
Interior Surfaces and Furnishings

OVERVIEW

This chapter provides the following guidelines:

- Guideline IS1: Carpeting
- Guideline IS2: Resilient Flooring
- Guideline IS3: Ceramic Tile / Terrazzo
- Guideline IS4: Concrete Flooring
- Guideline IS5: Wood Flooring
- Guideline IS6: Bamboo Flooring
- Guideline IS7: Gypsum Board
- Guideline IS8: Acoustical Wall Panels and Ceilings
- Guideline IS9: Paints and Coatings
- Guideline IS10: Casework and Trim
- Guideline IS11: Interior Doors
- Guideline IS12: Toilet Partitions
- Guideline IS13: Acoustics—Reverberation Time

The selection of interior finishes and furnishings affects a number of high performance goals including the following:

- *Health and indoor air quality.* Low-emitting materials can be selected to reduce chemical emissions that can be a source of indoor air pollution.
- *Visual comfort.* The surface reflectance of materials affects the efficiency of lighting systems, especially when recommended indirect/direct lighting systems are used.
- *Acoustic comfort.* Interior surfaces can absorb sound and reduce the reverberation time in classrooms and other school spaces.
- *Material efficiency.* The materials represented by interior surfaces and finishes are a quite significant and present opportunities to reduce waste (including construction and demolition waste); conserve raw materials and other resources used in the manufacturer, delivery and assembly in buildings; minimize maintenance; and be durable so they don't need to be frequently replaced.
- *Building as a teaching tool.* Since interior surfaces and finishes are so visible, they can be labeled or otherwise identified to communicate sustainable design principals to students.

Guidelines are presented in this Overview that provide advice on choosing among the various product categories for flooring, wall and ceiling finishes, other interior surfaces, and their associated coatings and adhesives. Once you have settled on a product such as carpet, then detailed guidelines are provided on how to specify the most high-performing product available.

While many other characteristics, including acoustical performance and visual appearance, factor into product decisions, selecting material efficient products that do not degrade indoor air quality are the main goals addressed in these guidelines. Evaluating resource efficiency and volatile organic compound (VOC) emissions is an emerging science with many uncertainties. No material or product is going to completely satisfy all the criteria. Choosing materials and products requires some professional judgment as to which of the criteria should be given the greatest weight.

Life-Cycle Assessment

Life-Cycle Assessment (LCA) is a procedure for assessing the impact of a product over its entire life. LCA considers the environmental impact from the very beginning of a product's life when resources are extracted from the earth and/or when materials from other products are collected and recycled to become raw materials for the manufacturer of the product. It considers the human labor and natural resources (especially nonrenewable resources such as energy) that are used in the manufacturer of the product. It considers possible health impacts to workers. It considers the impact of delivering the product to the building construction site and assembling it into the building, including human labor, natural resources, and waste at the construction site from discarded packaging or unused product. After the product is installed in the building, LCA considers human labor, energy and other resources needed to maintain it (the use phase in LCA parlance). LCA also factors in what happens to the product at the end of its useful life.

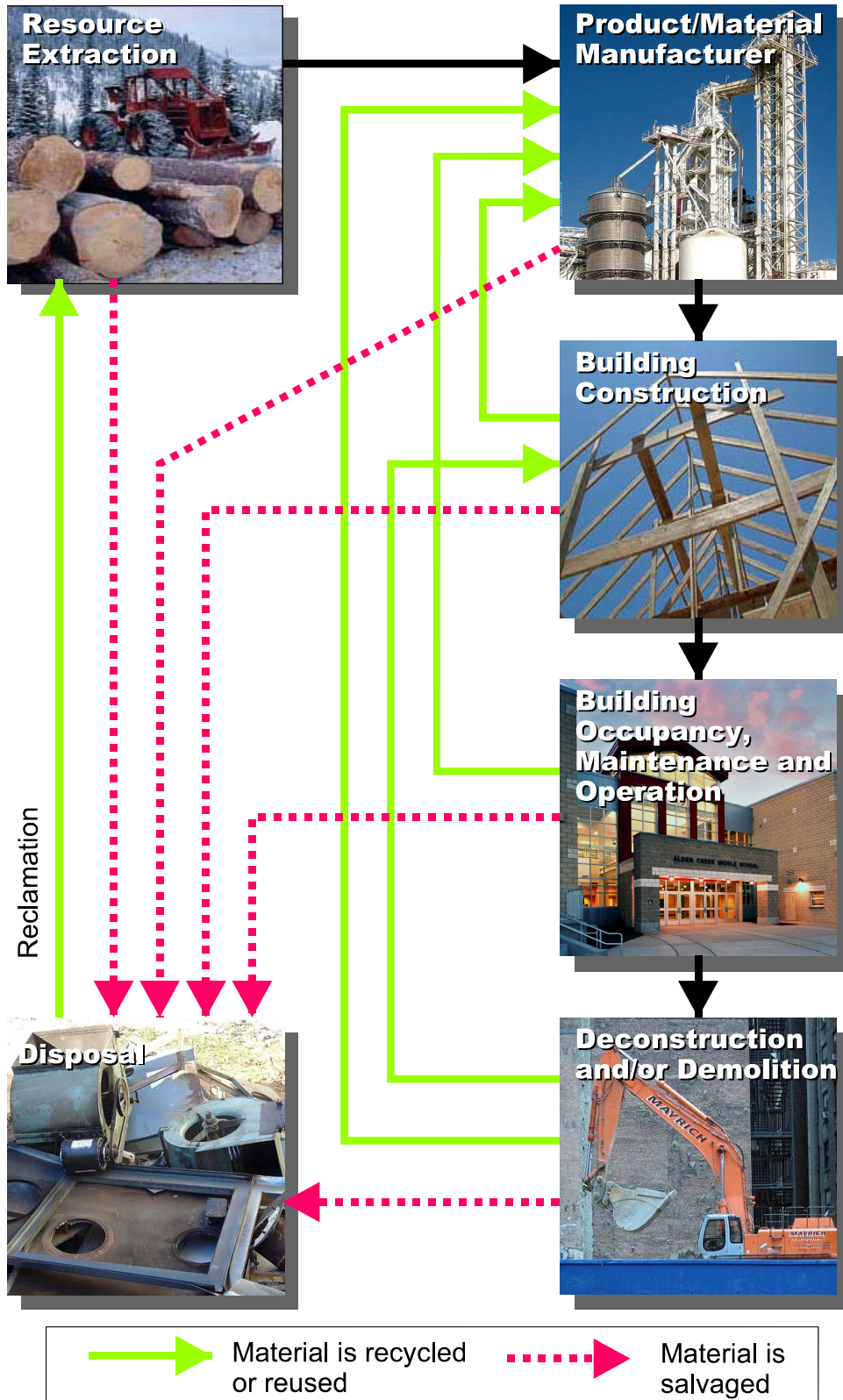


Figure 26 – Life-Cycle of Building Materials

The durability of the product and its useful life are also considered as well as its performance in its intended application. Performance includes the impact of the product on indoor environmental conditions such as visual comfort (the surface reflectance if the material is used on a ceiling or upper wall), thermal comfort (its insulating ability or surface temperature), acoustic comfort (its ability to absorb sound and reduce reverberation time), and/or indoor air quality (any chemicals that are emitted from the material). Of paramount importance is the durability of the material, its maintenance requirements, and its service life (how frequently will the product need to be replaced). LCA does not end there, however. It also considers what will happen to the product when it needs to be replaced (will it find its way into a landfill or will it be disassembled and recycled to provide a natural resource for new products?). This is why the term “cradle to cradle” is sometimes used to describe the period of time considered in LCA.

At each phase of a product’s pre-life, life, and post-life, natural resources are used, some of which may be non-renewable. Human labor is used and some persons involved in the manufacturer, delivery, assembly, or deconstruction of the product may be exposed to unhealthy or dangerous situations. The product may have positive or negative environmental impacts at any phase of its life.

LCA is an emerging science. At present it is less of a quantitative methodology and more of a way of conceptualizing the resource use and environmental impact of using products. The goal of some LCA researchers is that all the impact factors related to the use of a product be rolled up into one figure of merit that designers or product specifiers can use to make comparisons and selections. Before this can happen, and not all agree that it can, a number of issues have to be addressed. The following are examples:

- *Availability of data.* The materials and resources used to manufacture materials are considered proprietary by many manufacturers and data is not widely available.
- *Uncertainty about the future.* Even if a product is designed so that it can be maintained with non-toxic cleaning materials or so that it can be recycled when its life is over, what is the probability that this will happen? If the probability can be assessed how is it accounted for in the LCA?
- *Lack of standards.* Many product attributes such as reflectance, noise absorption, and insulating value can be measured and standards for making these measurements are widely accepted. Test standards and protocols are still needed, however, for many other important product attributes such as durability and service life.

Additional Information on LCA

The Sustainable Products Purchasers Coalition
www.sppcoalition.org

American Center for Life Cycle Assessment
www.lcacenter.org

International Organization for Standardization
www.iso.ch

Building for Environmental and Economic Sustainability (BEES)
www.bfrl.nist.gov/oe/software/bees.html

U. S. Environmental Protection Agency Environmentally Preferable Products.
www.epa.gov/epp

U. S. Life-Cycle Inventory Database Project
www.nrel.gov/lci

Athena
www.athenasmi.ca/

Life-Cycle Assessment for Buildings: Seeking the Holy Grail
Environmental Building News, March 2002
www.buildinggreen.com

- *Methodology issues.* There are a number of issues still to be resolved with regard to LCA methodologies, including the following:
- *Discounting future impacts.* In life-cycle cost analysis, future benefits and costs are discounted. Should a similar procedure be applied to LCA?
- *Applying weights.* How do you apply weights that place a relative value for factors as disparate as human life or global warming?

Progress is being made toward addressing these issues and LCA may emerge as a useful option in the future. Athena and the National Renewable Energy Laboratory are working to develop a life-cycle inventory database that would provide data. Also the Sustainable Products Purchasers Coalition, a network of government and private agencies and organizations is working to pressure manufacturers to provide data needed for LCA.

US LCI Database Project

The US LCI Database Project is a public/private research partnership dedicated to the creation of a publicly available LCI database of commonly used products and processes. The underlying intents are to support cost-effective LCA work by others; to facilitate the development of environmentally-oriented decision support systems and tools; to provide regional benchmark data for assessing company, plant or new technology data; and to provide a firm foundation for subsequent LCA tasks such as life cycle impact assessment.

A number of efforts are underway that address the methodology issues including research at Athena and the National Institute of Standards and Technology (NIST). NIST supports the Building for Environmental and Economic Sustainability (BEES) software, a tool that helps in the selection of building materials which take into account environmental and economic considerations. The ISO (International Organization for Standardization) has developed Standard 14040 that also provides guidance for LCA.

The literature on LCA, in particular the ISO standards, recognize four steps to be performed when doing a life-cycle assessment:

- *Scoping Phase.* In this phase, the purpose and goals of performing the LCA are identified and product phases to be considered are defined. Understanding the decisions that are to be informed by the LCA will often help define the precision and detail of information that needs to be collected in subsequent phases.
- *Inventory Analysis.* In this phase, information is collected on the materials, energy, water and labor used in each phase of the product's life.
- *Impact Analysis.* In this phase, information collected in the previous phase is combined and analyzed and aggregated into a series of environmental indicators such as embodied energy, greenhouse gas emissions, and water pollution.
- *Interpretations and Conclusions.* In this phase, the indicators developed in the previous are weighed and interpreted and recommendations are reached.

Current Ratings Systems for Materials

At present, CHPS, LEED™ and other high performance building rating systems are unable to use LCA and instead rely on setting criteria for individual product performance features. Credits are offered by either CHPS or LEED™ for low-emitting materials (part of the indoor environmental quality group of credits) as well as material credits for the storage and collection of recyclables, site waste management, building reuse, resource reuse, recycled content, rapidly renewable materials, certified wood, and locally manufactured products.

While imperfect, the system of individual credits serves to focus attention on a few of the important issues related to material efficiency and impact on human performance. While credits are not offered for some important features such as durability, the credits that are offered are a good first start.

CHPS, with its 2006 rating criteria, takes another step toward integrating the material attributes with the Environmentally Preferable Products (EPP) approach. The Combined Attributes Alternative is intended to offer more flexibility and give designers more options in specifying materials. It also allows EPP materials to be considered cumulative.

Product Suppliers

Some building material suppliers are making significant efforts to incorporate sustainable goals in their processes and operations and in their products. Companies serious about this commitment will provide detailed information about their product's performance. When investigating products, it is always recommended that the design team consult with the manufacturer's technical rather than sales staff.

Material Safety Data Sheets

Material Safety Data Sheets (MSDS), which must be prepared by product manufacturers, can provide some information and in particular can help "red flag" problem ingredients that may be toxic or emit significant VOCs. For example, the Health Hazard Rating (0 is low, 5 is high) found on an MSDS provides some indication of whether a product is appropriate for indoor school environments. MSDSs are often incomplete, however. Generally they do not include information about environmental attributes other than toxicity of regulated ingredients. MSDSs are primarily useful for eliminating building materials that may cause serious environmental problems.

Product Certification

Product certification programs can help identify environmentally preferable products. Many product suppliers have increased the credibility of their environmental claims by obtaining industry or independent certifications of their products' environmental attributes. Independent programs provide the most objective documentation, and include:

- EnergySTAR. A program of the federal government, manufacturers are allowed to use the Energy STAR label only if the product meets certain energy efficiency levels set by either the U.S. EPA or U.S. Department of Energy. Tel: (888) STAR-YES. Web site: www.energystar.gov/.
- *Green Seal*. Green Seal standards are based on environmental protection. They focus on reduced air and water pollution, reduced consumption of energy and other resources, protection of wildlife and habitats, reduced packaging, quality, and performance. Tel: (202) 588-8400. Web site: www.greenseal.org/.
- *Scientific Certification Systems*. Scientific Certification Systems is a nonprofit organization that assesses products based on a life-cycle or “cradle to grave” evaluation. Their Environmental Report Card gives detailed information about the environmental burdens associated with the production, use and disposal of the product. Tel: 800-ECO-FACTS. Web site: www.scs1.com/.
- *Forest Stewardship Council*. A product bearing the Forest Stewardship Council (FSC) trademark is made with wood certified to have come from a forest that is well managed according to strict environmental, social and economic standards. Look for FSC-certification as opposed to self-certification of forest management practices. FSC is an international nonprofit association working in partnership with industry and other groups to improve forest management worldwide. Tel: (802) 244-6257. Web site: www.fscus.org/. Also see Smart Wood, a U.S.-based program of the Rainforest Alliance, accredited by the FSC for the certification of forest management. Tel: (802) 434-5491. Web site: www.smartwood.org/.

Environmentally Preferable Product Directories

There are several good directories that identify environmentally preferable product options. Some focus on a product category (for example, recycled content products), while others cross categories.

- The CHPS Low-Emitting Materials Products List has products that have been chamber tested and certified according to the Department of Health Services Standard Practice and are acceptable for use in a typical classroom. See www.chps.net.
- Architects/Designers/Planners for Social Responsibility (ADPSR), Northern California chapter. Architectural Resource Guide. Organized by CSI, this guide lists sustainable, less polluting, local, and recycled building products as well as related information and a recommended reading list. Available as hard copy or CD. Web site: www.adpsr-norcal.org/.
- California Multiple Awards Schedule (CMAS). Schools can now directly purchase products listed on CMAS, part of the state’s procurement system. This allows direct purchases without going through the bidding process, saving time and offering economy of scale. Products are less expensive than if purchased through other means, but schools are encouraged to negotiate prices further. Schools may issue a purchase order directly to the supplier, while sending a copy of it to this address: CMAS, 1500 5th St. Suite 116, Sacramento, CA 95814. For assistance call the CMAS information line at (916) 324-8045. Web site: www.pd.dgs.ca.gov/(select CMAS).

- *Guide to Resource Efficient Building Elements (GREBE)*. 1998. Edited by T. Mumma. Contact: Center for Resourceful Building Technology, Box 100, Missoula, MT 59806. Tel: (406) 549-7678. Web site: www.crbt.org/introduction.html. Resource book on resource-efficient building systems. Updated regularly.
- *GreenSpec: The Environmental Building News Product Directory and Guidelines Specifications*. 1999. Published by E Build, Inc., Brattleboro, VT. Tel: (802) 257-7300. Web site: www.buildinggreen.com/. *GreenSpec* is organized in standard CSI divisions.
- California Integrated Waste Management Board's Web site provides a "Recycled-Content Product Directory" at www.ciwmb.ca.gov/RCP/. The database is searchable by product type and provides links to manufacturers. The CIWMB also sponsors many Buy Recycled programs. Information on these programs can be found at www.ciwmb.ca.gov/BuyRecycled/.
- Sustainable Products Purchasers Coalition (SPPC). Web site: www.sppcoalition.org/.
- The Ecoproducts Directory. Web site: www.ecoproducts.com/index.htm.
- U.S. EPA's *Comprehensive Procurement Guidelines (CPG)*. The CPG program promotes the use of products that contain recycled materials. Web site: www.epa.gov/epaoswer/non-hw/procure/index.htm. The products page, www.epa.gov/epaoswer/non-hw/procure/products.htm, provides an online list of construction, landscaping and other categories of products. The Web site briefly describes each of the listed products. You also can view EPA's recommended recycled content ranges and a list of manufacturers, vendors and suppliers for each item.

Environmentally Preferable Product Evaluation Tools

The following resources provide methodologies or suggestions for evaluating products:

- BEES (Building for Environmental and Economic Sustainability) software helps analyze the environmental and economic performance of some building products. The software is downloadable at www.bfrl.nist.gov/oea/software/bees.html.
- *Environmental Resource Guide*. 1996. Edited by Joseph A. Demkin. Offers a methodology for preparing life-cycle assessments of building materials, materials comparisons, and case study information about how high performance buildings have worked in practice. The ERG was funded by EPA and published by AIA in 1992 as an AIA publication, and was subsequently republished by John Wiley & Sons.
- *Environmental Building News (EBN)*. Brattleboro, VT. Tel: (802) 257-7300. Web site: www.buildinggreen.com/. The leading green building professional journal. Offers excellent articles, product reviews, book reviews and resources.

