1 Finish Selection and Specification

There are thousands of products available for use in interior environments, and each has its assets and disadvantages. More interior materials come into the market every day, while others are dropped from the list of possibilities. These factors can make the process of selecting the right interior material for the job bewildering and—sometimes—perilous. The purpose of this book is to aid designers in this process, to serve as a guide to learning about, evaluating, and selecting materials that will look good, work well, and respect human and environmental needs.

As interior designers select finishes for projects and present them to clients, they assess each alternative for its aesthetic contribution to the design concept. In addition to a material's surface appearance, they consider its tactile appeal, acoustic properties, light reflectance, and even its scent. Shape, texture, proportion, and scale are related to the balance and symmetry of the space and the harmony of the design. Whether a material transmits light influences how it can be used to open or enclose a space. Each selection becomes part of complex relationships between unity and variety, rhythm and repetition, and emphasis and hierarchy. The way a material expresses its function is also part of its aesthetic quality.

The selection of materials is restrained by codes and regulations that have been instituted to ensure the public's safety. Interior materials can either contribute potential fuel to a fire or resist ignition and flame spread, for example. The materials that line the paths to exits—the means of egress—are especially important.

Interior materials also often affect human health and well-being, so designers must:

- Review materials for their ability to prevent slips and falls and to cushion surfaces from impact.
- Check details of product manufacture and installation for exposed sharp edges and shatter resistance.
- Select electrically conductive materials where built-up static electricity is likely to be released as painful shocks.
- Insulate from contact materials that are likely to become very hot or cold.
- Design materials to protect both surfaces and people in spaces where potentially dangerous chemicals are in use.
- Avoid materials that expose people to harmful chemicals or unsafe conditions during their manufacture, delivery, installation, use, or disposal, or that degrade *indoor air quality* (IAQ).

Designers also must consider how a material will perform under the conditions of the project. They rate materials for durability, colorfastness and fading, and stain and water resistance, and evaluate them for ease of maintenance. Materials may be tested and labeled by the manufacturer for light, moderate, or heavy use. Designers rely both on their education and experience to select materials with solid reputations, and constantly investigate and screen new products for evidence of reliability.

Describing the Properties of Materials

- Color: Depends on quality and quantity of light; materials have one or more innate colors; other integral colors if processed.
- Durability: The ability to resist destructive forces, retain its original appearance, and continue to function as intended.
- Elasticity: Resiliency or flexibility; ability of a material to return to initial form after deformation.
- Form: Three-dimensional quality defined by length, width, and depth.
  - Linear form: One dimension significantly larger than others; provides vertical support, spans space, defines edges and corners, creates texture and patterns.
  - Planar form: Length and width dominate thickness; defines edges of shapes; visual weight and stability; has color, texture, and acoustic properties.
  - Blocklike form: Three-dimensional solid form with similar length, width, and depth.
- Plasticity: Ability to be formed or shaped; pliancy; continuous deformation without rupturing or relaxing.
- Refinement: Ability to form and retain precise, thin, closely spaced elements; depends on strength, durability, and manufacturing process.
- Strength: Ability to resist stress, to bend without breaking; long spans express resisting tension; massive materials resist compression.
- Texture: Relative smoothness or roughness of surface; has scale.
  - Tactile texture can be felt.
  - Visual texture is seen; depends on patterns of light and shadow, suggesting tactile texture.
- Workability: Ease of altering from primary form.

Sustainable, local, and recycled sources for materials reduce depletion of resources and energy use. The manufacture, shipping, and installation processes for materials that have received certification as environmentally friendly have been reviewed for energy and water use and for production of potentially damaging by-products. Demolition, construction waste, and eventual disposal of the material are examined to conserve and reuse resources.

A material's availability during a project's schedule is related to manufacturing schedules and shipping and warehouse arrangements. Custom-ordered items often require longer lead times and additional paperwork. Special government conditions apply to the export or importation of rare and antique materials.

Designers weigh a material's cost against its durability and useful life. They consider delivery, maintenance, replacement, and disposal costs. Energy costs are also a factor in material selection, production, and installation, and during use. Materials that help to reduce heat loss, decrease the need for air-conditioning, help in the collection and use of nonpolluting energy sources, and adjust to changes in climate all lower building energy costs.

HEALTH AND SAFETY CODES

Before starting to select the finishes and furniture for a project, a designer determines which codes are applicable. Recent changes in the organization of building codes are reflected in local jurisdictions. The three main building code organizations in the United States have now merged into the International Code Council (ICC), which publishes the International Codes (I-Codes). Although many jurisdictions use the I-Codes, some retain what are now referred to as *legacy codes*. An alternative set of codes, published by the National Fire Protection Association (NFPA), is called the C3-Codes. Some jurisdictions also use NFPA publications, including the *Life Safety Code* and the *National Electrical Code*.

Note: Code information in this text is meant for general reference only; designers must check which codes apply to a given project.

The Codes Guidebook for Interiors, 3rd edition (John Wiley & Sons, Inc., 2005), by Sharon Koomen Harmon, IIDA, and Katherine E. Kennon, AIA, has more comprehensive information on applying codes to interior projects. The major areas that affect interior design projects are listed in Table 1-1.

Most interior projects are required to be accessible to all, and accessibility requirements are included in most building codes. Many codes reference the ICC/ANSI accessibility standard ICC/ANSI A117.1. Federal law requires the use of the *ADA Accessibility Guidelines (ADAAG)* in many projects; these guidelines, published July 23, 2004, are still being incorporated into the work of government agencies.

The ADAAG are available free from the United States Access Board at www.access-board.gov.

Interior wall finishes that are subject to code provisions include most of the surfaces applied over fixed or movable walls, partitions, and columns. Interior finishes for ceilings (including suspended ceiling grids and coverings applied to fixed or movable ceilings, soffits, and space frames) are covered in codes. Coverings applied over finished or unfinished floors, stairs (including risers), and ramps are also included.

