesives." GS-36, October 19, 2000. Green Seal Inc., 1001 Connecticut, NW Suite 837, Washington, D.C., 20036-5525

Steel Recycling Institute (SRI), Fact Sheet, ***www.recycle-steel.org/index2.html.***

The resources listed above are not intended to be comprehensive and LANL encourages identification and use of other resources to support procurement of EP building materials.