Material Efficiency

Material efficient interior building products is an important CHPS high performance goal. There are a number of attributes of material efficiency including recycled content, product recyclability and reusability, embodied energy, durability, and the impact of mining and manufacturing. Structural materials that also provide the finish surface, such as concrete masonry units or brick, can also be efficient products. Understanding material efficiency is complex and involves making professional EPP decisions that weigh one attribute against another. For example, one type of flooring may be made from rapidly renewable resources, but is not very durable. Another flooring type is highly durable, but cannot be recycled. Weighing these pros and cons of products can make it difficult to determine which products are most environmentally preferable.

California state law recognizes environmentally preferable products. Public Resources Code (PRC) 42635 (enacted by Senate Bill 373 in the 2001-2002 session) defines an “environmentally preferable product” as one that promotes healthy indoor environments for children and uses environmentally preferable materials and systems (e.g., uses less energy during manufacture and use; contains more recycled content; results in less potential waste; poses less harm to indoor air quality; consumes less water; can be recycled or reused) relative to similar products with similar functions.

What Makes a Product Material Efficient?

In a high performance school, materials are selected for several characteristics beyond the traditional issues of performance, price, availability,

Designing for Disassembly and Deconstruction **The Chartwell School, Seaside, California**



The Chartwell school in Seaside, California (Monterey county) is designed so that it can be efficiently disassembled at the end of its life. The design process began with a methodical analysis of likely and typical construction materials and components to assess the ease of recovering materials and the relative value of the materials after recovery. This analysis was used to guide material selection. Wood was selected for the structural framing, since it is widely used in California and has a high economic value.

Since it is difficult to salvage materials from typical wood construction, the Chartwell School uses connectors that enable easy disassembly, but still meet seismic and other structural design requirements. Similarly, the wood siding is fastened with clips that are screwed into the backing for ease of disassembly.



Another strategy was to separate building services (plumbing, electrical, etc.) from the wood framing to reduce holes in the framing and increase the wood's value as a salvaged material and to enable easier disassembly. Not only does the wood have more value when it is salvaged, but there is better access to the buildings services which typically need to be replaced or modernized every 15 years or so.

Windows are detailed for disassembly so that they can be easily replaced without damaging adjacent finishes or weather tightness. When the windows need to be replaced, the job can be accomplished over the summer break with minimal disruption to the operation of the school.

The Chartwell School received an EPA grant to research these and other disassembly strategies.

Photos courtesy EHDD Architecture and © Gerald Ratto

and aesthetics. Designers should look for environmentally preferable materials that are:

- *Durable.* Offers (proven) longer service life compared to other options in a given product category.
- *Healthy.* Does not introduce toxics or polluting emissions into the building.
- *Made with recycled content.* Includes materials that have been recovered or otherwise diverted from the solid waste stream, either during the manufacturing process (pre-consumer), or after consumer use (post-consumer).
- *Salvaged or reused.* Includes materials that are refurbished and used for a similar purpose; not processed or remanufactured for another use.
- *Recyclable.* Can be collected, separated, or otherwise recovered from the solid waste stream for reuse, or in the manufacture or assembly of another package or product. Movable, refinishable, and reusable.
- *Responsibly produced.* Extracted, harvested or manufactured in an environmentally friendly manner (includes certified wood products).
- *Environmentally benign.* Includes or introduces no, or low amounts of, known pollutants to the natural ecosystem (includes non ozone-depleting or toxic materials).
- *Low in embodied energy.* Does not require significant amounts of energy to produce or transport the material (includes locally manufactured or extracted options in a given product category). Manufactured close to the project site to reduce transportation energy use.
- *Produced from rapidly renewable material.* Includes material that is grown or cultivated and can be replaced in a relatively short amount of time (defined by the type of material).
- *Made with industrial byproducts.* Includes material that is created as a result of an industrial process (flyash, for example).
- *Marketed in an environmentally responsible manner.* Includes products packaged in minimal, reusable, recycled content and recyclable containers. Purchased from a manufacturing source that embraces sustainability as corporate policy, which is reflected in the operation of the production plant.

Take Back Programs

It is difficult for designers or contractors to assure what will happen to materials at the end of the service life, but one option is to specify products from manufacturers that have take back programs. With take-back programs, a manufacturer agrees to recover and recycle a product at the end of its life.

Preference should be given to manufacturers that have such programs. Design teams may include requirements in the construction specifications. The following are examples of take back programs.

Tandus offers a reclamation and recycling program for vinyl-backed carpet at their Tandus Center for Environmental Innovation in Dalton, Georgia

Armstrong offers a recycling program for acoustical ceiling tiles. According to a Newsbrief in the October 2000 issue of Environmental Building News, "The company now pays the freight (within the lower 48) on trailer loads—30,000 ft² or more—of approved tiles, has streamlined the process of recycling, and gives great guidance on job-site practices for efficient removal and "packaging" of the tiles for transport.

Costs of removal for recycling have proven to be very competitive with disposal costs.

Reduce, Reuse, Recycle, Buy Recycled

Interior finishes are important from a resource conservation perspective because they are used in large amounts and because they wear, requiring periodic maintenance and/or replacement. Material efficiency for building products should be approached in high performance school design according to the hierarchy of “Reduce, Reuse, Recycle.”

Reduce. Waste prevention is the highest priority within the material efficient hierarchy and encompasses several components, including:

- *Dimensional Planning.* Techniques like dimensional planning reduce the amount of waste generated at the construction site. This form of waste prevention includes designing a building using: standard dimensions, a minimal structural footprint, and modular or preconstructed panels and elements. Standard dimensions take into account the standard sizes of major building materials, such as wallboard and carpet, when designing the size of a space. For example, wallboard is generally manufactured in 4 ft by 8 ft sheets, and a standard carpet roll measures 12 ft wide. One potential standard dimension for a space would be 8 ft by 12 ft, because that would reduce the number of cut-offs and scraps produced when installing these major building materials. Including pre-constructed panels and elements into plans is also known as designing for flexibility and adaptability, which prevents waste when remodeling spaces. For more details on dimensional planning, See 8.3 of the CIWMB publication, “Designing with Vision...A Technical Manual for Material Choices in Sustainable Construction” (July 2000).
- *Design for Disassembly.* This concept factors in the possibility for a product and its parts to be reused, remanufactured, or recycled at the end of their “useful life,” reducing the amount of demolition waste generated. Additionally, these materials, which are typically considered a “waste,” can be another building’s raw material/resource.
- *Avoiding Unneeded Materials.* Material reduction can also be achieved by avoiding unneeded materials as a means to conserve raw resources. An example of this concept is the elimination of finish materials such as ceilings, or staining and sealing and polishing concrete instead of applying a second layer of resilient flooring over concrete slab. It is also important to select products that contain minimal packaging.
- *Durability.* Specifying products with high durability (which includes low maintenance requirements) can reduce waste, since building materials that have been discarded after a short service life account for much of the content in landfills.

Reuse is defined as using a material over again in its current form without breaking it down into a raw material. Designs can promote the reuse of materials by specifying salvaged and refurbished materials and structures. Commonly salvaged materials include lumber, pipes, steel, fencing, wood flooring, doors, windows, stone flooring and wall panels, appliances, lighting fixtures, and decorative accessories. Existing buildings and structures can be reused during renovations and redevelopments.

Recycle and Buy Recycled. Since it can be quantified, recycled content is one of the most common indicators of material efficiency. Recycled content products create markets for the tons of materials that people recycle. However, it is important to understand the distinction between recycled content products and those that are recyclable. Preferred products are those that both contain recycled content and are also recyclable at the end of their service life. However, when choosing between specifying a product that contains recycled content and one that could be recycled, the recycled content product should always take precedence. While recyclability of a product is important, it does not reduce the consumption of raw materials, nor does it promote completion of the cycle for existing materials that have already been diverted from the waste stream. The designer, in collaboration with the client, should set recycled content goals for all building materials. Guidance on post-consumer recycled content is provided by the State Agency Buy Recycled Campaign (SABRC). See more information below

The term “recycled content” can refer to two types of recycled materials: post-consumer and secondary (also known as post-industrial). Post-consumer recycled content is “a finished material which would have been disposed of as a solid waste, having completed its life-cycle as a consumer item.”⁵ Secondary, or post-industrial, recycled content is defined as “fragments of finished products or finished products of a manufacturing process, which has converted a resource into a commodity of real economic value, but does not include excess virgin resources of the manufacturing process.”⁶ The California SABRC program only recognizes post consumer recycled content.

The CHPS Criteria (Best Practices Manual Volume III) offers credits for the use of products with recycled content. Credits are offered through either a prescriptive or a performance approach. Under the prescriptive approach, points are offered for the use of major materials. The Criteria identifies recycled content targets for major material categories such as insulation, carpet, and flooring. The targets were adapted from the EPA Comprehensive Procurement Guidelines 2000 Buy Recycled Series. A “major” material is defined as those covering more than 50% of a building’s surface or serving a structural function throughout the majority of the building. While this option may be the easiest to follow, the finite list of materials from which to select can be limiting. Under the performance approach, points are offered using the weighted average of postconsumer recycled-content value. This approach is based on the cost of recycled content products.

The CHPS Criteria has a more performance based option called the *Combined Attributes Alternative*. This option considers not just recycled content but other material efficiency properties, including recycled content, rapidly renewable materials, organically grown materials, certified wood, and the use of salvaged materials. With this option, points are earned for specifying a minimum amount of qualifying materials (in terms of project value), that meets one or more of the material efficiency properties.

⁵ California Integrated Waste Management Board.

⁶ Ibid.

State Agency Buy Recycled Campaign (SABRC)

The State Agency Buy Recycled Campaign is a good starting point for setting recycled content goals. The State Agency Buy Recycled Campaign is a joint effort between the Department of General Services (DGS) and the California Integrated Waste Management Board (CIWMB) to implement state law requiring California agencies to purchase products with recycled content.

SB 1106

The SABRC program was amended in 2005 through Senate Bill 1106. The emphasis of the program was shifted to post consumer recycled content. Each state agency is required to document that at least 50% of reportable purchases meet the standards for post consumer recycled content.

While the SABRC is not directly applicable to California schools, significant effort went into developing the program, and as such, it is a useful tool for school designers to avoid having to reinvent the wheel. For further information, refer to the CIWMB Web site: www.ciwmb.ca.gov/BuyRecycled/StateAgency/.

The SABRC identifies product categories of recycled content materials, including include paper products, printing and writing papers, compost, mulch, glass, oil, plastic, paint, tires, tire-derived products, antifreeze, and metal.. State agencies are required to report on the procurement and levels of recycled content in each category to keep a record of each item's recycled content certification. While this law does not apply to California's schools, it can provide a model for recycled content goals.

Table 6—Recycled Content Categories Applicable to Construction Projects

Source: SB 1106.

Product Category	Minimum Post-Consumer Recycled Content Requirement
Paper products	30%
Printing and Writing Paper	30%
Recycled Compost, Cocompost, and Mulch	80%
Glass products (windows, fiberglass insulation, tile)	10%
Plastic products (plastic lumber, carpet, entry mats, signage, and other building products)	10%
Paint	50%
Tire-derived products	50%
Recycled metal products	10%

Indoor Air Quality

Indoor air quality is one of the key goals of a high performance school and it can be significantly affected by the selection of interior surfaces and finishes. Since most of the occupants in schools are children or adolescents with still-developing respiratory systems, the importance of IAQ is heightened. The metabolic rates of children are significantly greater than adults causing them to breathe more air and as result absorb and retain more toxins. In addition children's immune systems are less effective.

The U.S. Environmental Protection Agency (EPA) documents that Americans spend more than 90% of their lives indoors, and that pollutant concentration inside buildings is two to five times greater than outdoors. News reports and scientific inquiries have brought increased attention to the symptoms and causes of poor IAQ. Symptoms range from mild discomfort (sick building syndrome) to more severe

illness and permanent injury (building related illnesses and multiple chemical sensitivity). Health effects include headaches, fatigue, memory problems, eye irritation, and coughs.

There are four principles in designing good IAQ:

- *Source control:* Reduce and/or eliminate the source of contaminants in buildings.
- *Ventilation control:* Provide adequate ventilation to dissipate the contaminants in buildings.
- *Building commissioning:* Building commissioning is a process used during the design, construction, and post-occupancy phases of a project to ensure that the project is built and performed as designed, and that the systems and equipment function as intended.
- *Building maintenance:* Buildings require regular scheduled maintenance and cleaning to ensure that they perform throughout their life as they did when first constructed. Using environmentally friendly cleaning agents will reduce the opportunity for air contamination during the building's life.

The emphasis of this chapter is source control. Ventilation control is addressed in the HVAC chapter; commissioning is addressed in CHPS Best Practices Manual Volume V: Commissioning and building maintenance is addressed in CHPS Best Practices Manual Volume IV: Maintenance and Operations.

According to a 2005 report to the California Legislature⁷, "Source control is the prevention or reduction of emissions at the source. It is the most effective and reliable approach to reducing indoor pollution because it keeps pollutants from entering and spreading throughout a building." The report also suggests that one action that should be taken to reduce indoor pollution is to establish emission limits and require emissions testing of building materials and some consumer products. Designers should seek to reduce or eliminate potential sources of indoor air pollution by selecting the lowest odor, least toxic, lowest emitting, most moisture-resistant, and most durable materials that can be safely installed and maintained. The CHPS Low-Emitting Materials Products List is a good place to start. See www.chps.net.

Indoor pollutants include volatile organic compounds (VOCs), microbial volatile organic compounds (MVOCs), particulates, inorganic compounds (such as CO₂, CO, and ozone), and semi-volatile organic compounds (SVOCs) such as pesticides and fire retardants. Pollutant sources include the outside air, construction materials, furnishings, the building envelope, equipment, maintenance, and the occupants themselves. VOCs are of special concern because they can damage the natural environment during building material production and disposal, create hazards for installers and manufacturers, as well as cause health problems for building occupants.

VOCs are some of the most commonly discussed chemical emissions that affect IAQ. VOCs can occur in the air at normal environmental conditions and are emitted from interior materials such as paints, adhesives, sealants, sealers, carpets, resilient flooring, furniture, and ceiling panels. Materials and

⁷ California Air Resources Board. 2005. "Report to the California Legislature. Indoor Air Pollution in California." www.arb.ca.gov/research/indoor/ab1173/finalreport.htm

products emit (“off-gas”) VOCs during and after installation, which can cause health problems for construction workers and building occupants.

Concentrations of a number of VOCs and formaldehyde are currently found in indoor air. In the indoor environment, formaldehyde can cause several health problems for occupants, including skin and eye irritation, upper respiratory system irritation, and symptoms of sick building syndrome. Formaldehyde is a known carcinogen so human exposure should be minimized, and indoor air concentrations should be kept as low as is reasonable to achieve.

In many cases, the best products, with the lowest VOC emissions, are made from water-based constituents. This said, it is also important to select materials that are easy to clean and maintain without the use of odorous, irritating, or toxic cleaning supplies.

Designers should also be aware that a product can be labeled as “low-VOC” or even zero-VOC and still emit VOCs that are odorous, toxic, or otherwise undesirable. Even small quantities of some chemicals can create problems indoors. The EPA VOC labeling requirements do not provide a straightforward way to compare VOC content since labels are required to only list chemicals classified as reactive, with the potential to create smog. Unreported non-reactive VOCs may react with oxidants to form odorous, irritating, or toxic chemicals in the indoor environment. While some VOC emissions may not cause an *air quality* problem for occupants, they may still be hazardous to installers and manufacturers.

VOC emissions are generally highest immediately after a new product is installed or a finish is applied, but emissions may continue for days, weeks, or months, and actual emission rates will be impacted by the ventilation conditions, indoor temperature, and humidity conditions. Even with low-VOC emitting materials, it is important to provide temporary ventilation during and after installation. However, the length of the required venting period depends on the amount of surface covered, as well as the volatility and toxicity of the finish. In addition, it is recommended that, prior to substantial completion, each school be flushed out with 100% outside air for a period long enough to eliminate the effects of construction and initial material emissions. The CHPS Criteria recommends a minimum of 14,000 ft³ of outside air ventilation for each ft² of space. If the fans deliver, say, 1.5 cfm/ft², the time required for outside air ventilation would be 14,000/1.5 or 9,333 minutes which is equal to about 155 hours. If the fans were operated continuously, the flushing period could be completed in about a week.

Fleecy and absorbent surfaces such as carpets, wall coverings, window coverings, and ceiling tiles should be protected from exposure to the air during periods of high VOC emissions. Even better, construction work should be sequenced so that soft and/or porous materials are installed after VOC-emitting materials, finishes, or sealants have had a chance to “off-gas.” Otherwise, emitted chemicals will be absorbed by porous surfaces, increasing the time required to clear the chemicals from the building.

Understanding chemical emissions adds to the complexity of reviewing contractor-initiated material and product substitution requests. Construction specifications should require that product ingredients and VOC emissions be reported, as well as information about any adhesives or solvents that are required

during installation or maintenance. However, substitutions should be welcomed when contractors and subcontractors can provide information about new and improved product alternatives.

CHPS Low Emitting Products List

To make specifying low-emitting materials easier, CHPS has developed a Web-based Compliant Materials Table (www.chps.net). Initiated by the Los Angeles Unified School District (LAUSD), this table lists products which have been tested using Section 01350/DHS Standard Practice and have been determined to have chemical emissions under the specified limits for a typical classroom.

CHPS Section 01350

CHPS provides a model Special Environmental Requirements Specification (Section 01350), which includes testing procedures for chemical emissions from materials. The chemical testing procedures have been superseded by the California Department of Health Services Standard Practice. The CHPS 01350 should still be used, however, as a model for specifying other environmental properties.

Other products may also have chemical concentrations under the specified limits but should be tested by an independent lab for compliance with Section 01350/DHS Standard Practice. The DHS Standard Practice is based on chamber testing of materials and analysis of concentrations of chemical compounds that have been identified as being harmful to humans and for which a reference exposure level (REL) has been determined.

Carpeting that has been approved under the Carpet and Rug Institute’s (CRI) ‘Green Label Plus’ program is considered equivalent to meeting the DHS Standard Practice emission criteria and is equivalent to being listed in the CHPS Low Emitting Products List.