Table 1-1 Code Sections

Code Section	International Building Code (IBC) Chapters	NFPA 5000 Building Construction and Safety Code Chapters
Use or Occupancy Classification	Chapter 3: Use or Occupancy	Chapter 6: Classification of Occupancy, Classification of Hazard of Contents, Special Operations. Chapter 16–13, on different occupancy classifications
Special Use or Occupancy Requirements	Chapter 4: Special Detailed Requirements Based on Use and Occupancy	Chapter 31: Occupancies in Special Structures Chapter 33: High-Rise Buildings Chapter 34: High Hazard Contents
Types of Construction	Chapter 6: Types of Construction	Chapter 7: Construction Types and Height and Area Requirements
Fire-Resistant Materials and Construction	Chapter 7: Fire-Resistance-Rated Construction	Chapter 8: Fire-Resistive Materials and Construction
Interior Finishes	Chapter 8: Interior Finishes	Chapter 10: Interior Finishes
Fire Protection Systems	Chapter 9: Fire Protection Systems	Chapter 55: Fire Protection Systems and Equipment
Means of Egress	Chapter 10: Means of Egress	Chapter 11: Means of Egress
Accessibility	Chapter 11: Accessibility	Chapter 12: Accessibility
Interior Environment	Chapter 12: Interior Environment	Chapter 49: Interior Environment
Plumbing Systems	Chapter 29: Plumbing Systems	Chapter 53: Plumbing Systems

Building and fire safety code requirements affecting furnishings include exposed finishes found in furniture and window treatments (fabrics, wood veneers, and laminates) as well as nonexposed finishes, such as the foam in seating and the linings in draperies. This encompasses whole pieces of furniture and upholstered seating, as well as panel systems.

Although the codes are much stricter for commercial projects, deaths occur more often in residential fires. Therefore, all wall and ceiling finishes for a residence—except for trims and materials less than 1/28 inch (0.9 mm) thick, wallpaper, and paint—are required to meet the testing requirements set forth in ASTM E84, issued by the American Society for Testing and Materials. Some finishes, such as wood veneer and hardboard paneling, must conform to other standards as well. Finishes in showers and bath areas are also regulated; they must be smooth, hard, and nonabsorbent, such as fiberglass, vinyl, or ceramic tile.

HUMAN FACTORS AND MATERIAL SELECTION

The selection of materials and furnishings involves considering which are culturally and age-appropriate, as well as designed to fit a variety of human sizes and shapes. Our need to maintain appropriate social distances and to have control over personal space affects the use of materials in interiors. However, the way space is defined and demarcated varies across cultures. In some, for example, spaces are divided according to gender, and domestic spaces are treated differently than public spaces.

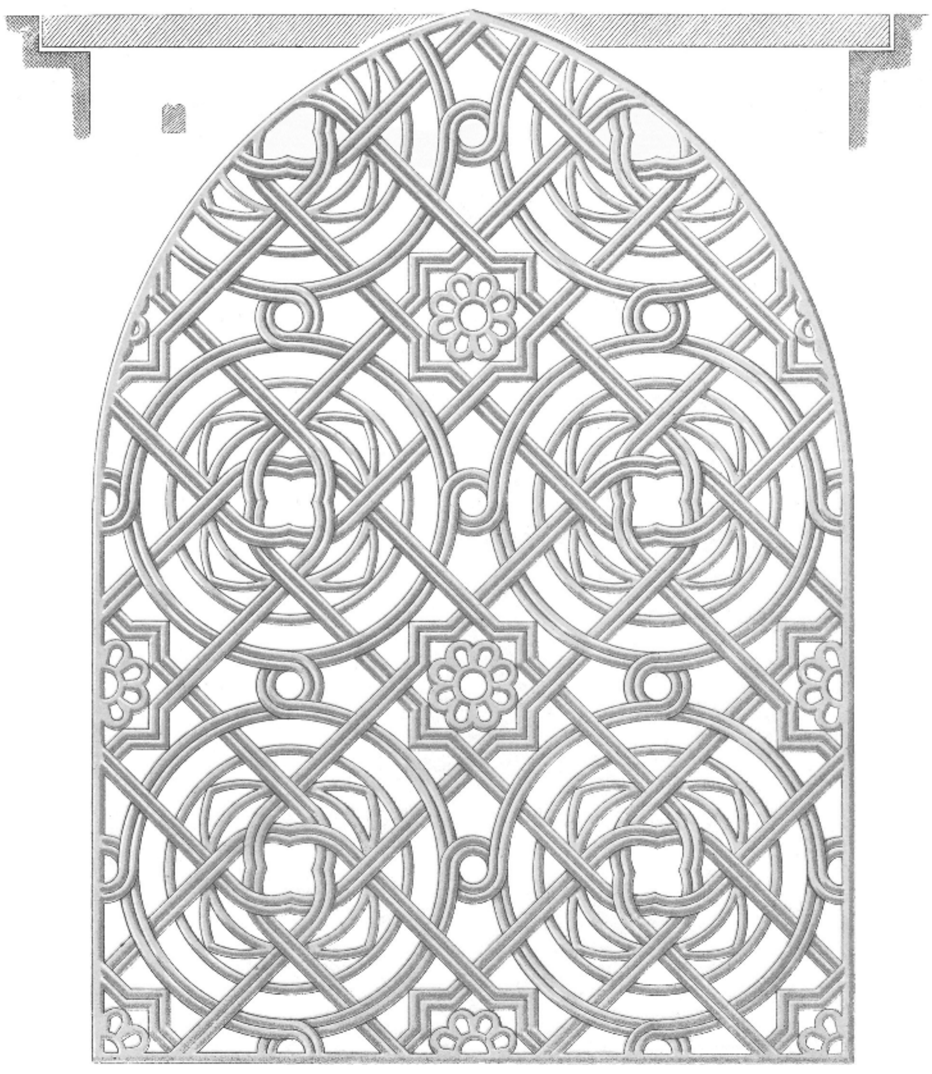

Figure 1-1 Islamic buildings often include sheltered views that preserve privacy for interior spaces.

Interior materials intended to create privacy are used to screen views. Materials intended to provide security are often designed to do so unobtrusively, to avoid the perception of being watched.

Researchers have identified four levels of interpersonal space:

- *Intimate space* allows physical contact, and any invasion by a stranger can cause discomfort.
- *Personal space* allows friends to come close, and possibly to penetrate the inner limit briefly; conversation is carried on at low voice levels.
- *Social space* is where informal, social, and business transactions take place at normal to raised voice levels.
- *Public space* accommodates formal behavior and hierarchical relationships, and louder voice levels with clearer enunciation are used.

Intimate interior spaces invite the use of precious or delicate materials. Small-scale and intricate detail are best appreciated with close observation and personal attention. Maintenance of intimate spaces may be more refined than for more public spaces.

Personal interior spaces reflect the character of their owners. Therefore, materials are selected with attention to individual taste and personal history. And because access to personal spaces is ordinarily limited, materials can be selected to support specific lifestyles and maintenance requirements.

Social spaces must accommodate varied activities, and materials are chosen that will suit the intended group of users. The materials used in an office workspace, for example, will be subject to spilled coffee and rolling desk chairs; the materials in a day care center must respond to the safety and durability needs of small children. Materials for hospitality spaces and restaurants, in contrast, demand a high level of aesthetic discrimination, matched with heavy use requirements. Health care facilities, too, have special needs, for cleanliness, maintenance, and durability.

Materials used in public spaces, naturally, must withstand a higher level of abuse than those intended for private use. Larger-scale interactions in public spaces suggest a larger scale of interior material treatment. Issues of public security and safety require materials to be durable, securely fastened, and vandalproof. (See color plate C-2 for finishes in a public space.)

Our body dimensions and the way we move through and perceive space also are determining factors for interior design. Dimensional requirements will vary according to the nature of the activity and the social situation, from how we reach for something on a shelf to how we sit at a table, walk down a set of stairs, or interact with other people.

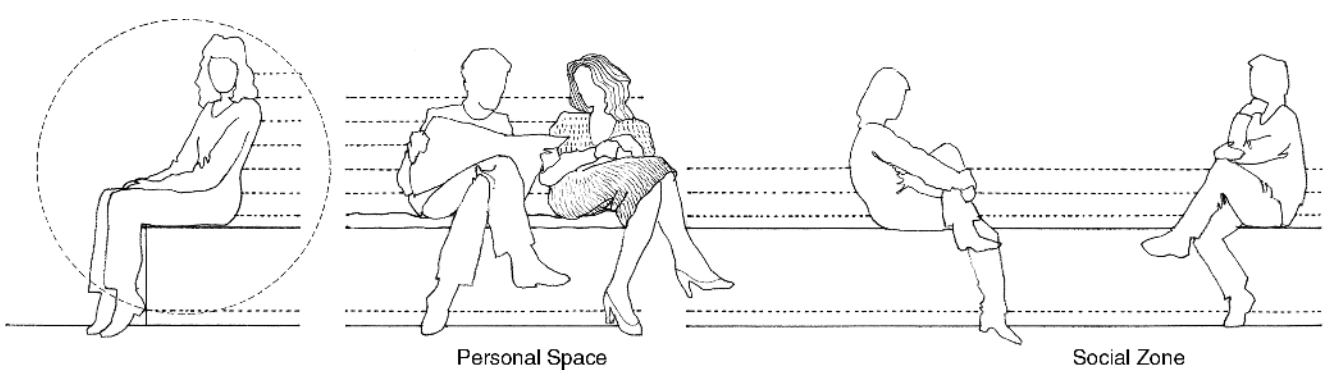

Figure 1-2 Intimate, personal, social, and public spaces. Reproduced with permission of the publisher from Francis D. K. Ching and Corky Binggeli, *Interior Design Illustrated,* 2nd ed. (Hoboken, NJ: John Wiley & Sons, Inc.), © 2005 by John Wiley & Sons, Inc.

When specifying and designing the details for materials, certain dimensions are particularly important to interior designers. These include, in order of importance:

1. Height
2. Weight
3. Sitting height
4. Buttock–knee length (the length from the buttock to the back of the knee)
5. Breadth across elbows and hips when seated
6. Knee front and back heights
7. Thigh clearance and heights

Note: Design for the most common body sizes generally omits extremes at both ends of the range.

When selecting materials, designers consider what will be within reach of the user. For example:

- Materials used overhead are generally out of reach, but may be handled to access equipment above the ceiling.
- A corridor floor must withstand traffic patterns as well as people leaning against the walls.
- The edges of counters are rubbed against and sometimes picked at.
- Chairs are scraped on floors, rubbed against walls, and turned onto tabletops for cleaning.
- Cleaning equipment bumps into walls and furnishings.

All these possibilities have to be considered and factored into the long-term cost of a material.

ACCESSIBLE AND UNIVERSAL DESIGN

Accessible design addresses the requirements of a single group within the larger population, specifically, people with disabilities. There are differences between appropriate accessible design for public facilities and the best approach for private, custom,

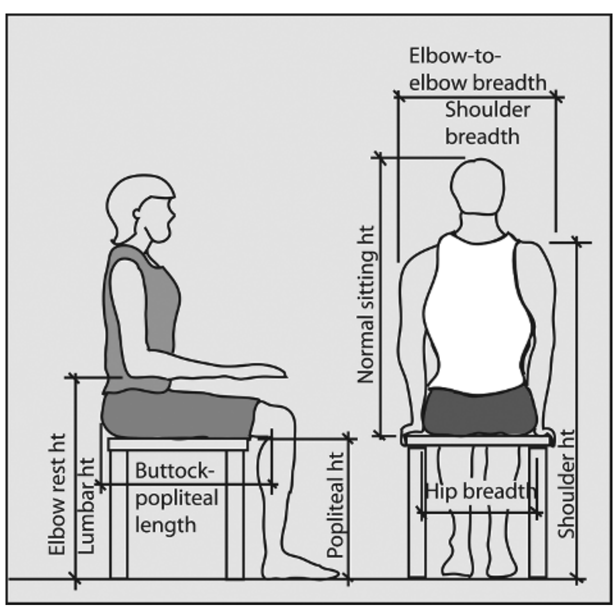

Figure 1-3 Important dimensions for furniture and built-in seating design.

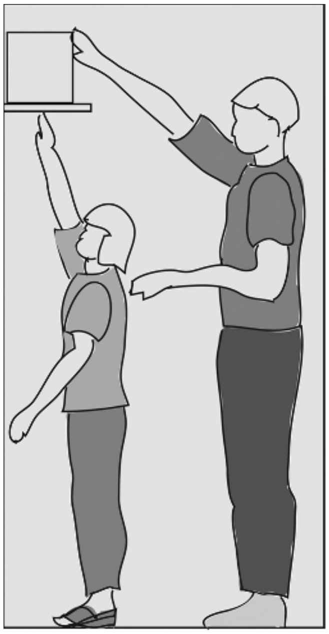

Figure 1-4 The ability of people to reach up and out varies greatly.