CHPS recommends that all interior materials that potentially emit VOCs (including adhesives, sealants, sealers, coatings, carpets, resilient flooring, ceiling materials, wall materials and coverings, insulation, architectural wood products, composite wood products, and furniture) meet the emissions criteria.

However, chemical testing alone cannot fully evaluate the potential for *odor* from VOC emissions. Relying on experience, and even ad hoc experiments such as carefully controlled clean glass jar “sniff” tests to determine the odor acceptability of a product, may also be necessary if there is a concern regarding the VOC emissions.

Managing IAQ During Construction

In addition to product selection, the designer should also look for other ways to mitigate potential IAQ problems during construction. Dust and mold are two common construction by-products that can compromise IAQ. Construction activities such as wood sanding and drywall finishing generate large amounts of dust and debris, which can become an IAQ problem. Thoughtful work practices and thorough cleaning before occupancy will mitigate this potential problem. (See Guideline GC3: Indoor Air Quality During Construction for more information.)

Microbial Growth

Mold growth requires moisture, warmth, and a material (food) on which to grow. Excess humidity, caused by moisture intrusion or condensation, will promote the growth of mold and other biological

contaminants within building materials that impact human health. Mold growth is commonly found on ceiling tiles, gypsum board, carpet, and other finishes. Special care should be taken during the delivery, storage, and handling of these materials to prevent moisture contamination on the construction site. If any moisture damage occurs, the materials must be removed and replaced as soon as reasonably possible. (See the Overview in the Building Enclosure and Insulation chapter of this manual for more information.)

Summary

In summary, objectives and strategies used to protect IAQ include selecting interior surfaces that are:

- Made with water-based coatings and adhesives.
- Nontoxic and non-polluting during installation and use (low-VOC emitting).
- Resistant to moisture or inhibit the growth of biological contaminants.
- Easy to clean with non-polluting maintenance products.
- Comply with the California Section 01350 Specification/DHS Standard Practice as low emitting.

CHPS Section 01350 Specification

To assist owners, designers, and contractors, CHPS has made available a model specification at www.chps.net (To download, click on “Publications and Resources”). This specification section, Special Environmental Requirements (Section 01350) has been used on several California state projects and is intended to be included in Division 1 of the Construction Document Specifications to lay out special environmental requirements related to IAQ, durability, recycled content and recyclability, wood from sustainably harvested sources, and product packaging. The intent of providing this sample specification is to give designers a base environmental specification from which to work. It is expected that each designer will customize this specification section for their specific project and coordinate with the other specification sections and the other parts of their project manual. Specification Section 01350 is intended to be placed into Division 1 of the project manual, so that it will govern all the other divisions (as is the case with submittal requirements and substitution requests, etc.).

Specification Section 01350 sets out environmental goals (specifically needed by the contractor if they are considering substitution requests), product emission testing methods, test protocols, sample procedures and reporting requirements. The indoor air quality parts of the CHPS Section 01350 references the DHS “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.” This standard is maintained by DHS on behalf of the “Green Action Team.” It establishes Chronic Reference Exposure Levels (CRELs)⁸ for hazardous

⁸ According to California’s Office of Environmental Health Hazard Assessment website, “Chronic RELs are designed to protect the individuals who live or work in the vicinity of emissions of these substances. A chronic REL is an airborne level that would pose no

airborne substances, based on the California Environmental Protection Agency Office of Environmental Health Hazard Assessment (OEHHA).

The Vinyl Debate

Few building materials have generated more debate over material efficiency and the environment than those containing polyvinyl chloride (PVC). PVC is a highly versatile, stable compound used in numerous building products, including pipes, siding, wire and cable coatings, resilient flooring, carpets, wall coverings, and furniture. In fact, construction materials account for the largest percentage of PVC use.

Commonly referred to as “vinyl,” PVC products are highly durable and require low maintenance, which have made them a popular choice in schools. For instance, vinyl composition tile (VCT) is the most commonly used flooring material for non-carpeted areas in schools due to its long life, low maintenance requirement, and moisture-resistant properties. First cost for PVC products is low.

Much of the debate focuses on environmental concerns with the production of PVC. PVC is derived from petroleum, which is a non-renewable resource and can be highly polluting during extraction, refinement, and manufacturing.⁹ It should also be noted, however, that because many PVC products are manufactured in the U.S., they can have lower embodied energy than other materials that are manufactured overseas.¹⁰

Vinyl chloride (VC), a colorless, flammable gas that serves as the building blocks for PVC, is a known human carcinogen. Studies of PVC factory workers have shown that long-term exposure (365 days or more) to high levels of VC can cause liver cancer, nerve damage, and immune system problems.¹¹ In response to these findings, the Occupational Safety and Health Administration in 1974 reduced the occupational exposure standard for VC gas in the air from 500 parts per million (ppm) to 1 ppm.¹² These tighter restrictions, in combination with a closed-loop polymerization process adopted by the industry in the U.S., have reduced the high-risk exposure for workers.¹³ While most of the studies on VC exposure have focused on long-term exposure in factory workers, breathing high levels of VC gas for short periods

significant health risk to individuals indefinitely exposed to that level. RELs are based solely on health considerations, and are developed from the best available data in the scientific literature.” http://www.oehha.org/air/chronic_rels/Jan2001ChREL.html.

⁹ U.S. Environmental Protection Agency, Environmentally Preferable Purchasing Program. “Leading by Example: Two Case Studies Documenting how the Environmental Protection Agency Incorporated Environmental Features into New Buildings.” December 1997. <http://www.epa.gov/opptintr/epp/pubs/grnbldg.pdf>.

¹⁰ Ibid.

¹¹ U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. “Vinyl Chloride Fact Sheet.” September 1997, CAS #75-01-04. <http://www.atsdr.cdc.gov/tfacts20.html>.

¹² Centers for Disease Control, Morbidity and Mortality Weekly Report. “Epidemiologic Notes and Reports: Angiosarcoma of the Liver Among Polyvinyl Chloride Workers—Kentucky.” 1974, update 1997. <http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00046136.htm>.

¹³ Ibid.

of time can cause dizziness and unconsciousness, while breathing extremely high levels in a short period of time can cause death.¹⁴

Concerns also exist surrounding the disposal of PVC products. PVC products are not biodegradable, and since recycling options for PVC are currently limited, most products are not recycled. PVC can also cause air quality problems due to dioxins emitted during combustion in improper waste incineration¹⁵ and building fires.

While some environmental organizations have serious concerns about its environmental impact, PVC also has some beneficial properties that have made it a widely used material in schools traditionally. CHPS has chosen to remain neutral on the use of vinyl products in schools. The guidelines in this chapter discuss the pros and cons of using PVC products for various building surfaces, but neither recommends nor discourages their use.

Other Considerations in Material Selection

Embodied energy is the energy consumed during the entire life cycle of a product, including resource extraction, manufacturing, packaging, transportation, installation, use, maintenance, and when appropriate, even disposal. Energy is but one of the resources used to manufacture products, but is one that is more easily measured and accounted for. Products with low embodied energy are environmentally preferable. Consideration of transportation energy gives preference to products that are manufactured locally.

Products produced in a way that protects the eco-system are also environmentally preferable. One example is certified wood products, which are produced from trees grown and harvested from Forest Stewardship Council (FSC)-certified, sustainably managed forests. FSC is the accrediting agency for organizations such as Smart Wood and Scientific Certification Systems (SCS), which in turn oversee forestry practices and certify their sustainability.

Acoustical benefits can also factor into a product selection. For instance, consider carpet and other acoustical materials for areas when noise control is a concern. Also, be aware of how the acoustical properties of certain products can be impacted by other interior materials. For example, most ceiling tiles will lose their acoustical benefits if painted.

A product's color can also influence the decision-making process. While color is always a factor for visual appeal, it can also have a functional impact. Consider light-colored finishes, including paints and coatings to enhance daylighting.

¹⁴ U.S. Department of Health and Human Services. "Vinyl Chloride Fact Sheet."

¹⁵ U.S. Environmental Protection Agency, Environmentally Preferable Purchasing Program. "Leading by Example: Two Case Studies Documenting how the Environmental Protection Agency Incorporated Environmental Features into New Buildings." December 1997.

Because of their high visibility, interior surfaces and furnishings provide an excellent opportunity to highlight the high performance approach. Environmentally preferable choices teach the importance of caring for the health of occupants, as well as the health of the natural environment.

In summary, when selecting materials, including interior building materials, for a high performance school, designers should look for cost-effective, durable, and material-efficient products that protect indoor air quality and provide the desired acoustical performance and aesthetic qualities. In addition, high performance school designers should attempt to minimize the impact on the natural environment, or are ecosystem protective, by selecting locally produced materials, as well as those produced in an environmentally benign manner, preferably using suppliers and manufacturers that practice “sustainable” or environmentally conscious management principles. Look for manufacturers that have a corporate policy incorporating sustainability. The selection process should consider installation and maintenance requirements as well as how the material or furnishing performs during its service life. Table 7 summarizes the goals and objectives described above and shows the relationship between them and the guidelines that follow later in this chapter.

Table 7—Interior Surfaces Goals and Relationship to Guidelines

Goals		IS1: Carpeting	IS2: Resilient Flooring	IS3: Ceramic Tile/Terrazzo	IS4: Concrete Flooring	IS5: Wood Flooring	IS6: Bamboo Flooring	IS7: Gypsum Board	IS8: Acoustical Wall Panels and Ceilings	IS9: Paints and Coatings	IS10: Casework and Trim	IS11: Interior Doors	IS12: Toilet Partitions	IS13: Acoustics—Reverberation Time
Protect Indoor Environmental Quality	Use low-VOC emitting coatings and adhesives.	●	●	●	●	●	●	●	●	●	●	●	●	
	Use low-VOC emitting materials.	●	●	●	●	●	●	●	●	●	●	●	●	●
	Use moisture-resistant materials.			●	●									
	Use low-VOC emitting maintenance products	●	●	●	●	●	●				●		●	
	Use sound-absorbing materials	●							●					●
Material Efficiency	Made from sustainable resources		●			●	●				●	●		●
	Made with recycled content	●	●	●	●			●	●	●			●	●
	Recyclable	●	●	●	●	●		●	●		●			●
	Movable, refinishable, and reusable					●					●	●	●	●
Other Environmental Considerations	Locally available	●	●		●	●		●	●	●	●	●		●
	Durable	●	●	●	●	●	●	●						●
	Low in embodied energy					●								
	Eco-system protective		●			●					●	●		

Selection Guidelines

This section of the Overview provides some guidelines for the selection of products for major finishes and surfaces within a school.

Flooring

Flooring should be durable to withstand heavy use without requiring frequent replacement, be easy to maintain, contain recycled content, be recyclable, contribute to a comfortable indoor environment, and not adversely affect human health. Based on life-cycle costs, highly durable materials are justified, especially for high-use areas.

Floor choices include resilient flooring, concrete, tile, wood, and carpet. When selecting these surfaces, review the cleaning products that might be used throughout the life of the flooring.

Carpet systems require maintenance, as do other flooring materials, and their need for more frequent replacement makes them materials- and energy-intensive over their lifetime. If selecting a carpet, select those carpets with a longer warranty to increase the service life and reduce the need for replacement. Consider using carpet tiles where worn or damaged sections can be replaced without the need to replace the entire carpeted area. However, carpeting offers acoustical and comfort benefits that are generally not available with other flooring choices. Smaller children especially will spend more time sitting or laying on the floor. For these reasons, carpeting is often used in classrooms and administrative areas.

Hard surfaces are often selected for use in high traffic areas not requiring the acoustical benefits of carpet. Hard surfaces are also used in specialty areas such as art rooms or labs.

Walk-off mats are recommended for all major school entrances to help minimize cross-contamination by pollutants brought into the building on occupants' shoes. Using walk-off mats to trap dirt, dust, grit, and moisture can also reduce maintenance costs, improve safety, and protect the life and appearance of the flooring. To be effective, walk-off mats should allow room for at least six footsteps. This can be from 12 to 20 feet depending on the age and size of the students, with most adults in the 18 to 20 foot range. Many California classrooms have direct access to the outdoors making the use of walk-off mats impractical. Table 8 summarizes advantages and disadvantages of the flooring choices addressed in these guidelines.

Table 8—Environmental Criteria for Floors

Type	Advantages	Disadvantages
Carpet Guideline IS1	<p>Material efficient options available: minimum recycled content guideline of 50%, with at least 10% post-consumer recycled content. (In the CHPS Criteria, Materials Credit 4: Recycled Content gives priority to products with high post-consumer recycled content.)</p> <p>Thermal comfort.</p> <p>Physical comfort (cushion).</p> <p>Provides safety for small children.</p> <p>Noise control.</p> <p>Some recycling options are available.</p> <p>Carpet tiles make partial replacement easier.</p>	<p>May emit some VOCs during and after installation (low VOC options are available).</p> <p>Can harbor dust and other allergy-causing particles.</p> <p>Requires regular maintenance. Requires frequent vacuuming, which stirs up dust.</p> <p>Can absorb VOCs and re-emit (desorb) later.</p> <p>Adhesives and maintenance products can add to indoor pollution load (but low-toxic/low-VOC options are available).</p> <p>Potentially need to allow time to air out carpet (precondition off site) before occupancy.</p> <p>Less durable and stains easier than other flooring options.</p> <p>Significant debris generated when it must be replaced.</p> <p>Can be a source of mold/mildew if placed in contact with moisture.</p>
Resilient Flooring Guideline IS2	<p>First cost can vary from low to high, depending on product, but due to its high durability, this flooring type tends to cost less per year of use than carpet.</p> <p>Easy to clean.</p> <p>High reflectivity can enhance daylighting.</p>	<p>Flooring adhesives and maintenance products can add to indoor pollution load (but low-toxic/low-VOC options are available).</p> <p>Most are not recyclable or biodegradable.</p> <p>Hard surface does not have the acoustic benefits of softer surfaces.</p>
Ceramic Tile / Terrazzo Guideline IS3	<p>Recycled content options available: minimum recycled content guideline of 55-77%. (Scrap glass and feldspar waste from mining are sometimes used.)</p> <p>Easy to clean and stain-resistant (some tile may need to be sealed first).</p> <p>Highly durable.</p> <p>High reflectivity can augment daylighting.</p>	<p>High initial cost but life cycle cost can be low for some applications.</p> <p>High embodied energy.</p> <p>Made from nonrenewable resources. Some ceramic tile is recycled as clean construction waste. When contaminated by bonding and setting agents, recycling is not feasible.</p> <p>Tile installation materials (mortar and grout) are sources of VOCs and toxic materials. (Portland cement-based mortar and grout appear to have less significant environmental impact than latex or solvent-based systems.)</p> <p>Terrazzo poses installation risks, depending upon type. (Cementitious type appears to have less significant environmental impacts than epoxy systems.)</p> <p>Hard finished surface can compromise physical comfort.</p> <p>Adhesives and maintenance products can add to indoor pollution load (but low-toxic/low-VOC options are available).</p>
Concrete Flooring Guideline IS4	<p>Material efficient if manufactured with high fly ash content.</p> <p>Highly durable.</p> <p>Low maintenance and low cost.</p> <p>Resource efficient when structural slab is finished floor.</p>	<p>Sealers and wax products can add to indoor pollution load (but low-toxic/low-VOC options are available).</p>
Wood Flooring Guideline IS5	<p>Renewable resource, if properly managed (FSC-certified).</p> <p>Low embodied energy.</p> <p>Wood flooring is recyclable and the market for recycled wood flooring is expanding.</p> <p>Biodegradable.</p> <p>Factory prefinished products offer air quality benefits (no sanding or finishing performed on site)</p> <p>Easy to clean.</p> <p>“Warm,” comfortable surface.</p> <p>Durable and can be refinished to prolong its life.</p> <p>Good aesthetics.</p>	<p>High cost.</p> <p>Adhesives, sealants, and maintenance products can add to indoor pollution load (but low-toxic/low-VOC options are available).</p> <p>Requires special moisture-prevention care in handling and installation to prevent later IAQ problems.</p> <p>On-site sanding requires special measures.</p>
Bamboo Flooring Guideline IS6	<p>Material efficient.</p> <p>Durable and hard.</p> <p>Easy to clean.</p> <p>“Warm,” comfortable surface.</p>	<p>High cost.</p> <p>Adhesives, sealants, and maintenance products can add to indoor pollution load (but low-toxic/low-VOC options are available).</p>

Walls and Ceilings

Walls and ceilings should be durable, be easy to clean, contain recycled content, and be recyclable, as well as contribute to a healthy and comfortable indoor environment. Classrooms and other rooms require plenty of tackable wall space for teaching aids and displaying student projects. The type and color of surfaces on teaching walls should also be visually comfortable and not detract from teacher presentations. Light colored finishes should be used to enhance daylighting and electric lighting by reflecting the light and providing for better light distribution.

Drywall is potentially recyclable and can be composted. Recycled content gypsum board core is available, but it is important to explicitly specify recycled content to ensure its use. Although they may not advertise it as recycled, many manufacturers already use post-industrial recycled content in their drywall product, and virtually all make the facing paper component from post-consumer recycled content paper. To protect indoor air quality, it is recommended that all drywall products meet the emissions requirements outlined in Specification Section 01350 and DHS' Standard Practice. See the discussion on Special Environmental Requirements (Section 01350) and the DHS' Standard Practice above. It is important that drywall remain free from moisture contamination during construction to prevent mold growth. Damaged materials should be removed and replaced as soon as is reasonably possible.

When using wall coverings, use biodegradable papers that contain recycled paper or fiber content. Vinyl wall coverings are widely used but have raised concerns since they contain polyvinyl chloride (PVC). (For further discussion of vinyl, see the Vinyl Debate section above.) Installation of wall coverings using traditional wallpaper paste is preferable to using self-stick wall coverings, due to the levels of VOC content in the adhesive. Wall coverings should also meet the emissions requirements outlined in Specification Section 01350 and DHS' Standard Practice.

Avoid using ceiling tile and sprayed-on ceiling finishes containing asbestos, formaldehyde, or crystalline silica, as these items are possible cancer and respiratory tract hazards. Table 9 summarizes advantages and disadvantages of the wall and ceiling choices addressed in these guidelines.

Table 9—Environmental Criteria for Walls and Ceilings

Type	Advantages	Disadvantages
Gypsum Board Guideline IS7	Gypsum is highly recyclable if not contaminated (with paint, tape, compound, adhesives or other coatings). Recycled content gypsum is readily available at no cost premium, and the paper facing is typically made with recycled paper. Durable, high impact drywall contains up to 15% post-consumer recycled content. Recycled gypsum is more durable than conventional wallboard. Easy to repair. Low cost.	Dust generated during sanding (can specify “wet sanding” process). Gypsum surfaces are potent “sinks” for odors, which they can later re-release. Requires periodic painting. Paints and primers can add to indoor pollution load (but low-toxic/low-VOC options are available). Low durability compared to concrete block.
Ceramic Tile Guideline IS3	See Table 8, Ceramic Tile/Terrazzo Flooring.	See Table 8, Ceramic Tile/Terrazzo Flooring.
Acoustical Wall Panels and Ceilings Guideline IS8	Recycled content materials readily available: minimum recycled content guidelines for ceiling tile is 79-85%, for suspension system is 25%. Formaldehyde-free products available. Reclamation programs available (though limited). Easy installation. Acoustical ceiling tiles often cost less than wallboard ceilings and are easier and less expensive to repair. Do not require painting or other finish materials to complete the installation. Easy to reuse. Provides for easy relocation of fixtures, if required. Reduce reverberation time within the classroom.	Tile collects dust and adsorbs odors. Tile and plenum requires periodic maintenance. Due to the grid organization, acoustical tile ceilings may not be as adaptable to renovations as a gypsum board ceiling. If the T-bar ceiling space has a return air plenum, as is common, this type of air handling design is difficult to clean. Many materials are used in the space above the T-bar ceiling. Material off-gassing, odors and microorganisms in the plenum area can spread and be distributed to other areas. (Avoid this by installing return air systems using dedicated metal ductwork with access hatches for inspection and cleaning.)

Coatings

Paints and other coatings affect indoor air quality and may produce hazardous waste. Most conventional products off-gas VOCs, formaldehyde and other chemicals that are added to enhance product performance and shelf life. These chemicals, especially in combination, may pose health concerns. Fortunately, high quality, low-toxicity and low-VOC substitutions are now available for all these products. It is recommended that only paints that meet Section 01350/DHS Standard Practice emission criteria be used in classrooms and other high occupancy areas.

Adhesives and Sealants

Many conventional construction adhesives, sealants, caulking, grouts, and mortars used to bond structural components are solvent-based, toxic and may off-gas large amounts of toxic VOCs (including solvents and aromatic hydrocarbons). Avoid using products, which include butyls and urethanes, indoors. Low VOC, low-toxic, water-based formulations are now available for many more applications.

Specify the least toxic/lowest VOC product suitable for the application and require installer to use the smallest amount of adhesive necessary to fulfill the manufacturer’s performance specifications for that product.

Non-solvent adhesives have 99% less hazardous emissions than solvent adhesives, although their emissions may last much longer. When used to adhere dense floor coverings, emissions will be low, but prolonged. Yellow and white glues are recommended. When specifying sealants, consider using only silicone sealants in interior areas. However, some silicone sealants do contain acetic acid, which has an

unpleasant odor that may be irritating. Other environmentally preferable alternatives include acrylics and siliconized acrylics. They are typically the safest to handle and have the lowest solvent content. All other sealant types, especially butyl sealants, emit VOCs and other toxic compounds, and emission test data should be requested and reviewed prior to including the product in a specification.

Adhesives and sealants are also covered by should also be low emitting and be in compliance with Section 01350/DHS Standard Practice emissions testing. Many products are tested as an assembly which includes any applicable adhesives. Be sure to check the test results or web listing to see if a specified adhesive has been tested with the flooring or other material.

Applicable Codes

Applicable state and local school district design and materials standards.

California State Ventilation and Indoor Air Quality Code.

State of California, South Coast Air Quality Management District Rule #1168 for adhesives and sealants.

State of California, South Coast Air Quality Management District Rule #1113 for coatings.

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California Integrated Waste Management Board (CIWMB) Database of Recycled Content Products. www.ciwmb.ca.gov/rcp.

Center of Excellence for Sustainable Development, U.S. Department of Energy, Energy Efficiency and Renewable Energy Network (EREN). Provides web pages on green building and green development. www.sustainable.doe.gov.

Los Angeles, City of. Sustainable Building Reference Manual. Contact: Nady Maechling. (213) 473-8226. Contains detailed local information and many resources.

Maryland State Department of Education. Building Ecology & School Design; Technical Bulletin: *Carpet and Indoor Air Quality in Schools*; and *Interior Painting and Indoor Air Quality in Schools*. To order, contact the Maryland State Department of Education, Division of Business Services, School Facilities Branch, 200 W. Baltimore St., Baltimore, MD 21201. Phone for Capital Projects Assistant Manager, (410) 767-0097.

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Acknowledgments

The following resources were particularly useful for developing this chapter:

Sustainable Building Task Force. The Sustainable Building Task Force was formed by a number of state agencies to institutionalize sustainable building practices into state construction projects. The task force meets on a monthly basis to discuss strategies for implementing sustainable building practices in all future and current state buildings, including those leased by the State. Visit www.ciwmb.ca.gov/GreenBuilding/TaskForce/ for more information and links to member agencies.

Santa Monica, City of. 1999. *Santa Monica Green Building Design and Construction Guidelines*. Available on-line at <http://greenbuildings.santa-monica.org/>.

Partnership for Resource-Efficient Schools. 1998. *Recommended Best Management Practices Promoting: Energy Efficiency, Resource Conservation, and Environmental Quality*. A publication of the Seattle Public Schools Building Excellence Program and the City of Seattle (Solid Waste Utility, Water Department, and Seattle City Light). The following Web site provides information about the Partnership for Resource-Efficient Schools project and a link to download the Best Management Practices manual: www.seattle.gov/util/services/.

BUILT GREEN™ Handbook. 1999. BUILT GREEN™ is a program of the Master Builders Association of King and Snohomish Counties (MBA) in partnership with King County and Snohomish County, Washington. www.builtgreen.net/.

Maryland State Department of Education. Building Ecology & School Design; Technical Bulletin: *Carpet and Indoor Air Quality in Schools*; and *Interior Painting and Indoor Air Quality in Schools*. To order, contact the Maryland State Department of Education, Division of Business Services, School Facilities Branch, 200 W. Baltimore St., Baltimore, MD 21201, (410) 767-0097.

GUIDELINE IS1: CARPETING

Recommendation

Select a carpet, carpet tile, cushion, pad, and adhesives that:

- Cause minimal pollution (low-volatile organic compound emissions).
- Are durable. Compare warranties.
- Are made with recycled-content.
- Can be easily cleaned and maintained.
- Are constructed so as to prevent liquids from penetrating the backing layer where moisture under the carpet can result in mold growth.
- Can be easily removed without the use of toxic chemicals.
- Can be easily replaced.
- Absorb sound.

To reduce waste during construction and installation consider the use of carpet tile instead of broadloom carpet, if applicable. Carpet tile also allows for the replacement of worn or damaged sections without replacing the entire carpeted area. This helps to keep maintenance and replacement costs lower and can extend the life of the carpet.

Where practicable, select a carpet and pad that is recyclable at the end of its life. Even when made from recycled materials and/or with potential for recycling at the end of their useful lives, carpet service life is relatively short compared to other flooring alternatives. Energy and other resources are consumed in the recycling process. Also, some carpet recycling does not re-use the material as carpet but rather in a lower form of carpet materials. Due to these factors, carpet should be used only when its performance characteristics outweigh its environmental costs. Most carpet produced in the United States is manufactured in the state of Georgia; therefore energy is consumed in the transportation of the product to California.

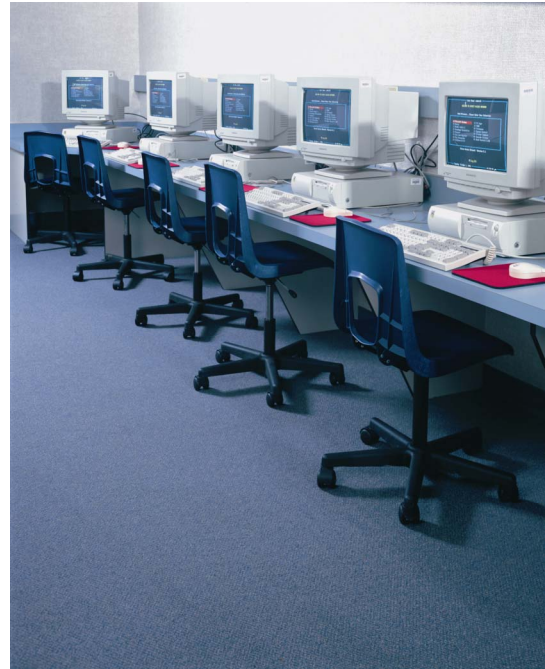


Figure 27—Recycled/Reused Carpet Tiles

This environmentally sound, no-VOC carpet line is leased and maintained by the manufacturer who reduces waste by recycling and reusing the carpet tiles. The up-front and maintenance costs are lower and the environmental and health benefits are substantial. Photo courtesy National Renewable Energy Laboratory (PIX # 03041).

	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Follow recommendations from the Carpet & Rug Institute (CRI) for installation and maintenance.

Description

Because carpet systems off-gas when new, carpet is a potential source of indoor air pollution. Typically, most volatile organic compounds (VOCs) are emitted from the backing, adhesive, and seam sealer rather than from the wear layer. The specifications listed under the Design Details section below provide guidelines for procurement of low-emissions carpeting and adhesives.

Particles and debris accumulate on carpets, exposing occupants who regularly use the room. Easy and effective cleaning of carpets is critical to reduce long-term exposure to pollutants. Cleaning requirements include both vacuum use and wet-extraction processes. Most of the dirt, dust, grit and moisture tracked in on shoes is trapped within the first 12 to 15 feet of the carpet. Providing walk-off mats in this area can reduce the amount of cleaning required and reduce maintenance costs.

Moisture trapped below a carpet can result in mold growth and the release of mold spores and mold metabolic products (microbial VOCs) into the air. Concrete must be sufficiently cured, dried, and/or sealed before carpet is installed over it.

CRI's Green Label Plus program makes it easy to choose a carpet or rug that meets standards in Section 01350 and DHS' Standard Practice. The CRI Green Label Plus logo displayed on carpet and adhesive samples informs customers that the product type has been tested and certified by an independent laboratory and has met stringent criteria for low emissions.

Applicability

Most suitable for classrooms, libraries, and administrative areas.

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

Integrated Design Implications

Flooring type selection affects thermal comfort (carpeting retains heat longer than most resilient flooring, for example) and lighting (floor finishes with high reflectivity enhance daylighting). Recycle clean construction/installation waste carpet, if possible (require subcontractor to take back for recycling). Research carpet reclamation programs if the project involves disposing of an existing carpet. Flooring type also affects acoustics, noise control, safety, and maintenance. Complete all painting and other adhesive use prior to the installation of carpets to prevent VOC "sinks."

Cost Effectiveness

A typical nylon carpet installation costs between \$2.20/ft² and \$3/ft². Recycled content padding and carpeting are priced competitively, with a life expectancy between 10 and 15 years.

Costs	L		■	
	M			■
	H			
		L	M	H
		Benefits		

Benefits

Although not as material efficient as durable flooring, recycled content and recyclable flooring are material efficient. Carpeting provides acoustic benefits not available with other flooring types. Carpeting provides a more comfortable surface than hard flooring. This is an especially important consideration for classrooms with small children who spend more time sitting or laying on the floor. Section 01350/DHS Standard Practice or the equivalent Green label Plus certification programs provide easy access to databases of low emitting carpet products. Low-toxic adhesives minimize the indoor air pollution load and health risks to both installers and occupants.

Design Tools

See the Overview at the beginning of this chapter.

Design Details

If regular, effective maintenance and cleaning cannot be assured (due to budget constraints, inadequately trained staff, or other reasons), then carpeting should not be used. (See the Operations and Maintenance discussion below).

Emissions Criteria

The adhesives used to attach face fibers to backing materials and the adhesives used to install carpets usually contain VOCs. These compounds may not be listed on the container or on manufacturer's literature if they are considered exempt under the definition of VOCs in the Clean Air Act regulating reactive chemicals known to be precursors of photochemical smog. However, many of the exempt VOCs are of concern for indoor air quality. Depending on the strength, type, and duration of emissions from these chemicals, carpet can be a significant source of indoor air contamination.

The CRI has developed a program known as the CRI Indoor Air Quality Carpet Testing Program. This includes the Green Label and Green Label Plus testing procedures. While the Green label program should be a bare minimum requirement for carpet selection, it is not a sufficient indicator of carpet emissions into indoor air. Green Label Plus has been developed in cooperation with California's Department of Health Services (DHS) and the Sustainable Building Task Force and is deemed equivalent to Section 01350/DHS Standard Practice emissions testing.

It is recommended that all carpet products (virgin and recycled-content) and adhesives meet the emissions criteria outlined in Specification Section 01350, and the subsequent DHS Standard Practice, or the equivalent Green label Plus to ensure improved IAQ benefits required for a high performance school. Additionally, the specific criterion for 4-PC emissions applies to carpets.

- Under a test over a 96-hour time period after 10 days of conditioning (as described in Specification Section 01350 and DHS Standard Practice), the carpet should emit less than 10 $\mu\text{g}/\text{m}^2\text{-hr}$ of 4-PC.
- The proposed specifications should require that the contractor submit a compliance table, which documents the required performance criteria (as provided in the specifications) and actual test results as well as a letter from the laboratory stating the product has been approved for use in the specific application for which it is intended.

School designers should also require manufacturers to submit the following information for each product making up the carpet system:

- The ingredients, including identification and quantified amounts of substances that are listed on either: (a) the International Agency for Research on Cancer List of Chemical Carcinogens; (b) the Carcinogen List of the National Toxicology Program; or (c) the Reproductive Toxin List of the Catalog of Teratogenic Agents.
- Emission factors for VOCs contained in the product, in $\text{mg}/\text{m}^2\text{-hr}$.
- Product TVOC emission factor (after 10 days of conditioning in clean air at 1 air change per hour then tested at 24, 48, and 96 hours ($\text{mg}/\text{m}^2\text{-hr}$)).
- Emissions test protocol used.
- Organization evaluating the product.

Type of Carpet

When selecting carpet, space classification, desired design life, and desired aesthetics are the traditional considerations.

Look for low pile, dense loop, and needle-punch carpet types, which trap the least soil and show the least wear. One good choice for schools is a low-nap, all-nylon carpet, which is less attractive to dust mites and mold.

Natural carpets are made from grasses, cotton, and wool with minimal treatment. However, natural carpet materials can harbor insects and support mold growth, as well as being more difficult to maintain. For these reasons, natural carpet is not recommended for schools.

Recycled Content

Select a carpet with a minimum of 50% total (yarn and backing) recycled content (minimum 25% post-consumer recycled content). The manufacturer's warranty period should be reserved for such carpets, and those with a shorter life span should be used in low-traffic areas. Type One Commercial Carpet is

available, either a tile or a broadloom, with backing made with post-consumer plastic (typically nylon, polypropylene or a mix of these two plastics). Some manufacturers offer product lines that contain 50% or more recycled content plastic by weight and above. Generally commercial carpet made from nylon 6 or 6,6 is the most durable type of carpet. At this writing, at least two manufacturers supply products made with 100% recycled nylon. Many manufacturers will offer a surface wear warranty of 15 years or more (e.g., 10% surface wear by weight). Some carpet manufacturers also offer reclamation programs to facilitate carpet recycling at the end of its useful life.

The life expectancy of recycled content carpet is between 10 and 15 years.

Carpet Tiles

Carpet tile systems save money and resources. They generate less waste during installation. They are also easily removed and replaced during renovation, and individual tiles can be easily replaced as needed, considerably extending the average service life of the carpet. A few disadvantages to carpet tiles are that they may be more subject to vandalism by students who discover the system is modular. Also, flooding or spills may cause moisture to infiltrate the joints, creating potential IAQ hazards.

Refurbished Carpet

At least one manufacturer refurbishes commercial carpet for reapplication as modular carpet tiles. The manufacturer super-cleans, re-textures and overprints new colors and patterns to previously used carpet. The end product has a warranty and costs about half of new. Refurbished carpet is considered a 100% post-consumer recycled content product. However, in some instances, manufacturers will add new backing to the refurbished product, which would reduce the amount of post-consumer recycled content.

Pad

Specify carpet pad with the highest percentage of recycled content (and is compatible with selected carpet product). Fibrous pad is also available in commercial grades made from recycled synthetic and natural fiber from textile mill waste.

Recyclability

Carpet recycling is a priority because of the large volumes being disposed and its resistance to decomposition. A national agreement for carpet stewardship called the Memorandum of Understanding for Carpet Stewardship (MOU) was signed on January 8, 2002. The MOU states that, "the amount of carpet that is reaching the end of its useful life and entering the waste stream is ever-increasing: estimated total discards for 2002 are 4.7 billion pounds." Fully recyclable carpets are just newly available. Many manufacturers now take the carpet and carpet tile at the end of its useful life and will recycle it back into new carpet backing (i.e., closed loop system).

Installation

Where new carpet odor is a concern, require suppliers to unroll and air out carpets in a warehouse before bringing them into the building. Tests indicate that carpet emissions will decrease significantly within 48 to 72 hours with proper ventilation. Ideally carpets should be installed at least two weeks before the school is occupied.

When installing carpet over concrete floors, ensure that the concrete is sufficiently dry prior to installation. If water vapor emissions from the concrete floor are greater than 5 lb/1,000 ft², a vapor emission control treatment should be applied to the floor until emissions meet the maximum levels allowed by the carpet manufacturer.

Specify the least toxic carpet adhesive system compatible with selected carpet products. Section 01350/DHS Standard Practice and Green Label Plus list carpeting and adhesives that have been tested as an assembly and should be specified as such. Require installer to use the smallest amount of adhesive necessary to fulfill the manufacturer's performance specifications for that product. Alternately, specify tack-down carpet to eliminate gluing, while taking precautions to prevent potential mold and mildew growth under the carpet.