Figure 1-5 Shelves must be within the reach of most users. Drawers and files need additional space in front for the user.

accessible projects. When designing for a broad range of users, it is important to ensure that the design meets the needs of the targeted population. For example:

- Materials are selected to eliminate irregularities and avoid slipping on walking surfaces.
- Surfaces are protected from contact with wheelchairs.
- Wall-mounted materials are limited as to height and extension from the wall.
- Changes in finishes indicate changes in location. Carefully chosen materials help users find their way through interior spaces.

Universal design is based on principles that include:

- Equitable use
- Perceptible information
- Flexibility
- Tolerance of error
- Simple and intuitive use
- Low physical effort

Universal design is inclusive of all people with respect to human factors issues. It differs from accessible design in that it addresses as widespread a group as possible. Providing securely braced grab bars in all bathtubs, for use by children as well as older people—by anyone who might slip—is an example of universal design. Provisions for universal design do not have to be institutional in style, and can add to the beauty, function, and safety of an interior design.

Materials that accommodate the majority of users and include those with special needs also enable people to continue to use an interior as their physical needs change.

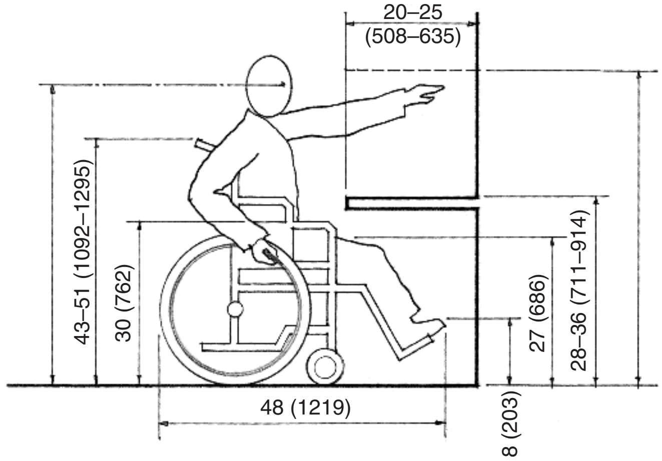

Figure 1-6 Wheelchair footrests are likely to come in contact with doors and walls. Kickplates and durable finishes help prevent damage.
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Figure 1-7 Universal design kitchen at Seniors Residence, Weston, Massachusetts. This kitchen is in the shared common area for the use of residents and guests.

The increasing mobility of a growing child, for instance, is taken into account in selecting finishes for a bedroom or play space. A family home can be designed to accommodate the needs of the parents as they age. Commercial and public interior spaces that employ universal design make business, government, and recreation open to all.

In the case of children, their needs change as they grow, as does how they perceive and use objects and spaces. Very young children will be unable to read signs, for example, and so will need to rely on graphic symbols for guidance. Design options such as attractive yet durable finishes that are located at a child's eye and hand level also will help to create welcoming spaces. (See color plate C-3 for a space designed for children.)

Note: The ADAAG cites special considerations for spaces used by children; materials selected for use in these spaces must address the health and safety needs of all children.

In the case of older people, they typically become less active and move more slowly, and design must accommodate these changes. Aging does not, however, inevitably lead to disability, and interior spaces that are designed to be both accessible and efficient allow older people to retain their independence. Many of the same features that make an interior convenient for the general population also work for seniors. Handrails and nonslip flooring promote safety and independence. (See color plate C-4 for a space designed for older people.)

OTHER DESIGN CRITERIA

Code requirements, human factors, and accessibility are all very important to the selection of materials for interior spaces. Three other design criteria are budgetary, functional and environmental considerations.

Budgetary Criteria

To respect a client's budget, a designer should provide guidance as to where money can be spent wisely—and where it makes sense to economize. Creativity need not be limited by financial constraints, however, and interior designers who find creative solutions without breaking the budget are highly prized.

One of the most important budgetary considerations for interior designers is the *life-cycle cost* of a product. The life-cycle cost of a material includes its purchase cost, as well as costs for transportation from its source, maintenance, replacement, and disposal or recycling. Interest rates on invested money are also factors.

Many energy-efficient designs may have a higher initial cost, but show savings in energy costs over time.

Figures are available in published and software forms and on the Internet for estimating the cost of interior design materials and labor. Note, however, these sources are based on figures for a specific year and, therefore, must be adjusted for inflation if not for the year in which construction will take place.

An estimate generally includes the cost to purchase and install interior improvements to a space. Depending on the project, the estimate may include furniture, window treatments, accessories, cabinets and millwork, and installation of specified furnishings and equipment. Some sources include information on adding allowances for profit, overhead, and shipping.

Many interior design projects involve elements of building construction or modification. Consequently, some estimating data sources include information in assembly form (cost to build a standard handicapped accessible bathroom, for example) and/or broken down into components (individual plumbing fixtures, finishes, wall construction, etc.). The cost of interior design and construction work will vary from region to region and country to country. The cost of local materials and local labor will affect the estimate, as will the currency exchange rate. And, of course, the cost of a project will vary according to size. When economies of scale are taken into account, the cost of improving a single room will be higher than the cost per room of a project with 100 rooms.

Scheduling affects costs as well, with aggressive timelines typically increasing the cost. Likewise, work in occupied buildings may have to be done at night or on weekends, adding to labor costs. When work has to be done during a contractor's busy season, the contractor may ask for more money than if the work is taken on during a slow season. Similarly, prices may be higher in a booming economy than in a slow one.

A number of other design factors have budgetary ramifications:

- Designs that are highly detailed and include unusual or unique features may be more expensive to build than conventional designs.
- A design that takes advantage of stock material sizes and uses materials efficiently is generally less expensive to build.

- Materials that are difficult to acquire, rare, or unusual tend to increase overhead as well as materials costs.
- The level of refinement that the designer specifies will also affect costs. A project that demands perfect surfaces and impeccable detailing takes more skill and usually more time to produce than one that is intended to be a bit rough. An experienced designer can create designs that achieve aesthetic and functional goals while simplifying the fabrication process.

Functional Criteria

The basic functional qualities of major materials categories suggest their appropriate uses. These include safety, durability, comfort, ease of care, fire resistance, and acoustic properties.