If covering a large surface area, carpet and other fabrics can act as "sinks" for the adsorption of VOCs from other sources (during application of paint and other finish coatings, for example) and re-emit them later. To minimize this "sink" effect and subsequent extended re-emitting of VOCs, install soft surfaces as late as possible and/or remove or cover all soft surfaces and use direct ventilation until the offensive coating dries.

Air out space(s) where carpet has been installed for a minimum of 72 hours. With a central HVAC system, the ventilation supply should be on, the return grille(s) sealed, and windows open.

In renovations, carpet installation should occur only when the school building is not in use. An exception would be for small installations in which the space can be exhausted directly to the outdoors, causing the room to be under negative pressure relative to adjacent spaces in the building. Extra ventilation should continue for a minimum of 72 hours after installation.

To reduce the risk of mold growth on carpet, do not install carpet near water fountains, sinks, showers, pools, or other locations where it may get wet.

Operation and Maintenance Issues

Carpeting acts as a highly-effective reservoir for allergens such as dirt, pollen, mold spores, pesticides and other toxins, which are present outdoors and often introduced into the indoor environment in dirt from occupants' shoes. Old carpeting may pose more health risks to its occupants than new. Microbial contamination resulting from water infiltration or inadequate cleaning procedures is a potential problem. The presence of fungi and dust mites can exacerbate allergies. To help ensure longer life, maintain appearance, and help protect indoor air quality, carpet requires regular vacuuming with a well-

functioning vacuum cleaner equipped with strong suction and a high-performance filtration bag. Walk-off mats should also be provided at all major entrances.

Spills must be cleaned up immediately and thoroughly. If carpet becomes saturated and water is not quickly removed (less than 24 hours), experience suggests that carpeting will have to be discarded.

See CHPS Best Practices Manual Volume IV: Maintenance and Operations for a more detailed discussion on this topic.

Commissioning

Airing out the space during and after carpet installation is essential and is recommended by the CRI, the U.S. Environmental Protection Agency, and the U.S. Consumer Product Safety Commission. The typical recommendation is to continuously operate the building ventilation system at normal temperature and maximum outdoor air during installation and for 72 hours after installation is completed. A longer flush out of the entire building should also be considered. CHPS recommends flushing out the building for 30 days after all VOC emitting materials have been installed. The CRI *Standard for Installation of Commercial Carpet* (CRI 104) includes Guidelines for Maintaining Indoor Air Quality During Carpet Installation and other installation procedures.

References/Additional Information

California Integrated Waste Management Board (CIWMB) Database of Recycled Content Products:
www.ciwmb.ca.gov/rcp.

Carpet and Indoor Air Quality in Schools. Published by the School Facility Branch of the Maryland State Department of Education. To order, contact the Maryland State Department of Education, Division of Business Services, School Facilities Branch, 200 W. Baltimore St., Baltimore, MD 21201, phone for Capital Projects Assistant Manager, (410) 767-0097.

Carpet & Rug Institute (CRI) website, www.carpet-rug.com. Provides information on selection, installation, and maintenance.

Comprehensive Procurement Guidelines. The recommended recovered material content for polyester face carpet fiber is listed as 25% to 100% PET resin (recycled plastic soda bottles). Envirotech (Image) and Envirolon (Talisman) lines meet this standard. The Environmental Protection Agency is expanding its definition of environmentally preferred carpet by including nylon fiber with recycled content backing (i.e., Collins and Aikman, Shaw, Interface). These new standards will soon be reflected in the CPGs. For more information on carpet manufacturers and suppliers and a GSA link, visit EPA's Web site: www.epa.gov/epaoswer/non-hw/procure/products/carpet.htm.

Environmentally Responsible Carpet Choices, Sustainable Practices and Opportunities Plan. A project of the Department of Interior, National Park Services. www.nps.gov/sustain/spop/carpet.htm.

Standard for Installation of Commercial Carpet, CRI 104. An industry minimum commercial installation standard published by the CRI. Contains detailed outlines of technique, procedure, and terminology used in specification writing, planning, layout, and installation. Includes accepted tools and materials, floor preparation, installation in special areas, diagrams and charts. (800) 882-8846.

GUIDELINE IS2: RESILIENT FLOORING

Recommendation

Select resilient flooring and adhesives that:

- Cause minimal pollution (low-volatile organic compound emissions).
- Are durable. Compare warranties.
- Are made with recycled-content.
- Can be easily cleaned and maintained.
- Are material efficient.

Description

Vinyl composition tile (VCT) has been the finish of choice for uncarpeted areas in schools, due to its durability and low maintenance. However, VCT is made of non-renewable resources and there is concern about environmental degradation associated with its production (see the Vinyl Debate section in this chapter’s Overview).

Linoleum, often the choice of environmentally conscious designers, is durable as well and is produced from minimally processed, rapidly renewable materials. However, it also poses some risks, including offensive odor during its early months and, sometimes, much longer.

Chlorine-free resilient flooring and recycled content rubber (tire-derived) tile/sheet flooring are also becoming available. The compositions of these products differ from VCT in that they do not contain vinyl.

With respect to materials efficiency and air quality, there are important distinctions between material types, installation methods, and maintenance requirements. Final selection will depend upon the application and cost constraints.



Figure 28—Natural Linoleum

Natural linoleum was one of the renewable resources used in the construction of the Chesapeake Bay Foundation Philip Merrill Environmental Center. Photo Courtesy National Renewable Energy Laboratory (PIX # 10885).

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Applicability

Most suitable for high traffic areas not requiring the acoustic benefits of carpet, such as hallways, kitchens, cafeterias, art rooms, toilets or anywhere that liquid spills are likely. Resilient flooring is also suitable for classrooms in cases where school districts have a no carpet policy.

Applicable Codes

See Applicable Codes section in this chapter's Overview.

Integrated Design Implications

Flooring type selection affects thermal comfort (carpeting reduces heat loss slightly more than resilient flooring, for example) and lighting (floor finishes with high reflectivity enhance daylighting). Resilient flooring does not generally provide the acoustic benefits of carpeting. Teacher preferences should also be considered, if feasible. Resilient flooring is more easily cleaned than carpeting and may last considerably longer. Some resilient flooring requires application of sealants and waxes, which result in periodic increases in occupant exposure to the chemicals emitted from these products. Recycle waste flooring, if possible (require subcontractor to take back for recycling).

While often considered environmentally preferable, linoleum contains linseed oil, which does off-gas. The oxidation products when the emissions occur are odorous compounds that may affect the acceptability of linoleum as a floor covering. It is recommended that resilient flooring products be tested under Section 01350/DHS Standard Practice emission testing procedures to ensure good indoor air quality will be maintained. The CHPS Compliant Materials Table (www.chps.net) list products which have been tested and approved for use in a typical classroom.

Cost Effectiveness

Costs will vary with type of product chosen. Cork and vinyl-free resilient flooring products have recently entered the marketplace and may be more expensive than VCT products.

The designer should obtain cost data.

	L		
Costs	M		
H			
	L	M	H
	Benefits		

Benefits

- Resilient flooring is highly durable.
- Recycled content flooring and recyclable flooring are material efficient.
- True linoleum is made with renewable materials (linseed oil, cork, wood dust and jute). Its known ingredients are minimally processed, commonly available, and biodegradable. Linoleum is durable.

- Low-toxic adhesives and coatings minimize the indoor air pollution load and health risks to both installers and occupants.

Design Tools

See the Overview at the beginning of this chapter.

Design Details

Most resilient flooring products produce some air pollutant emissions; so do their setting and maintenance products. It is recommended that all resilient flooring products meet the emissions criteria outlined in Specification Section 01350 and DHS' Standard Practice.

Natural linoleum is another chlorine-free product, made out of all nearly natural ingredients. Linoleum is highly durable, does not show scuffs or scratches and is flexible and resilient. Linoleum is naturally biodegradable, therefore reducing waste problems, does not burn easily and is waterproof. Linoleum emits far lower levels of contaminants than other products, however it is recommended that all products be tested to be sure they meet the emissions criteria outlined in Section 01350 and DHS Standard Practice. Linoleum emits a fairly strong smell when the flooring is newly installed. The smell comes from linseed oil's oxidation products, which are primarily fatty acids—compounds that react with oxidants to produce new chemicals that have a strong smell even at very low concentrations. Emissions of odors have been measured and observed on aged linoleum as well.

Resilient textile flooring is a newly formulated product that comes in 1-m² (39 in. x 39 in.) tiles, comprising a sandwich of very different materials that is designed to come apart for recycling. Developed as part of the specific manufacturer's corporate sustainability policy and initiative, resilient textile flooring is recyclable, durable, and manufactured using renewable energy. Acoustically it performs like carpet, according to the company. The manufacturer has targeted schools and hospitals as its primary markets, because both those settings benefit from the comfort and acoustic qualities of carpet but struggle with the maintenance and cleanliness issues.

Cork is a natural material and harvested from trees in a sustainable manner; the bark is peeled off the tree in nine year cycles without harming the tree. Cork flooring is durable, fairly easy to clean, thermally insulating, and naturally moisture-, mold-, rot-resistant and has good acoustical properties. Drawbacks are its high cost and high-embodied energy (because it is imported and is energy intensive to ship to North America). Also, some flooring manufacturers use hazardous materials as binders and in installation. It is recommended that binders, adhesives, and coatings meet Specification Section 01350 and DHS Standard Practice specifications. If Specification Section 01350/DHS Standard Practice has not been used to test particular products, request and carefully review the MSDS and ASTM emissions test data for these materials. Emissions tests of cork flooring have shown that some of the binder elements are emitted. Some chemicals emitted from cork flooring are toxic at elevated concentrations.

Recycled rubber tile and sheet goods made with waste tires are also available. These are material efficient choices for heavy traffic and utility areas, but may be strong volatile organic compound (VOC) emitters and odor sources.

Specifications should require the installer to use the smallest amount of adhesive necessary to fulfill the manufacturer's performance specifications for that product. (In some applications, interlocked rubber tiles and heavy linoleum can be laid without adhesive.)

When installing resilient flooring over concrete floors, ensure that the concrete is sufficiently dry prior to installation. If water vapor emissions from the concrete floor are greater than 3 lb/1,000 ft², a vapor emission control treatment should be applied to the floor until emissions meet the maximum levels allowed by the flooring manufacturer.

Specify adequate ventilation during installation and flush out the building for a minimum of 72 hours after installation.

Operation and Maintenance Issues

Maintenance products are also significant pollution sources. Flooring with sealed "low maintenance" surfaces should be preferred, both for reducing maintenance costs and the use of cleaners and waxes. It may be possible to require manufacturers to provide cleaning and maintenance product specifications and application procedures. In these cases, the chemicals in these products should be evaluated along with the emissions from the flooring itself.

Low-VOC cleaners and sealers are available. Be sure to consult with the manufacturer when specifying sealers and other maintenance products. Use of the wrong products can cause problems, especially with natural linoleum. To help ensure longer life, maintain appearance, and help protect indoor air quality, resilient flooring requires proper cleaning/vacuuming. Walk-off mats should also be provided at all entrances to prevent dirt from being tracked onto the flooring surface.

See CHPS Best Practices Manual Volume IV: Maintenance and Operations for a more detailed discussion on this topic.

Commissioning

None.

References/Additional Information

See resources listed in this chapter's Overview.

Also see the following articles from Environmental Building News:

"A New Chlorine-free Competitor to Vinyl Flooring," Volume 7, No. 10, November 1998. (About Amtico Stratica flooring.)

"Solenium—The First Resilient Textile Flooring," Volume 8, Number 5, May 1999.

"Cork Flooring," Volume 5, No. 1, January/February 1996.

GUIDELINE IS3: CERAMIC TILE / TERRAZZO

Recommendation

Select locally available, recycled content ceramic or clay tile. If installing terrazzo, avoid the epoxy type; substitute cementitious terrazzo where appropriate. Specify low-toxic adhesives, grouts, caulks, sealants, and setting materials.

Description

Recycled content ceramics, clay tiles, and terrazzo (made with cement and crushed stone) are durable and low-emission interior finishes. Maintenance of these flooring types may require toxic or VOC emitting products however.

Terrazzo is a family of flooring materials that incorporates natural marble chips and other aggregates in a cementitious or epoxy mixture, which is usually applied wet and allowed to cure in place.



Figure 29—Ceramic Tile With Recycled Content

TerraTraffic from Terra Green Ceramics is made in the USA from over 55% recycled glass and select ceramic materials. Photo reprinted with permission from Terra Green Ceramics. www.terragreenceramics.com/.

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Applicability

Tile is most suitable for traffic areas requiring high durability and low maintenance, but not requiring the acoustic benefits of carpet, such as entryways and toilets.

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

Integrated Design Implications

Flooring type selection affects thermal comfort (carpeting retains heat longer than resilient flooring, for example) and lighting (floor finishes with high reflectivity enhance daylighting). Tile/terrazzo flooring does not provide the physical comfort or acoustic benefits (tile flooring does not absorb sound and does not reduce impact noise transmission to spaces below) of carpeting, so this, along with teacher preferences,

should be considered. As part of the C&D plan, recommend that the subcontractor take back waste tile for recycling.

Cost Effectiveness

Terrazzo costs between \$5/ft² and \$10/ft² to install, and will last the life of the building. Ceramic tile costs between \$6/ft² and \$12/ft² installed, and will last 40 to 80 years. Recycled-content tile can be higher priced than average tile products. Low-toxic adhesives used with tile and terrazzo are generally available locally and at competitive prices.

Costs	L	■	□	□
	M	□	□	■
	H	□	□	□
		L	M	H
		Benefits		

Though costly to purchase and install, the ceramic tile/terrazzo *life-cycle* cost is among the lowest of all finishes for some applications, due to its long life and minimal maintenance. Ceramic tile with recycled content may cost 1.5 to 2 times more than conventional.

Benefits

Use of local or regionally manufactured ceramics reduces the high transportation consumption/cost associated importing with this heavy building material. Ceramics and terrazzo (made with cement and crushed stone) are durable and low emitting. Some tile is available with recycled content (up to 70%), such as scrap glass and feldspar waste from mining, which is material efficient, durable, and low- to non-emitting. Some manufacturers also have added heat recovery, water recovery, and clay mine restoration measures to their operations that exceed industry norms, which is ecosystem-protective.

Low toxic adhesives and coatings minimize the indoor pollution load and health risks to both installers and occupants. It is recommended that adhesives meet the emissions criteria outlined in Specification Section 01350 and DHS' Standard Practice.

Design Tools

See the Overview at the beginning of this chapter.

Design Details

Tile is a packaging-intensive product. Specify recyclable packaging. Check with the manufacturer to see if there is a collection program in place at no cost to owner or contractor. Packaging and construction waste should be included in the C&D plan.

Terrazzo

The two types of binders used in terrazzo flooring raise different environmental issues during installation. Cementitious terrazzo is composed of inert ingredients mixed with water. The primary installation hazard is dust during mixing and grinding. The installation of epoxy terrazzo, however, requires the use of

OSHA-approved respirators, protective gloves, and safety glasses, as well as ventilation with 100% fresh air. The epoxy matrix contains a number of toxic materials. For these reasons, use of the epoxy type terrazzo should be avoided.

A variety of techniques are available to add designs—for example, cultural, school, community symbols—for use as teaching tools or school identity. Such artistic/educational amenities, however, will increase the cost.

Tile

Avoid the use of imported tile. The glazing used on imported tiles can contain lead, which is toxic and a potential health threat. Another disadvantage is that imported tiles have high-embodied energy.

Mortar, Adhesives, Caulking, and Sealants

Cement mortars, usually modified with acrylic additives, are the safest to handle for tile setting and offer the best performance for most applications. All plastic adhesives contain some solvents and will contribute to indoor air pollution. Where adhesives and caulking must be used, such as for cove bases and flexible joints, choose a low-solvent content product such as an acrylic. Cement-based, cellulose-based and acrylic-modified grouts are safe and have low emissions. Glazed tile and high-fired tile usually do not require sealers. If a porous tile is chosen, the safest sealers are the low-volatile organic compound, acrylic, or water-based silicone types. Check with the tile manufacturer to select the lowest VOC, low-toxic mortars, sealers, caulks, and adhesives that will provide the desired performance. Review MSDS and emission test data for sealers, caulks, and other adhesives to understand their impact on indoor air quality.

Installation

- Specify adequate ventilation during installation.
- Tile is a non-porous surface and should be installed prior to porous, fleecy, and absorbent materials, which can act as “sinks”, absorbing VOCs from other materials and later re-emitting them.
- Require the installer to use the smallest amount of adhesive and sealant necessary to fulfill the manufacturer’s performance specifications for that product.
- Perform building flush out after floor installation.

Operation and Maintenance Issues

Terrazzo flooring should be sealed to prevent absorption of dirt and stains. Water-based sealers are available. Maintenance for ceramic tile varies with the type of surface and grout. Most unglazed tile is sealed after installation. Once floors are sealed, they may require re-sealing throughout their lives, in which the process may impact indoor air quality. Walk-off mats should also be provided at all entrances to help ensure longer life, maintain appearance, and help protect indoor air quality. Three types of

binders are used in terrazzo flooring with each type having its own maintenance requirement. It is important that the custodial staff knows which type of floor it is maintaining and the proper procedures and products for that type of flooring.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter.

GUIDELINE IS4: CONCRETE FLOORING

Recommendation

Select concrete flooring, made with fly ash. Use low-toxic adhesives, sealers, and wax.

Description

Finished concrete flooring is an integral system of slab and finish, produced by adding colorants and a sealer to the topping concrete (colorized cement) either before or after it cures. This is a resource efficient system as a finished flooring system is not needed. The concrete is often stamped with tile patterns and grid lines that also control cracking.

Applying a colorized stain to a cured concrete surface produces stained concrete flooring.

Both types of concrete flooring provide a durable and low maintenance finish. Saw-cut and other designs and colors can add interest and educational value.

Fly ash is a byproduct of burning coal for electricity production. Fly ash is captured from the boiler exhaust and was originally treated as waste and disposed of in landfills. Over the past decade the use of coal combustion products that are recovered and used for productive uses has increased by 50%. Fly ash acts as a lubricating agent in concrete causing it to flow and pump better while using 10% less water. Fly ash is cost effective as the amount of concrete needed is reduced. (Refer to: www.flyash.com/ and www.geocities.com/CapeCanaveral/Launchpad/2095/.)



Figure 30—Installation of Finished Concrete Flooring

Photo reprinted with permission from Davis Colors, Inc. www.daviscolors.com/.

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Applicability

Especially suitable for high traffic areas, such as hallways, cafeterias, and gathering areas. Staining existing concrete flooring is generally appropriate for renovation. Finished concrete flooring with integral colorants is generally applicable to new installations. Concrete may be used for other building surfaces.

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

Integrated Design Implications

Flooring type selection affects thermal comfort (carpeting retains heat longer than resilient flooring, for example) and lighting (floor finishes with high reflectivity enhance daylighting). Concrete flooring adds thermal mass which has an effect on the thermal properties and energy requirements of the space in which it is used. Concrete floors do not absorb sound or reduce impact noise transmission to spaces below.

Cost Effectiveness

Medium (\$3/ft²) to high first cost, depending upon complexity of the installation/design.

Costs	L	■	■	□
	M	□	□	□
	H	□	□	□
		L	M	H
		Benefits		

Benefits

Concrete flooring is highly durable and low maintenance, which conserves materials and reduces potential indoor air quality (IAQ) problems due to maintenance products. Concrete with fly ash is material efficient. Low-toxic coatings minimize the indoor air pollution load and health risks to both installers and occupants.

Design Tools

See Design Tools listed in this chapter's Overview.

Design Details

Selection

Finished systems with integral color added to the entire topping layer are more resistant to damage, and less likely to require re-coloring than systems that are dyed after placing the concrete.

Ask supplier to recommend least toxic, volatile organic compound (VOC)-compliant sealers and wax that will fulfill performance requirements. It is recommended that sealers meet the emissions criteria outlined in Specification Section 01350 and DHS' Standard Practice.

Concrete staining is a technique often used in renovation of existing buildings with existing concrete sub-floors.

A variety of techniques are available to add designs—for example, cultural, school, community symbols—for use as teaching tools or school identity. Such artistic/educational amenities, however, will increase the cost.

Installation

Specify adequate ventilation during installation and flush out the building in accordance with project specifications.

Require installer to use the smallest amount of sealers and wax necessary to fulfill the manufacturer's performance specifications for that product.

Operation and Maintenance Issues

Proper sealing and re-waxing of stained concrete floors will ensure a long service life. Stained concrete flooring requires periodic re-waxing. Maintenance materials should be reviewed for low-VOC emissions.

Walk-off mats should also be provided at all entrances to help ensure longer life, maintain floor appearance, and help protect IAQ.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter:

Lick Wilmerding High School, San Francisco, CA—stained concrete flooring in the corridors of a new library.

Ross Middle School, Ross, CA (Marin County)—Installed stained concrete floors, eliminating all carpet, resilient flooring, and related adhesives. Used low-VOC sealers.

GUIDELINE IS5: WOOD FLOORING

Recommendation

Select environmentally preferable products for wood flooring. Specify low-toxic adhesives, sealers, and finishes.



Description

Environmentally preferable wood flooring types include Forest Stewardship Council (FSC)-certified hardwood, salvaged wood, and laminated or veneered wood products. When permitted by the school district, other environmentally preferable choices include salvaged or reclaimed wood, sources of which are locally available in California. Salvaged flooring is material efficient and considered a 100% post-consumer recycled content product. Points are earned under the CHPS Criteria for FSC certified wood, recycled wood or salvaged wood.

Figure 31—FSC Logo

Trademark reproduced with permission. FSC Trademark © 1998 Forest Stewardship Council A.C.

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

If using hardwood, specify products certified by the FSC. FSC is the accrediting agency for organizations that certify forests as well managed. Other environmentally preferable alternatives to conventional hardwood flooring include a wide range of veneered and laminated products that have a hardwood surface with plywood, MDF, or other materials in the core.

Applicability

Wood flooring is typically now specified for schools only where its performance characteristics make it uniquely desirable: gymnasiums, stages, and dance studios. However, some studies suggest that wood flooring from sustainable forests may be an appropriate flooring material for more functions, including classrooms, especially in regions where desirable species are native.

Applicable Codes

See the Applicable Codes section in this chapter’s Overview.

Integrated Design Implications

Flooring type selection affects thermal comfort (carpeting retains heat longer than resilient flooring, for example) and lighting (floor finishes with higher reflectivity enhance daylighting). Wood floors do not absorb sound or reduce impact noise transmission to spaces below.

Cost Effectiveness

Wood flooring costs between \$6/ft² and \$10/ft². The life expectancy averages 38 years. The cost premium for certified wood ranges from modest to significant, depending upon quantity, type, and current availability.

	L		
Costs	M		
	H		
	L	M	H
	Benefits		

Benefits

FSC-certified wood is eco-system protective. Low-toxic adhesives and coatings minimize the indoor air pollution load and health risks to both installers and occupants. The factory pre-finished products have substantial air quality benefits because no sealer is applied, no sanding is performed, and no finishing is done on site.

Design Tools

See the Design Tools listed in this chapter's Overview, and:

Certified Forest Products Database, Certified Forest Products Council. Web site: www.certifiedwood.org.

Contact: 14780 SW Osprey Dr., Suite 285, Beaverton, OR 97007. Tel: (503) 590-6600. Industry information on suppliers and standards.

Design Details

Selection

Several FSC-certified hardwood-flooring products are available. Look for woods grown in regional forests, which reduce the energy consumption involved in transportation. Woods common to the western area include pine, aspen, spruce, fir, and hemlock. Other forest certification systems exist and each must be evaluated to ensure their goals coincide with the environmental issues discussed in this chapter. The key concepts to understand in comparing forest certification systems include openness and transparency of standards development and governance, objectives of its standards and the rigor of its operating procedures.

Veneered and laminated products that have plywood, composite wood products, or MDF cores are material efficient, but are less easily repaired than solid wood. These are usually pre-finished at the factory with a very durable, low-maintenance finish.

Low-toxic, clear sealers are also available to use as finishes for woodwork. Water-based varnishes, polyurethane, and other finishes for hardwood floors are very durable and much safer to handle than traditional products. Low-toxic solvents, water-based strippers, and all-natural thinners are also locally available.

A word of caution: not all water-based products are low emitters and, in fact, some emissions continue far longer than those from traditional, oil-based sealers. For example, acid cured lacquers can be strong emitters of formaldehyde while they are curing, and for considerable time afterwards. Formaldehyde-free alternatives should be specified for schools. It is recommended that all veneered and laminated products should meet the emissions requirements outlined in Specification Section 01350 and DHS' Standard Practice.

Handling

Specify that woodwork be protected from water damage during transit, delivery, storage, and handling. In addition to saving materials, this helps prevent future moisture/indoor air quality (IAQ) problems.

Installation

A steel track system using wedges to hold the flooring in place, or a "floating system," using edge gluing where necessary, makes wood floors easy to remove. A nail down system is also salvageable, but with some loss of material. Avoid parquet systems, which require a glue-down system and are therefore the least salvageable. Eliminating the use of adhesives reduces the impact on IAQ.

If sanding is done on the premises, the area must be carefully isolated, including sealing off the doors and HVAC system, and using temporary fans. Specify final cleanup with a HEPA filter-equipped vacuum.

Require installer to use the smallest amount of adhesive/coating necessary to fulfill the manufacturer's performance specifications for that product.

For finishing on site, use low-VOC emitting finishes. Hardening oils, varnishes, and acid cured varnishes have prolonged emissions. If edge gluing is required, specify a low toxicity product such as white carpenters or woodworkers glue. If glue-down methods are required, such as for parquet, specify a low-VOC emitting flooring adhesive.

Specify adequate ventilation during installation and for 72 hours afterwards.

Woods naturally emit formaldehyde.

Operation and Maintenance Issues

After being finished with a synthetic topcoat, maintenance requirements for wood floors are similar to VCT and terrazzo. A typical hardwood floor might need re-sanding (which generates airborne dust) every eight to 10 years and can be re-sanded up to five times. Annual screening and re-coating maintains the protective wear layers. Wood flooring is easier to repair than most other materials.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter:

For general information on certified lumber, contact: Certified Forest Stewardship Council, Jeff Wartelle. Tel: (503) 590-6600. Refer also to: www.fscus.org/. Industry group provides information on distribution and other assistance.

Certified Forest Products Database, Certified Forest Products Council, www.certifiedwood.org. Contact: 14780 SW Osprey Dr., Suite 285, Beaverton, OR 97007. Phone: (503) 590-6600. Industry information on suppliers and standards.

Two private companies in the U.S. are authorized to issue the FSC stamp of approval: Scientific Certification Systems (SCS) in Oakland, CA (www.scs-certified.com/forestry/), and SmartWood Certified Forestry, based in Richmond, VT, with an affiliate in Oregon (www.isf-sw.org).

GUIDELINE IS6: BAMBOO FLOORING

Recommendation

Specify domestically produced flooring made from rapidly renewable bamboo (it matures in less than five years). Install and finish with a low toxic, water-based sealer and wax.

Description

Bamboo is a natural material, technically a grass that can reach timber height of 100 ft. It is a renewable resource, requiring no pesticides, fertilizers or irrigation, so it is not labor intensive to farm. Some manufacturers source their bamboo from managed forests using a harvesting method done by hand. This reduces the impact on the local environment in terms of erosion and habitat destruction. Most bamboo used in flooring production is grown in, and imported from, China. Boric acid is sometimes added during the manufacturing process. Bamboo flooring is harder than most common wood flooring, very durable, fast-growing, and dimensionally stable.

Applicability

Suitable wherever wood flooring would be used. Bamboo may also be used as plywood, paneling, and veneer.

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

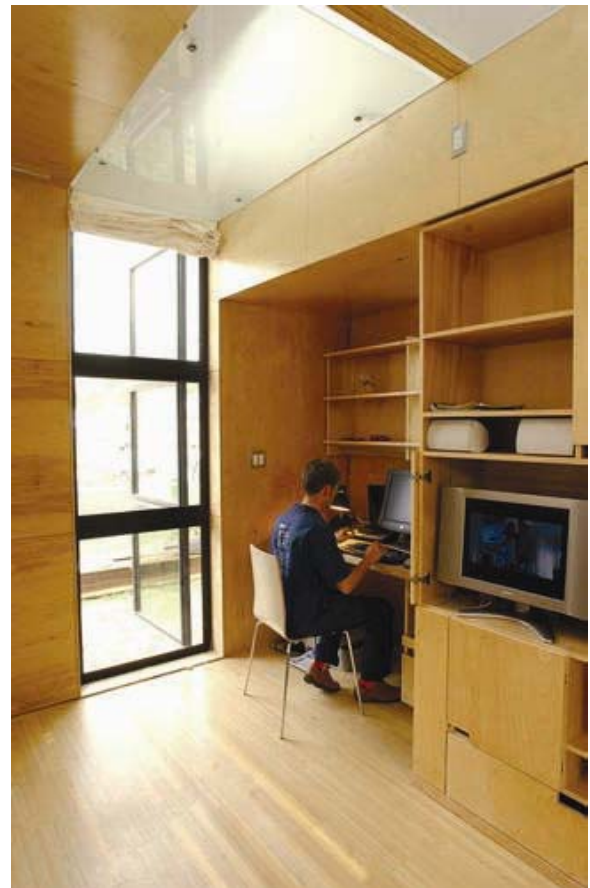


Figure 32—Bamboo Flooring Photo Courtesy: SoundSuckers (permission not requested)

Bamboo flooring in student housing at the University of Virginia. Photo courtesy National Renewable Energy Laboratories (PIX # 12173).

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Integrated Design Implications

Flooring type selection affects thermal comfort (carpeting retains heat longer than other flooring does, for example) and lighting (floor finishes with high reflectivity enhance daylighting). Bamboo floors do not absorb sound or reduce impact noise transmission to spaces below.

Cost Effectiveness

Costs range from \$4/ft² to \$8/ft², which is slightly more than domestic hardwoods. However, bamboo is more durable than wood (25% harder than oak, 12% harder than maple, and 2.5 times more dimensionally stable than maple, according to one manufacturer).

	L		
Costs	M		
	H		
	L	M	H
	Benefits		

Benefits

Bamboo flooring is aesthetically pleasing, low emitting, durable, and produced from a renewable, harvested resource which matures in 3 years. Low-toxic adhesives and coatings minimize the indoor air pollution load and health risks to both installers and occupants.

Design Tools

See the Design Tools listed in this chapter's Overview.

Design Details

Specify use of adequate ventilation during installation. Flooring is best applied by nailing, stapling, or gluing to a wood sub-floor, but can be glued to concrete at or above grade. If installing over concrete, moisture testing is recommended prior to installation.

Operation and Maintenance Issues

Place mats at entrances and exits to trap dirt from incoming traffic. Bamboo floors must be vacuumed or swept regularly with a nylon broom. Use non-alkaline cleaning solutions. Do not mop with water, since excess water can damage the floor.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter, and:

The American Bamboo Society. Web site: www.americanbamboo.org/.

West Coast suppliers include:

Terafren, LLC, 9790 NE Murden Cove Drive, Bainbridge Island, (206) 842-9477 or (800) 929-6333.

Email info@teragren.com or Web site: www.teragren.com .

Bamboo Hardwoods, 3834 4th Ave. South, Seattle, (206) 264-2414. Web site:

www.bamboohardwoods.com/.

Smith & Fong Company, San Francisco, CA., Web site: www.plyboo.com/.

Bamboo Hardwoods Mfg. Co, Seattle, WA. Web site: www.bamboohardwoods.com/.

Bamboo Flooring International Corp., Walnut, CA. Web site: www.bamboo-flooring.com/.

GUIDELINE IS7: GYPSUM BOARD

Recommendation

Specify gypsum wallboard with a minimum 100% recycled content paper facing. Post-consumer recycled content gypsum board core is also available.

Gypsum used for recycling should be clean construction waste, uncontaminated by paint, tape, compounds, adhesives, or other coatings.

Description

Gypsum products are the most common interior panels used due to their fire retardant characteristics and low cost.

Applicability

Suitable for all spaces. High impact gypsum is appropriate for spaces requiring higher than normal durability.

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

Integrated Design Implications

Wallboard installation should be coordinated with the job-site waste reduction plan. Recycle clean construction waste drywall (require subcontractor to take back to the manufacturer for recycling). Several manufacturing facilities in California will accept clean gypsum board construction waste by the ton. Contributing this material back into the manufacturing process increases the amount of post-consumer recycled content in the core of gypsum board products available in the marketplace.



Figure 33—Gypsum Board

Photo courtesy of O'Brien & Company, Inc.

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

When recycling gypsum board from a demolition site, check to see if the joint or topping compounds contained asbestos fibers. Sanding such material will result in the release of fibers into the air. State and federal laws regulate disposal of asbestos-containing materials.

Cost Effectiveness

Gypsum board is the lowest cost option for walls. However, for ceilings, it is competitively priced with drop-in ceilings.

Costs	L			
	M			
	H			
		L	M	H
		Benefits		

Benefits

Gypsum is highly recyclable if not contaminated (with paint or adhesives) and the paper facing is generally made with recycled paper. Use of recycled-content gypsum is material efficient. High impact gypsum is more durable than conventional wallboard and has higher recycled content.

Design Tools

See the Design Tools listed in this chapter’s Overview, and:

Designing with Vision: A Technical Manual for Material Choices in Sustainable Construction. Revised July 2000. A publication of the California Integrated Waste Management Board. See Chapter 8, “Strategies to Reuse Materials and Reduce Material Use in Construction,” Appendix F sample specifications for: Section 09250 Gypsum Board. Designing with Vision can be downloaded in four parts from www.ciwmb.ca.gov/GreenBuilding/. Chapter 8 is in Part D.

Design Details

Selection

Specify a minimum 10% recycled content gypsum board core with 100% recycled content facing paper. (Recycled content board must be specified, since recycled content is not automatically provided).

Consider gypsum produced by a recent innovation, the fibergypsum process. This board, now available in the U.S., has no paper facing but contains recycled wood, paper fiber, and perlite. It is very strong and scratch-resistant, and appropriate for high-wear areas such as schools. Fiberbond from Louisiana Pacific Corporation is an example of this type of gypsum.

Another environmentally preferable option is the use of gypsum board made with synthetic gypsum. Synthetic gypsum is produced with flue-gas desulfurization (FGD) gypsum, fluorogypsum, citrogypsum, and titanogypsum. This technology is not widely available in plants on the west coast, so embodied energy loads should be considered when selecting synthetic gypsum. Also, synthetic gypsum can have a negative environmental impact on agricultural land if it is ever applied as a soil amendment, due to its heavy metal content.

It is recommended that all gypsum board products (virgin, recycled content, synthetic) meet the emissions standards outlined in Specification Section 01350 and DHS' Standard Practice.

Installation

Special care should be taken during the delivery, storage, and handling of gypsum board to prevent to accumulation of moisture on the material or within its packaging. Exposure to moisture can cause mold growth in the gypsum paper facing. To prevent possible interior mold problems, any stored or installed gypsum board showing evidence of moisture damage, including moisture stains, mildew, and mold, should be immediately removed from the site and disposed of properly. Replace contaminated gypsum board with new, undamaged materials.

Specify wet sanding processes during finishing. An exception is that dry sanding may be allowed subject to full isolation of the affected space(s), installation of protective plastic sheeting to provide air sealing during the sanding; closure of all air system devices and ductwork, sequencing of construction to prevent contaminating other spaces with gypsum dust, use of proper worker protection, and owner approval of these measures. Using vacuums during dry sanding to reduce dust can also help protect the health of installers.

Unpainted gypsum surfaces are potent "sinks"—they absorb volatile organic compounds (VOCs) and then re-emit them. Require adequate ventilation during installation of adhesives and other materials that emit indoor pollutants. Where feasible, sequence work to avoid applying VOC-containing materials in spaces with exposed, unpainted gypsum surfaces.