Safety

Safety issues for interior materials include toxicity, health effects, slip resistance, and shatter resistance. Not only should designers select a material to be safe for use as intended, but they should also consider the unexpected; for example, wired glass will not break when hit by water from a fire hose (its intended function), but will break if struck by a strong fist, causing cuts and bleeding. It is important to keep in mind that safety concerns change over time. A case in point is asbestos: when introduced to prevent the spread of fire, its effect on human health was not clearly understood, or was not considered.

Durability

Durability involves evaluating a material for its ability to stand up to its intended use. Materials are rated for their resistance to abrasion, exposure to sun, and freeze/thaw cycles. Some materials will melt when they come in contact with a heat source; others will deteriorate from contact with alcohol or acetone (nail polish remover). Water will damage or weaken some materials, while others will dry out in low humidity. The preparation of the substrate (for example, a clean, smooth surface) for installation of the material and the use of proper installation procedures affect the durability of a material, as does its finish.

Comfort

Comfort is a functional criterion for interior materials that come in contact with the human body. A sturdy but hard chair may encourage short visits in a food court; in contrast, a cozy, large one will induce lingering. Materials that carry heat away from the human body may be welcome in a tropical climate but will feel unpleasantly cold to the touch elsewhere. The texture of a floor may not be important for someone passing through a space one time, but it becomes critical for those who spend their workday on their feet in the same space.

Ease of Care

Ease of care affects a material's continued performance over time. A material that can be used in a carefully controlled environment with excellent maintenance procedures may not withstand exposure to unsupervised users and less diligent maintenance. Products with frequent, complex, or expensive maintenance requirements often fail to retain their initial appearance, especially if untrained personnel, rather than skilled labor, are performing the maintenance.

Fire Resistance

Fire resistance is such an important topic that designers often limit their initial materials selections to those that meet the requirements of fire codes. Codes consider not only the ability of a material to ignite and burst into flame, but also how much smoke it will produce and whether fire will quickly spread across its surface. When exposed to fire, some materials produce toxic chemicals that may be odorless and produce no smoke or flame.

Acoustic Properties

Acoustic properties of materials make a big difference in how that space will function. Interior materials affect the acoustic quality of a space by absorbing or reflecting sound within a space, and by transferring sound from one space to another.

Within a space, a sound generated from one location will spread out and away from its source; this is referred to as *diffusion*. It continues to spread and gradually becomes weaker, which is called *attenuation,* until it is either absorbed or reflected by an intervening material. In some spaces, a designer will want sound to be *reflected* and bounced around. In other interiors, a high level of sound absorption will keep noise at an acceptable level. Within a single interior space, there may be areas of relative quiet and noise.

The materials chosen for the ceiling surface usually have the greatest impact on *sound absorption*. Next in importance are the surfaces behind the source of the sound. The surfaces in front of the sound source are also important. In terms of sound absorption, the flooring material is generally the least important. However, the sound of footfalls and chairs scraping on a hard-surfaced floor can add a considerable amount of noise to a space.

Impact sound—the sound made by one object striking another, such as a shoe on a floor—will reflect into the room where it originates but may also pass through the building structure to another location. For example, sometimes footfalls are more audible to people in a room below than in the room of origin.

Some materials tend to block the transfer of sound. These include large amounts of sound-absorbent material and massive materials. Other materials are considered to be acoustically transparent, allowing sound waves to pass directly through to the other side; open-weave fabrics and perforated panels are used this way. Some materials will pick up the vibration of a sound wave and amplify it, much like the head of a drum.

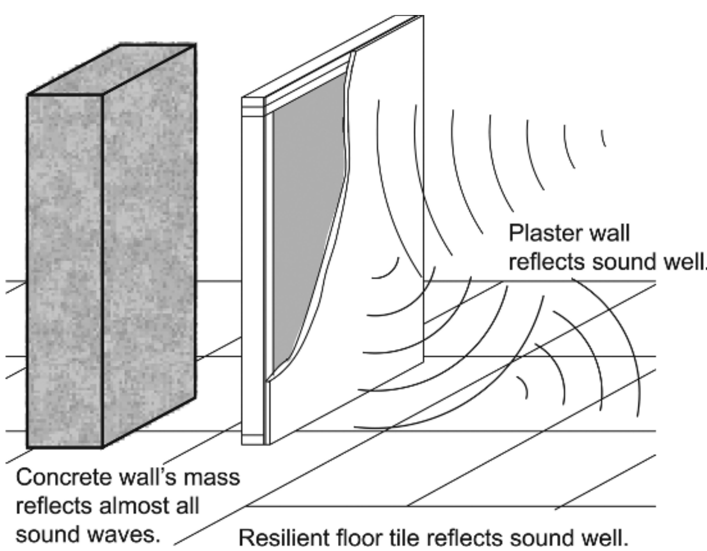

Figure 1-8 Reflected sound

Environmental Criteria

The indoor air quality (IAQ) of a space depends on three factors:

- Introduction and distribution of adequate ventilating air
- Control of airborne contaminants
- Maintenance of acceptable temperature and humidity

Although these are usually considered mechanical systems issues, the decisions made by interior designers play a substantial role in ensuring clean indoor air. By selecting materials that avoid adding contaminating chemicals to the air and that do not encourage the growth of molds or bacteria, interior designers contribute to the environmental quality of the interior.

Sustainable materials are renewable or regenerative materials that can be acquired without ecological damage and used at a rate that does not exceed the natural rate of replenishment. Manufacturers wishing to attain environmental certification for materials must inform the certifying organization of the reasons the materials should be certified, and in which category. Products accepted for evaluation go through extensive testing by accredited laboratories before meeting standards for environmentally friendly design.

Closed-loop models for the use of materials treat waste material as raw material for new products. Thus, a closed-loop recycling process is one in which a manufactured product is recycled back into the same or a similar product without significant deterioration of quality of the product. Steel and other metals, glass, and some types of plastic are examples of materials that can be recycled in a closed-loop process. This *cradle-to-cradle approach* is economically sustainable, and does not rely on nonrenewable resources. William McDonough and Michael Braungart employ cradle-to-cradle design to create products and systems that contribute to economic, social, and environmental prosperity. Their

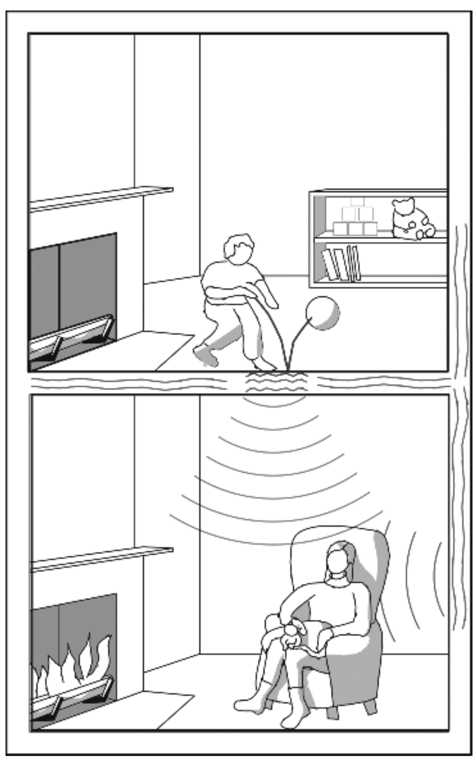

Figure 1-9 Cushioning a floor with carpet and pad is one of the best ways to reduce impact sound.

innovations are revolutionizing the production of what are often called "green" interior finish materials.

Environmentally preferable products (EPPs) are defined by U.S. federal government Executive Order 13101 as products that have "a lesser or reduced effect on human health and the environment when compared to competing products that serve the same purpose." EPPs are not necessarily fully sustainable, but are considered better than other readily available materials.

Green products are those considered to be environmentally preferable or to have a low impact on the environment. This is an informal designation that is applied to products that promote IAQ, usually through reductions of *volatile organic compounds* (VOCs) such as formaldehyde. It is often used for durable materials with low maintenance requirements. Green products often incorporate recycled content, such as postconsumer and/or postindustrial materials. However, the term's use is not regulated, and "green" is sometimes used for products with minimal environmental benefits.

Material Safety Data Sheets

Material Safety Data Sheets (MSDS) are forms that contain data on the properties of particular substances. They are intended for workers and emergency personnel as part of workplace safety programs, rather than for general consumer information. An MSDS contains information regarding potentially significant levels of airborne contaminants. These forms are supplied by manufacturers of products containing hazardous chemicals.

The search for accurate information about green materials requires research, critical evaluation, and common sense. A designer preparing an evaluation of environmentally preferable materials would, for example, collect information on critical performance criteria; available environmental products; MSDS information on potential hazards associated with installation, use, and disposal; maintenance expectations for the material or system; and the corporate environmental policy statements from manufacturers under consideration.

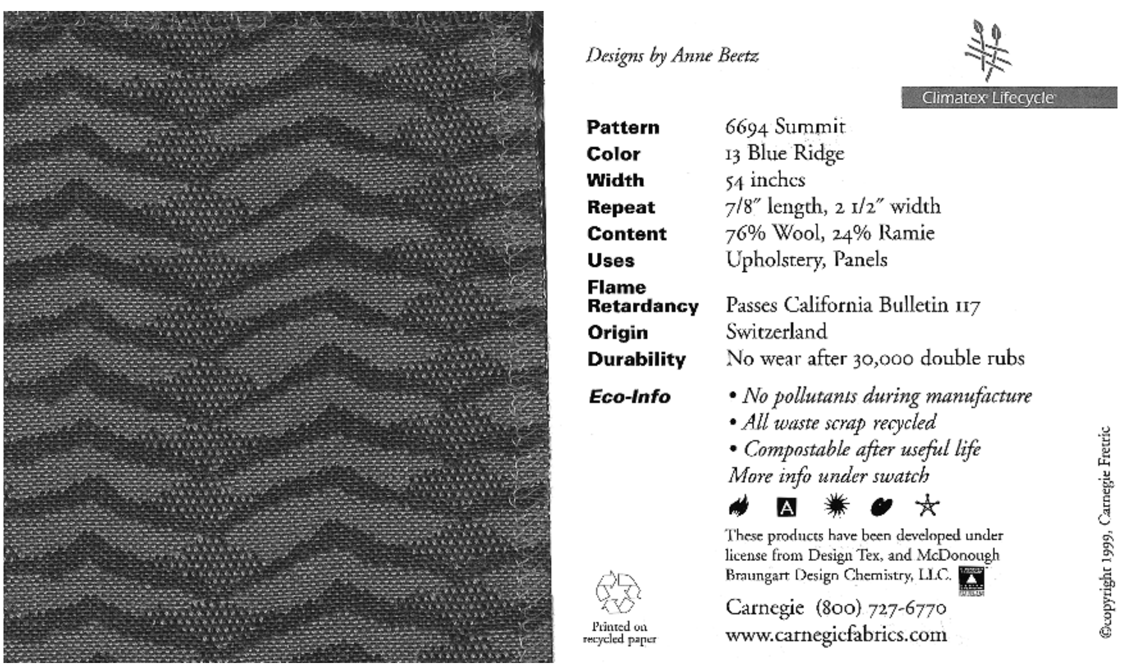

Figure 1-10 McDonough Braungart fabric protocols. This fabric is designed for minimum environmental impact.

Material Safety Data Sheets

The American National Standards Institute (ANSI), which coordinates code development, publishes a standard form for Material Safety Data Sheets, composed of 16 sections:

- Substance identity and company contact information
- Chemical composition and data on components
- Hazards identification
- First-aid measures
- Firefighting measures
- Accidental release measures
- Handling and storage
- Exposure controls and personal protection
- Physical and chemical properties
- Stability and reactivity
- Toxicological information
- Ecological information
- Disposal considerations
- Transport information
- Regulations
- Other information

ENERGY USE

The source and amount of energy used to produce a material, as well as its effect on the environment, should be major concerns for the interior designer. *Embodied energy* is energy that is used to obtain, process, fabricate, and transport a unit of building material. For example, the embodied energy for wood includes the sunlight used for its growth, the fuel needed to cut, transport and process wood products, and to install them at the site. Embodied energy calculations can also include the material's impact on building heat gain or loss, and energy used for disposal.

By choosing to reuse existing interior materials, a designer saves energy and lowers disposal costs. *Selective demolition*—the dismantling of reusable building parts for reuse—adds to the availability of low-cost construction materials and helps keeps waste out of landfills.

Fossil Fuels

Our most commonly used energy sources—coal, oil, and gas—are fossil fuels that are not renewable. Often, energy from fossil fuels is used to obtain and process raw materials, to manufacture products, and to transport them to distributors and then to building sites. Additional energy is used to install and finish materials, and to maintain, repair, and ultimately replace and dispose of materials. Even recycled materials use energy for transportation, separation and processing, and manufacturing.