"The Nailer" is a wallboard installation hardware product made by The Millenium Group, Inc. of Estes Park, CO ((800) 280-2304) that replaces wood backing used in traditional gypsum board installation. Besides saving wood, the product is material efficient (contains 25% post-consumer plastic and 75% post-industrial waste) and laborsaving.

Operation and Maintenance Issues

Requires periodic painting for aesthetic purposes. Type of paint determines cleanability. Wallboard is easy to repair.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter, and:

Information on synthetic gypsum may be obtained from manufacturers' Web sites and the following gypsum trade sites: www.gypsum.org/environmental.html and www.gypsum.org/topical.html#synthetic.

Ross Middle School, Ross, CA (Marin County)—Used recycled content gypsum board.

GUIDELINE IS8: ACOUSTICAL WALL PANELS AND CEILINGS

Recommendation

Select formaldehyde-free acoustical ceiling and wall systems with recycled content and high light reflectance.

Description

Acoustical wall and ceiling systems are widely used in school for sound absorption. A variety of products are available including modular wall panels (textile and metal-covered), suspended ceiling tiles (t-bar ceilings), and surface mounted ceiling and wall panels.

Ceiling tile (usually in a T-bar ceiling) is the most common ceiling finish in schools. Because of the large ceiling surface area, the likelihood of its being disturbed during modifications/renovations, and its contact with HVAC systems, it is an important product to consider for air quality and materials efficiency.

Types currently available include recycled content ceiling tiles made of recycled newspaper, mineral wool, perlite, glass fiber, and clay. Look for a minimum recycled content of 79%. (A recent informal survey conducted by the California

Integrated Waste Management Board indicates that the recycled content of acoustical ceiling tiles varies between 18% and 82%). New products on the market can attain 85% recycled content, but with some diminished noise reduction value. Natural fiber acoustic ceiling panels are also available, for both walls and ceilings.



Figure 34—Acoustical Ceiling Tile/T-Bar Installation

Acoustical ceiling tile/T-bar ceiling installation at the Central Market, a recycled content products demonstration project, Poulsbo, Washington. Photo reprinted with permission from O'Brien & Company, Inc.

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Applicability

Use anywhere sound absorption and easy ceiling plenum access is desired.

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

Integrated Design Implications

The T-bar ceiling system integrates with HVAC system ducting layout and operation. Do not use the space above the T-bar ceiling as a return air plenum because it is difficult to clean, and, if there is any off-gassing, odors, or microorganisms from any material in this area, contaminants can spread throughout the air space and be distributed to other areas. Instead, install return air systems using dedicated metal ductwork with access hatches for inspection and cleaning. Recycle construction waste (require subcontractor to take back for recycling).

Make sure insulation is not installed directly over drop-in ceilings. Lighting fixtures, diffusers, and other equipment interrupt the insulating barrier, leading to poor insulating performance. (Often the space above the ceiling is considered an attic space, requiring outside air ventilation.)

Make sure no fiberglass is exposed in the plenum.

High light reflectance levels (light colored) ceiling tiles work in conjunction with electric lighting and daylighting strategies to provide better quality and energy efficient classroom lighting.

Cost Effectiveness

Costs are low.

Costs	L			
	M			
	H			
		L	M	H
		Benefits		

Benefits

Formaldehyde-free acoustical panels with recycled content are available. These panels are considered a material efficient, low-volatile organic compound (VOC) product that promotes healthy indoor environmental air quality. At least one manufacturer offers a reclamation program (see References below for more information).

Acoustical products from wood fiber and other sustainable raw materials are highly durable.

Ceiling tile waste, either from construction or demolition, is non-toxic (as long as lead paint and asbestos were not used on older ceiling installations). One company claims that its panels can be ground up successfully and composted to produce a soil amendment.

Design Tools

See the Design Tools listed in this chapter's Overview.

Design Details

General

It is recommended that ceiling tiles meet the emissions standards outlined in Specification Section 01350 and DHS' Standard Practice. Emission test data and MSDSs for ceiling tile materials should also be obtained and reviewed.

Acoustical materials, including acoustical ceiling tiles, can act as "sinks" for the absorption of odorous or irritating VOCs from other sources (during application of paint and other finish coatings, for example, or from occupant activities) and re-emit them later. Where feasible, sequence work to avoid exposing acoustical ceiling and wall systems while applying VOC-containing materials in spaces with exposed acoustical surfaces. Require adequate ventilation during installation of finish materials that emit pollutants.

Consult with the manufacturer before painting/coating any acoustical material. For example, with most ceiling tiles, the material loses its acoustical properties once it has been painted. Exceptions include several product lines from Tectum, which they certify for up to 10 applications of a non-bridging paint.

Sound absorbing materials such as acoustical wall panels and ceiling tiles should have their sound absorbing properties measured in a laboratory environment. Sound absorption is typically rated in terms of NRC (Noise Reduction Coefficient). The NRC scale ranges from 0.00 (totally reflective) to 1.00 (totally absorptive). Materials with "good" sound absorbing capabilities should have a minimum rating of NRC 0.65. Another acoustical parameter to be considered is the Ceiling Attenuation Class (CAC). Ceiling tiles typically range from CAC 25 to 40. Ceiling tiles with higher CAC ratings allow less sound to pass through and tend to absorb less sound than those with lower CAC ratings. In areas that have noise-producing elements (i.e., Variable Air Volume (VAV) or Fan Powered Boxes (FPB)) in the ceiling space and also have a need for low background noise levels, a high CAC ceiling tile may want to be considered to help reduce background noise from terminal air devices or other noise sources. The important acoustical concept for use within a classroom or other occupied space is reverberation time which is a measure of the echo from sound generated within the space. Acoustical wall panels and ceiling tiles with high NRC ratings absorb noise in the mid frequency range, thus reducing the echo within the space.

Acoustical Wall Panels

Low-density fiberboard is made from paper and wood fiber, and is available made from 100% recycled newsprint. Most processes use no glue. They are suitable for use as acoustic panels. Fiber-free foam panels are also available from some manufacturers.

Ceilings

Coordinate placement of lighting fixtures and other equipment in ceilings to provide clear access for inspection and servicing of HVAC system air filters and other components.

Where daylighting has been incorporated as a design strategy and/or suspended indirect or direct/indirect luminaries used, consider using ceiling tiles with high light reflectance as specified in ASTM Standard E1477 (0.83lr).

Special care should be taken during the delivery, storage, and handling of ceiling tiles to prevent the accumulation of moisture on the material or within its packaging. To prevent possible interior mold problems, any stored or installed ceiling tiles showing evidence of moisture damage, including moisture stains, mildew, and mold, should be immediately removed from the site and disposed of properly. Replace contaminated tiles with new, undamaged materials.

Suspended light fixtures allow more of the ceiling to be covered by the acoustical ceiling tiles. This helps to reduce reverberation time and noise infiltration from the plenum.

Operation and Maintenance Issues

Ceiling tiles and other acoustical materials collect dust as well as absorb and re-emit VOCs. Tile with mineral fiber content may also begin to shed hazardous fiber if disturbed or as it deteriorates. Both problems are a particular concern where the ceiling is used for a return plenum to carry air back to the HVAC air handlers. If this type of return system is used, the tile should be checked for damage and the plenum space occasionally cleaned with a high performance vacuum. If possible, in new and renovation design, HVAC returns should be ducted instead of risking contamination by debris in suspended ceilings (See the Integrated Design Implications discussion above.)

Commissioning

None.

References/Additional Information

See the Overview section of this chapter, and:

Armstrong World Industries has a program for recycling old ceiling tiles, which it collects from building owners and uses as raw materials in the manufacture of new acoustical ceilings. For more information: Phone: (888) CEILINGS. Armstrong ceilings Web site: www.armstrong.com/armstrong_ceilings. (From Newsbriefs, Environmental Building News, Oct 00, p. 6). Armstrong also provides software for analyzing and comparing the acoustical performance of acoustical products.

“Natural-fiber Acoustic Ceiling Panels,” Environmental Building News, Volume 7, No. 4 (April 1998).

Ross Middle School, Ross, CA (Marin County)—Acoustic ceiling tile has 75% recycled content.

Tectum Web site, www.tectum.com/. According to a Tectum rep, their biggest users are schools. For certain applications (e.g., gymnasiums), their product is lowest cost option. In its 1-in. form, it costs about \$2/ft² to the installing contractor.

GUIDELINE IS9: PAINTS AND COATINGS

Recommendation

Specify the least toxic, low-formaldehyde, low- or zero-volatile organic compound (VOC) paint that meets durability and other high performance requirements. Light colored surfaces enhance daylighting.

Description

Emissions from paints and coatings are primarily from evaporating solvents, other VOCs and by-products released after oxidation. Water-based acrylic latex paints are lower in VOCs (<250 mg/L) than solvent-based paints. Low-VOC is generally accepted to mean paint with a VOC content less than 100 mg/L.

Low-VOC paints are usually those in the lighter color ranges. Tinting may increase VOC emissions.

Formaldehyde-free paint is not yet available, but several low-formaldehyde options exist. Select paint with the lowest formaldehyde concentrations possible.

While a variety of low-VOC and zero-VOC paints are now available to choose from, they vary in cost, potential toxicity, and performance. Therefore, paint selection should consider VOC content as well as overall composition and required performance characteristics, including cleanability, hideability (i.e., how well a product conceals a surface), and durability.

Recycled content paint is now available and may be considered for interior and exterior use.

Applicability

All interior painted surfaces.



Figure 35—Paint Being Applied

Photo courtesy Eartheasy

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Applicable Codes

See the Applicable Codes section in this chapter’s Overview, as well as OSHA and local regulations for lead-containing paint (for renovation work).

Integrated Design Implications

Light colors enhance daylighting. Integrate with ventilation system installation/operation to provide proper ventilation during application, curing, and occupancy. Change out HVAC filters following application and before occupancy.

Cost Effectiveness

Costs vary widely with paint type and application. Low-VOC and zero-VOC paints have tended to cost 10% to 30% more than conventional paint, but prices are becoming more comparable as demand/production increases. Many low-VOC paints are now comparable in price to conventional paint.

Costs	L		
	M		
	H		
		L	M
			H
		Benefits	

Benefits

Zero-VOC or low-VOC paints minimize the indoor air pollution load, odors, and health risks to both workers and occupants. Water-based paints are generally safer to handle and can be cleaned up with water, reducing health risks to workers and minimizing/avoiding hazardous waste. Leftover latex paint may be recyclable, thus reducing waste.

Design Tools

See the Design Tools listed in this chapter’s Overview.

Design Details

Where practicable, leave surfaces of exposed structure unpainted.

A paint can be labeled low-VOC yet still contain odorous, irritating, toxic, or otherwise undesirable ingredients such as ammonia, formaldehyde, crystalline silica (a known carcinogen in dust form)¹⁶, acetone, odor-masking agents, glycols, and many other compounds, including fungicides and bactericides. Some of these may not be an *air quality* problem for occupants, but they may be hazardous to painters and those involved in manufacture of the paint. In addition, hazardous ingredients can degrade the natural environment during production and after disposal. Look for water-based paints

¹⁶ Some low-VOC paints contain crystalline silica, a known carcinogen. One manufacturer’s representative stressed that this ingredient is not a hazard in the wet paint — it is an issue only when dried paint is sanded, and dust is generated.

that are low-formaldehyde, zero- or low-VOC, *and* low toxic. While information supplied on manufacturers' data sheets may make certain claims about VOC content or toxicity, speak with technical staff at the manufacturers' headquarters or manufacturing facility to obtain detailed information on product performance and environmental hazards. It is recommended that all paints meet the emissions testing standards outlined in Specification Section 01350 and DHS' Standard Practice.

Specification Section 01350/DHS Standard Practice testing standards require a 10-day conditioning period followed by a 96-hour test period. During this 14-day period many of the more volatile compounds dissipate entirely. In the course of renovation projects and routine maintenance paint may be applied within 14 days (and sometimes within 24 hours) of the classroom being occupied. In this case the paints should be labeled low VOC as well as meeting Section 01350/DHS Standard Practice criteria. The ingredient list should be checked to verify that harmful VOCs are not present that will off gas during the first 14 days.

Specify products containing no lead, mercury, hexavalent chromium, or cadmium. Though regulations have eliminated many toxic components from consumer paint lines, industrial and commercial paints may still contain them. Check the MSDSs; all hazardous contents present at 1% of total weight and listed by OSHA as hazardous must be disclosed. Besides using Specification Section 01350/DHS Standard Practice and the MSDS review, more detailed information can be obtained from the manufacturer and by reviewing emissions test results to determine the type of biocides used as well as the presence of other potentially hazardous ingredients.

High-traffic areas or areas vulnerable to graffiti may call for a more durable and smoother (enamel) finish. These paints typically have a higher VOC content. While there is little test data comparing "high durability" and low-VOC paints, anecdotal information suggests that "high durability" (usually alkyd paint) products would be expected to show roughly twice the performance of low-VOC paints.

If possible, the selection process should include a side-by-side paint comparison of the various products being considered, and should include comparison of abrasion resistance (durability), hideability, volume solids, odor, and overall appearance. Final paint selection should consider the following elements:

- What is the allowable drying cycle for initial painting and subsequent maintenance cycles? Is the paint locally available? (An important consideration for future maintenance.)
- What is the expected durability or life expectancy required? Requirements will likely vary with the space. For example, one manufacturer had specific and different recommendations for gymnasiums, cafeterias, restrooms, general classrooms, and hallways.
- What is the method of application? Choices, such as in-house versus contractor and spray versus roller, have a bearing on paint choice.
- What are the budget constraints, including first-time and maintenance? Budget analysis should consider not just cost per gallon, but also evaluate area coverage per gallon and projected time between re-painting, which can vary greatly with conditions of use.

Installation

Paint should be installed prior to soft surfaces such as carpeting to prevent absorption of VOCs. Specify isolation requirements (isolation of construction zones from completed zones to prevent cross-contamination; removal, coverage, or isolation of porous materials to avoid their absorption and subsequent re-emission of solvents; maintaining negative pressure by exhaust ventilation in construction areas). Low-VOC paints may require a longer airing out time than other paints, so be certain to specify appropriate ventilation. When sanding dried paint, a dust mask should be worn.

Operation and Maintenance Issues

Review recommended duration between paint application and occupancy and review for compatibility with maintenance schedules/requirements. Ideally, work should be scheduled during unoccupied periods or periods of least occupancy. Large projects should be scheduled during the summer vacation months or other breaks. The maintenance schedule should also factor in manufacturer recommended air temperatures for application.

Caution

In jobs that require removal of old paint and may require chemical strippers, closely observe manufacturers recommendations for use, including ventilation and personal protective equipment.

If performing renovation at a school constructed prior to 1980, do not begin work until testing paint samples for possible lead contamination. If lead-containing paint is present, observe appropriate abatement controls.

Where possible, perform painting and stripping off-site or select materials with factory-applied finishes. For on-site interior painting, cover surfaces, such as fabric-covered furnishings, to which VOCs may adsorb. Consider constructing barriers (for example, walls or curtains of plastic sheeting) to help isolate portions of larger areas and minimize the distribution of dust and other pollutants.

Wipe down all surfaces with a wet cloth as soon as practical after completing all dust-generating work typically associated with surface preparation.

Carefully observe manufacturers recommendation for cleanup, storage, and disposal, for paints, primers, and thinners. Some products are classified as “flammable liquids” under federal regulations and must be stored in a specifically constructed safety cabinet. Keep paint containers covered as much as possible during and following use to protect against VOC release. For excess paint, consider recycle/reuse options.

All paint containers with residual liquid must be disposed of as hazardous waste per U.S. Environmental Protection Agency regulations. Only dry containers can be placed in municipal landfills. The contractor should leave only enough excess paint for touch up work after completion of the project and properly dispose of the remaining paint.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter, and:

Bainbridge Island High School (Bainbridge Island, Washington)—As part of a major renovation at the existing high school, Capital Works personnel, with assistance from an environmental consultant, conducted an investigation of locally available, low-VOC paint options.

Interior Painting and Indoor Air Quality in Schools. To order, contact the Maryland State Department of Education, Division of Business Services, School Facilities Branch, 200 W. Baltimore St., Baltimore, MD 21201. Phone for Capital Projects Assistant Manager: (410) 767-0097.

Ross Middle School, Ross, CA (Marin County)—Interior wall & ceiling paint is “zero” VOC formulation.

GUIDELINE IS10: CASEWORK AND TRIM

Recommendation

Specify casework and trim constructed from formaldehyde-free binders and other environmentally preferable materials. Design for easy future disassembly and reuse. Specify assembly off-site where major off-gassing can occur before products are brought into the building. Install with least hazardous, low-volatile organic compound (VOC) content adhesives and coatings.

Description

Conventional particleboard is made with bonding agents including urea-formaldehyde, which can off-gas for years after application. (Please refer to the discussion of formaldehyde-related indoor air quality problems in the Overview.) Authorities recommend fully covering all six sides of each surface with plastic laminate, or coating the particle board with a sealer to prevent off-gassing of formaldehyde and other volatiles (see Caution callout, below). However, unless a product's particleboard is fully-covered, CHPS recommends using only products that use formaldehyde-free binders for interior use in high performance schools.

Environmentally preferable product alternatives for interior casework and/or trim include exterior grade plywood with phenolic formaldehyde resin, formaldehyde-free medium density fiberboard (MDF), oriented strand board (OSB), certified wood, salvaged lumber, bamboo, recycled plastic, metal, biocomposites (only for areas not subject to frequent wetting), and engineered wood. Certified MDF and plywoods also exist. Pre-assembled cabinets made with low-toxic materials and finishes, solid wood, engineered wood, and enameled metal are also available.