Greenhouse Gases

Human activities are adding *greenhouse gases*, pollutants that trap the earth's heat, to the atmosphere at a rate faster than at any time over the past several thousand years. A warming trend has been recorded since the late nineteenth century, with the most rapid increase occurring since 1980, raising the global temperature and changing our planet's climate at an unprecedented rate. As greenhouse gases accumulate in the atmosphere, they absorb sunlight and infrared (IR) radiation and prevent some of the heat from radiating back out into space, trapping the sun's heat around the earth.

A global rise in temperatures of even a few degrees could result in the melting of polar ice and the ensuing rise of ocean levels, and would affect all living organisms. Energy from fossil fuels used to produce and transport materials add to greenhouse gas buildups.

THE LEED SYSTEM

The nonprofit U.S. Green Building Council (USGBC) has created a comprehensive system for sustainable design methods called LEED, short for Leadership in Energy and Environmental Design. LEED provides investors, architects, designers, construction personnel, and building managers with information on environmentally preferred

Table 1-2 Green Product Standards

Organization	Standard	Content
Carpet and Rug Institute	Green Label program for carpets	Certifies that product has been tested by independent lab and has very low chemical emissions.
EcoLogo	Canadian third-party certification program examines available research and life-cycle assessments, but does not typically carry out primary research.	Covers environmental, health, and safety issues; resource and energy consumption; contains market data on the product and industry sector, and socioeconomic data.
Environmental Building News	*GreenSpec* Directory (6th ed.) third-party evaluations	Evaluates building materials.
Forest Stewardship Council (FSC)	Third-party certification program	Lists certified or sustainably harvested wood products obtained from well-managed forests.
Green Seal	Third-party certification program considered a mark of environmental responsibility	Uses standards and research by others.
Oikos Green Building Source, from Iris Communications	Publisher of books on environmental issues	Provides a gallery of environmentally responsible building materials.
Rainforest Alliance	Certification and rating program for wood products and paper	Monitors products from rain forests.
Scientific Certification Systems	Third-party certification; auditing and testing services; standards	Recognizes highest levels of performance in food safety and quality, environmental protection, and social responsibility.
U.S. Environmental Protection Agency (EPA)	Executive Order 13101–Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition	Addresses green standards in federal agency procedures.
	Executive Order 13123–Greening the Government Through Efficient Energy Management	Covers standards for government buildings.

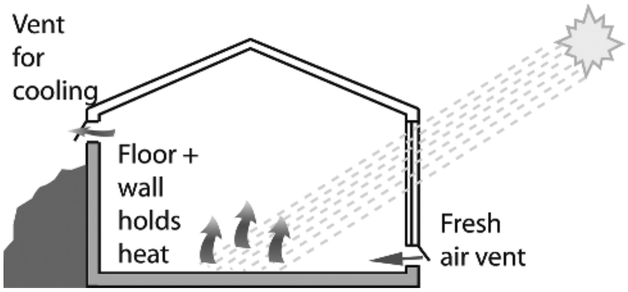

Figure 1-11 Floor and wall materials with high thermal capacity store the sun's heat, thereby containing solar energy.

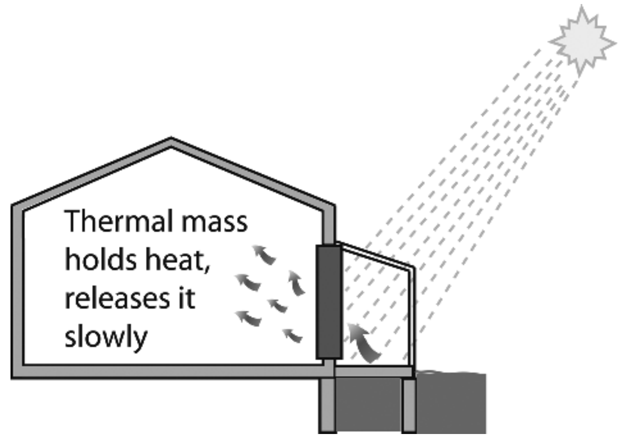

Figure 1-12 Materials with high thermal capacity can block unwanted solar heat from entering a building directly and store it for later use.

Table 1-3 Greenhouse Gases

Type of Gas	Sources
Carbon dioxide (CO_2)	Burning fossil fuels for transportation, electrical generation, heating, and industrial purposes.
Methane	Human production of fossil fuels, livestock and manure, rice cultivation, biomass burning, and waste management account for about 60 percent of global methane emissions. Natural sources of methane include wetlands, gas hydrates, permafrost, termites, oceans, freshwater bodies, nonwetland soils, and other sources such as wildfires.
Carbon monoxide (CO)	Internal combustion engines burn CO to produce CO_2. Human-produced sources include unvented kerosene and gas space heaters; leaking chimneys and furnaces; backdrafting from furnaces, gas water heaters, wood stoves, and fireplaces; gas stoves; generators, and other gasoline-powered equipment; automobile exhaust from attached garages; and tobacco smoke.
Hydrofluorocarbons (HFCs)	Refrigerants, propellants, and cleaning solvents. HFCs have been banned by the Montreal Protocol on Substances That Deplete the Ozone Layer. Although being phased out, off-gassing still occurs from foam building insulation.
Perfluorocarbons (PFCs)	Aluminum smelting and semiconductor manufacturing.
Chlorofluorocarbons (CFCs)	Polyurethane foams used for insulating homes and other buildings. Some have dissolved into the oceans and will eventually come out into the atmosphere. Current decline is due to a ban by the Montreal Protocol.
Sulfur hexafluoride	Insulating gas used in electrical equipment
Nitrous oxide (NOx)	Naturally emitted by bacteria in soils and oceans. Agriculture: soil cultivation, nitrogen fertilizers, animal waste handling. Production of nylon and nitric acid. Burning of fossil fuel in internal combustion engines.
Tetrafluoromethane	Refrigerant. Slowly being phased out.

building techniques and strategies. LEED also certifies buildings that meet the highest standards of economic and environmental performance, and offers professional education, training, and accreditation. LEED professional accreditation recognizes an individual's qualifications in sustainable building.