OSB, MDF, and other composite wood products can be strong sources of VOCs. Some of the emitted VOCs are terpenes which, when oxidized, form formaldehyde, higher molecular weight aldehydes, and acidic aerosols. Some of these oxidation products are more irritating or toxic than the chemicals emitted

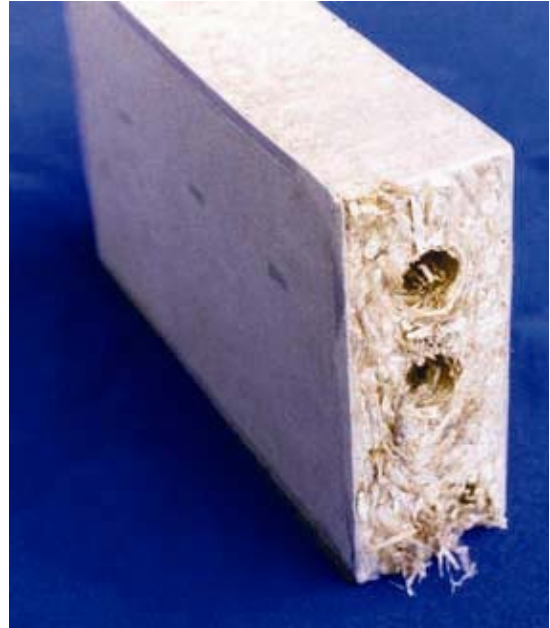


Figure 36—Wheatboard

This construction particleboard is made from wheat straw instead of wood fibers. Utilizing strawboard eliminates formaldehyde and other emissions, reduces forest exploitation and supports the use of an agricultural by product. Cabinetmakers found that the product is less coarse than wood fiber particleboard, although the edges required several coats of paint for proper sealing. For woodworkers, the product was lighter than wood fiber particleboard, and was more pleasant to work with because of its odor. Photo courtesy National Renewable Energy Laboratory (PIX # 09811).

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

from the wood products. For instance, composite wood is the leading contributor to indoor formaldehyde levels, so reducing the amount of composite wood used is crucial to protecting indoor air quality. Some composite wood products manufactured with urban waste wood can contain wood preservatives, lead-containing paint, and other toxic compounds.

Acid-cured lacquers applied as finishes to wood products can be long-lasting sources of formaldehyde emissions.

Applicability

All interior casework and trim.

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

Integrated Design Implications

None.

Cost Effectiveness

There is a cost premium for certified wood, ranging from modest to significant, depending upon quantity, type, and current availability. Engineered wood often costs less than virgin lumber. MDF made with formaldehyde-free binders may also cost more.

Costs	L	■	□	□
	M	□	■	□
	H	□	□	□
		L	M	H
		Benefits		

Benefits

Formaldehyde-free products and low toxic glues/adhesives and coatings minimize the indoor air pollution load and health risks to both installers and occupants. Certified wood is produced in a way that is ecosystem-protective. Products made from certified hardwoods are durable and reusable.

Engineered lumber makes use of wood waste that would otherwise be discarded. Products made with engineered wood have low moisture content and are warp-resistant and shrink-resistant, adding to their durability. The products are strong, and their predictable qualities lead to less rework.

Bio-composite materials are made from natural, renewable resources including straw, recycled paper products, and a soy-based resin systems. These products have reduced emissions and are material efficient.

When plastic laminates are selected, look for options made from recycled laminating manufacturing wastes, which are material efficient and recyclable.

Design Tools

See the Design Tools listed in this chapter's Overview, and:

Certified Forest Products Database, Certified Forest Products Council, www.certifiedwood.org. 14780 SW Osprey Dr., Suite 285, Beaverton, OR 97007. (503) 590-6600. Industry information on suppliers and standards.

Design Details

Caution

Many of the engineered lumber products contain formaldehyde or other chemicals that are detrimental to the environment and to indoor air quality. Some types of particleboard are now being manufactured with resin binders that do not contain formaldehyde. If formaldehyde-free particleboard or plywood products are not available, select exterior grade plywood in lieu of interior grade products. Exterior grade contains phenol formaldehyde, which is less harmful than the urea formaldehyde in interior grade plywood.

Note: Some practitioners recommend coating conventional particleboard with an impermeable sealant to prevent out-gassing of formaldehyde and other volatiles. However, others disagree that this is effective mitigation.

Design interior building components for future disassembly, reuse, and recycling.

Selection

Environmentally preferable alternatives include:

- Using certified hardboards with woods grown in regional forests, which reduces the energy consumption involved in transportation. Woods common to the western area include pine, aspen, spruce, fir, and hemlock.
- For casework, consider urea formaldehyde-free MDF, or equal, exterior grade plywood (made with phenolic formaldehyde, which emits far less formaldehyde than the urea formaldehyde in traditional interior grade products).
- Consider veneered wood panels, such as OSB with hardwood facing, for cabinets and millwork. If installed for easy removal, they are reusable.
- Powder-coated finishes are harder than many paints and can actually rival plating for durability. For woods, factory-applied and -cured coatings such as urethanes have minimal emissions, and the factory can capture the resulting dust and recycle solvent.
- Bamboo can be used for countertops. Also consider biocomposites for countertops in reception or other high profile (but not wet) areas.
- Low-density fiberboard is made from paper and wood fiber, available made from 100% recycled newsprint. Most processes use no glue. They are suitable for uses such as underlayment and tackboards.

- Recycled plastic panels made from consumer product waste are available for functional worktops. If installed for easy removal, they are reusable.
- Vegetable oil-based plastics are available in both flexible and rigid types. They can be colored and filled with minerals, metal shavings, or other plastic waste and wood fiber giving them a large range of texture and color possibilities. If installed for easy removal, these also have good reuse potential.
- Fiber reinforced cement boards made with recycled fiber are a durable, material efficient choice for use as substrates for tile and decorative finishes. If installed for easy removal, these also have good reuse potential.
- It is recommended that all casework assemblies and wood furnishes meet the emissions standards outlined in Specification Section 01350/DHS Standard Practice. It may also be beneficial to obtain and review MSDS and emission test data. Wood naturally emits formaldehyde, so test data should be carefully reviewed.

Installation

Dust from cutting and emissions from glues used for installation are indoor air quality issues during and after installation. Specify work to be performed in a shop off the premises where practicable. Require installer to use the smallest amount of adhesive/sealant necessary to fulfill the manufacturer's performance specifications for that product. Specify use of adequate ventilation and VOC-safe worker masks. Where appropriate, specify installation to permit easy removal and reuse, for example, screwed assembly instead of glued.

Operation and Maintenance Issues

Issues will vary with type of material selected, but are similar to requirements for traditional materials.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter, and:

For general information on certified lumber, contact: Certified Forest Stewardship Council, Jeff Wartelle. Phone: (503) 590-6600. Industry group provides information on distribution and other assistance.

Certified Forest Products Database, Certified Forest Products Council. Web site: www.certifiedwood.org. Contact: 14780 SW Osprey Dr., Suite 285, Beaverton, OR 97007. Phone: (503) 590-6600. Industry information on suppliers and standards.

Two private companies in the U.S. are authorized to issue the FSC stamp of approval: Scientific Certification Systems (SCS) in Oakland, CA (www.scs-certified.com/forestry/), and SmartWood Certified Forestry, based in Richmond, VT, with an affiliate in Oregon (www.isf-sw.org/cert.htm).

The American Bamboo Society. Web site: www.bamboo.org/abs.

APA -The Engineered Wood Association. Phone: (206) 565-6600. Web site: www.apawood.org. Email: product.support@apawood.org

American Institute of Timber Construction. Phone: (303) 792-9559. Fax: (303) 792-0669. Web site: www.aitc-glulam.org. Email: webmaster@aitc-glulam.org.

American Wood Council. Phone: (202) 463-2700. Web site: www.awc.org/. Email: AWCINFO@afandpa.ccmil.com.

National Particleboard Association. Phone: (301) 670-0604. Web site: www.pbmdf.com. Email: info@pbmdf.com.

Western Wood Products Association. Phone: (503) 224-3930. Web site: www.wwpa.org. Email: info@wwpa.org.

Phenix Biocomposites, LLC. Makes a variety of engineered panel products using agricultural byproducts and other renewable, sustainable and recycled resources. Phone: (800) 324-8187. Web site: www.phenixbiocomposites.com.

GUIDELINE IS11: INTERIOR DOORS

Recommendation

Select formaldehyde-free interior doors constructed with recycled content or from certified wood. Avoid particleboard core board doors, which contain urea-formaldehyde and luan doors, which are made from wood harvested from rain forests. Select pre-finished products, if possible. If finishing on-site, select low-toxic, low-volatile organic compound coatings.

Description

Interior doors are usually wood, molded hardboard, or hollow core. Luan plywood is harvested from rain forests, so it should be avoided unless it has a Forest Stewardship Council (FSC) or other certification. Molded hardboard is often made with recycled material and pressed into shape, but some is made with urea-formaldehyde and should be avoided.

If using solid wood doors, select products with FSC or other certification (clear stock is becoming rare and if uncertified, often comes from old-growth forests).



Figure 37—Interior Door

Randy Karels, photographer.

Applicability

All spaces.

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Integrated Design Implications

In areas where a high degree of speech privacy and/or sound isolation is required, doors should be solid core wood or hollow metal with acoustic fill. Full perimeter gaskets should also be included to reduce sound leaks around the edge of the door. Standard weather stripping with a door bottom sweep will minimize sound leaks, but wears down with use. Doors in areas that require a high degree of sound isolation should have heavy-duty adjustable sponge neoprene gaskets at the head and jamb. Automatic door bottoms with a neoprene element should also be used.

Cost Effectiveness

Costs are low.

Costs	L	■	■	□
	M	□	□	□
	H	□	□	□
		L	M	H
		Benefits		

Benefits

Avoiding luan and solid wood doors help protect limited forest resources. Formaldehyde-free materials protect indoor air quality and contribute to a more healthful environment. Low-toxic finish coatings minimize indoor air pollution load and health risks to both installers and occupants.

Design Tools

See the Design Tools listed in this chapter's Overview.

Design Details

Review emissions data and MSDS prior to specification of a recycled content molded hardboard product to ensure that it is urea-formaldehyde-free. It is recommended that all hardboard products meet the emissions specifications outlined in Specification Section 01350 and DHS's Standard Practice.

Operation and Maintenance Issues

May require periodic re-coating for aesthetic purposes. Type of paint determines the ability to clean the surface.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter.

GUIDELINE IS12: TOILET PARTITIONS

Recommendation

Select high durability, solid plastic toilet and shower partitions with recycled content.

Description

Several styles of toilet partitions are available, including baked enamel over metal, plastic laminate over particleboard, and solid plastic panel. Solid plastic toilet/shower partitions are the most durable type overall. Recycled content products are made with a post-consumer, high-density polyethylene (HDPE) content between 20% and 35%, depending on the manufacturer. In addition, some brands contain postindustrial plastic material. Look for purified HDPE, as it contains a predominant amount of post-consumer waste.



Figure 38—High-Density Polyethylene Partitions

High-density polyethylene (HDPE) restroom partitions are maintenance-friendly and durable. Photo reprinted with permission from Santana Solid Plastic Products.

www.santanaproducts.com

Applicability

All toilet/shower partitions.

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Applicable Codes

See the Applicable Codes section in this chapter's Overview.

Integrated Design Implications

None.

Cost Effectiveness

Recycled content units cost 20% more than conventional units, but are more durable, require less maintenance, and can be reused. In addition, recycled content toilet partitions generally have a 15-year warranty verses the standard five-year warranty of other partition products.

Costs	L	■	□	□
	M	□	■	□
	H	□	□	□
		L	M	H
		Benefits		

Benefits

Recycled content partitions are material efficient, low maintenance, rot resistant, and graffiti/vandal resistant.

Design Tools

See the Design Tools listed in this chapter's Overview.

See also Santana Solid Plastics Products, www.santanaproducts.com/products-partitions.asp, for sample specifications for solid plastic, recycled content toilet partitions, floor-mounted, ceiling mounted, and floor-to-ceiling models.

Design Details

None.

Operation and Maintenance Issues

None.

Commissioning

None.

References/Additional Information

See the Overview section of this chapter, and:

Cold Spring Elementary School, Santa Barbara, CA. Used recycled content toilet partitions.

Designing with Vision: A Technical Manual for Material Choices in Sustainable Construction. Revised July 2000. A publication of the California Integrated Waste Management Board. See Chapter 8, "Strategies to Reuse Materials and Reduce Material Use in Construction," Appendix E sample specifications for: Section 10160; Solid Plastic Partitions. Designing with Vision can be downloaded in four parts from www.ciwmb.ca.gov/GreenBuilding/. Chapter 8 is in Part D.

GUIDELINE IS13: ACOUSTICS—REVERBERATION TIME

Recommendation

Specify soft interior surfaces which have an appropriate Noise Reduction Coefficient (NRC) and result in a reverberation time of less than 0.6 seconds in typical classrooms.

Description

Reverberation time is an important acoustical measure that is used to determine the amount of time it takes for a sound to decay within a room. Simply put, it is the echo within the room. Softer surfaces with a higher NRC absorb more sound therefore reflecting less back into the room. Ceiling tiles, carpeting and acoustic wall panels are the primary sound absorbing materials that are specified in schools.



Figure 39—Acoustical Ceiling Tiles

Photo Courtesy: SoundSuckers (permission not requested)

Applicability

Reverberation time is critical in classrooms and other teaching spaces. Auditoriums, cafeterias, gymnasiums, multipurpose rooms and administrative areas also have acoustical considerations.

Applicable Spaces	Climates	When to Consider
Classrooms	South Coast	Programming
Library	North Coast	Schematic
Multi-Purpose / Cafeteria	Central Valley	Design Dev.
Gym	Mountains	Contract Docs.
Corridors	Desert	Construction
Administration		Commissioning
Toilets		Operation
Other		

Applicable Codes

ANSI Standard S12.60-2002.

See also the Applicable Codes section in this chapter’s Overview.

Integrated Design Implications

Classroom acoustics is also affected by external noise transmitted into the classroom and noise from the HVAC system. See the Building Envelope chapter for a discussion on Sound Transmission Classification (STC) ratings and the HVAC chapter for Noise Criteria (NC) considerations in the design and selection of HVAC systems. Finish surface materials also have an effect on other issues. Carpeting, for instance, absorbs sound and makes for a more comfortable surface for sitting, while hard floors reflect sound but may be easier to maintain. The NRC of a ceiling tile is independent of its ability to reflect light for use with daylighting strategies.

Cost Effectiveness

The cost of a mediocre acoustical ceiling (NRC 0.55) and a good acoustical ceiling (NRC 0.75) is about \$ 0.40 /ft². (The reverberation time for the mediocre classroom is 0.75 seconds and the good classroom is 0.55 seconds, a noticeable improvement to within the classroom standard). The cost of poor acoustics includes teacher absenteeism (data shows that teachers miss 2 days a year on average due to vocal fatigue¹⁷) and reduced student learning.

Costs	L			
	M			
	H			
		L	M	H
		Benefits		

Benefits

Proper classroom acoustics will ensure an environment conducive to learning. Teachers should be able to use a natural teaching voice free from stress and students should be able to clearly hear teachers and other students. Studies have shown (ASA 2000) that in many classrooms only 75% of spoken words can intelligibly be heard by the students.

Design Tools

See the Design Tools listed in this chapter's Overview.

Reverberation time can be estimated by the following formula:

$$RT(60) = \frac{0.05 \cdot V}{\sum S \cdot \alpha}$$

Where V is the volume in ft³, S is the surface area of a room surface in ft² and α is its sound absorption coefficient at a given frequency. Absorption coefficients of common interior surface materials are provided in the ASA guideline on classroom acoustics (ASA 2000) and from manufacturer's data. The Noise Reduction Coefficient (NRC) is the average of absorption coefficients at different frequencies that occur in human speech.

¹⁷ See Classroom Acoustics II, p 8. See the bibliography for a complete citation.

Design Details

A RT of 0.4 to 0.6 seconds is the standard for classrooms, depending on volume. A longer RT results in echoes, reducing speech intelligibility. On the other hand, too much sound absorption can reduce the benefits of early sound reflections causing the speaker's voice to fall off rapidly with distance. This is especially true in larger spaces such as lecture halls. Diffusing elements placed on the walls of a classroom are another method to reduce reverberation time. This technique scatters the sound into many directions thereby reducing the sound reflected in any one direction.

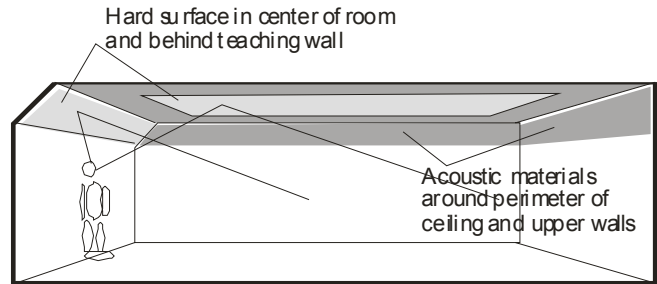


Figure 40—Classroom Acoustics

Using both hard and soft (NRC) materials can be used to achieve good classroom acoustics.

Reverberation Time (RT) depends on the physical volume and the surface materials of a room. Since the size of the classroom and the ceiling height are determined by program requirements and needs for lighting and daylighting. The only reasonable way to design for acceptable reverberation is through the use of materials with an appropriate noise reduction coefficient.

Reverberation time is a common problem in large spaces such as gymnasiums. Recommended maximums for reverberation time is 0.8 seconds for auditoriums, and 1.2 for gymnasiums. If the roof construction is an exposed metal deck, perforations on the deck and fiberglass above the deck can absorb sound. Adding fiberglass or wood panels to the interior walls will also help.

Acoustic wall panels can help reduce reverberation where ceiling panels alone do not achieve the recommended reverberation time of ANSI Standard S12.60. A 1" thick panel provides a noise reduction coefficient of 90% or higher. A new panel made of recycled cotton fibers, bonded acoustical pad, meets flammability and durability standards and is relatively inexpensive. Their application in classrooms is limited to the small amount of wall space not covered by white boards, casework and student posting. They are a good high performance option for school gymnasiums and a good retrofit option for classrooms with excessive noise levels.

Operation and Maintenance Issues

It is important that surfaces be maintained in their original form to retain their acoustical integrity. Painting over acoustic ceiling tiles, for example, raises the NRC, effectively negating their acoustical benefits.

Commissioning

None.

References/Additional Information

Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, American National Standards Institute (ANSI) Standard S12.60-2002.

Classroom Acoustics, A resource for creating learning environments with desirable listening conditions. Acoustical Society of America, 2000.

Classroom Acoustics II, Acoustical barriers to Learning. Acoustical Society of America, Acoustical Society of America, 2002.