The LEED green building rating system is based on overall performance criteria for entire buildings. LEED evaluates buildings for performance in five categories:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality

Further, the LEED system establishes criteria for the use of reused materials, recycled-content materials, local or regional materials, rapidly renewable materials, certified wood, and low-emitting materials.

Interior designers are among those becoming LEED-accredited by passing the LEED Professional Accreditation Examination, which establishes minimum competency in much the same way as the National Council for Interior Design Qualification and other professional exams. The LEED Rating System for Commercial Interiors (LEED-CI) is now in use. In order to meet LEED-CI standards, an interior space must be located in a LEED-certified building or in a building that takes advantage of brownfield redevelopment, water management, renewable energy, and/or community density and connectivity measures. New LEED residential standards for single and multifamily residences with three or fewer habitable floors define features of a green home and provide a consistent rating system with third-party verification and on-site inspections.

Water Use

Ninety-nine percent of the earth's water is either saltwater or glacial ice. One-quarter of the solar energy reaching the earth is employed in constantly circulating water through evaporation and precipitation in a process known as the *hydrologic cycle*. The most accessible sources of water for human use are precipitation (rain and snow) and runoff. These provide a very large but thinly spread supply of relatively pure water that, when absorbed into the ground as *groundwater,* makes up the majority of the water supply.

The manufacturing process uses large amounts of water. In closed-loop manufacturing, water is repeatedly circulated and reused. Wastes are prevented from polluting the water supply downstream and, ideally, are turned into useful products.

Recycling

The best way to conserve materials and energy is to retain existing materials in new designs. Reducing the amount of new material is the second most effective method. Using recyled materials or new materials with recycled content is a third way to support sustainable design. Recycled materials almost always require additional energy for manufacture or transportation.

There are three major categories of recycled materials:

- *Postconsumer recycled material* is defined as a reclaimed waste product that has already served a purpose to a consumer and has been diverted or separated from waste management collections systems for recycling. An example would be used newspaper that has been made into cellulose building insulation.
- *Preconsumer recycled material* takes waste removed from production processes, including scrap, breakage, and by-products, and reuses it in another process

before consumer distribution. One example is mineral (slag) wool, a by-product of the steel blast furnace process, which is used for mineral fiber in acoustical ceiling panels.
- *Salvaged material* such as used brick is collected from existing or demolished buildings for reuse.

Interior designers play a key role in the reuse of nonstructural interior building components when they consider which elements can be reused in a new design or salvaged for another project. Demolition by hand salvage produces useful building components, and even some architectural gems. The dismantling of a building generates reusable roof boards, framing lumber, and tongue-and-groove wood flooring. Doors, windows, bathroom fixtures, plywood, siding, and bricks all can be reused, as can furniture, equipment, and appliances.

Interior designers work with contractors to ensure that materials removed during renovation and the waste generated by construction have a second life; recycling

LEED Project Credits

LEED-CI (commercial interiors) project credits are given for:
- Site Selection: Space in a LEED-certified building or in a building located so as to take advantage of brownfield redevelopment, water management, renewable energy, and community density and connectivity measures.
- Water Use Reduction: 20 percent and 30 percent decreases.
- Energy and Atmospheric Measures:
  - Energy-efficient and nonpolluting lighting power and controls, HVAC systems, equipment and appliances
  - Green power sources
  - Energy use, management, and payment accountability
- Materials and Resources:
  - Storage and collection of recyclables
  - Long-term tenants
  - Reuse of nonstructural interior building components
  - Construction waste diversion from landfills
  - Resource reuse of furniture and furnishings
  - Recycled content of materials
  - Use of regional materials
  - Rapidly renewable materials
  - Certifiable wood
- Indoor Environmental Quality:
  - IAQ performance minimums, environmental tobacco smoke controls, outside air delivery monitoring, and increased ventilation.
  - IAQ management during construction and before occupancy
  - Low-emitting materials: adhesives and sealants, paints and coatings; carpet systems; composite wood and laminate adhesives; systems furniture and seating.
  - Indoor chemical and pollutant source controls
  - Lighting, temperature and ventilation controls
  - Thermal comfort compliance and monitoring
  - Daylight and views
- Innovation and Design Process including use of LEED-accredited professional

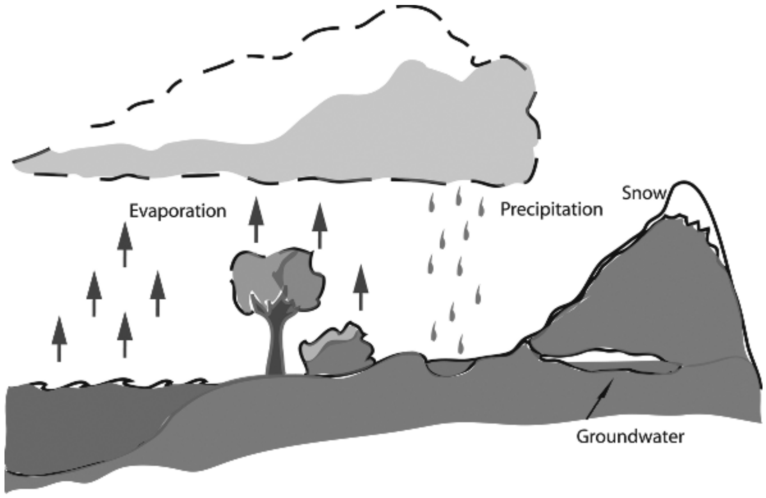

Figure1-13 Hydrologic cycle. Continual evaporation of water into the environment distills the earth's limited supply. This clean water is then returned to Earth as rain or snow.

requirements are now commonly included in demolition specifications. Asphalt, concrete, bricks, and metal are routinely recycled to meet market demands. Shingles, carpet, wallboard, doors, windows and other pieces of demolished homes and offices can be diverted into the resale and recycling market. Concrete and masonry can be crushed and used as aggregate for road building. Glass can be recycled into "glassphalt" road-surface reflectors. Chopped-up wood becomes mulch or helps the composting of sludge at sewage treatment facilities. Manufacturers that take back used carpet grind it up for attic insulation or recycle it into new carpet. Plate glass becomes fiberglass insulation, and used acoustic tiles are recycled into new ones.

The disposal of drywall, or gypsum wallboard, can pose an environmental danger. Many landfills today won't accept gypsum wallboard scrap because it produces toxic hydrogen sulfide gas when buried. Fortunately, it can be recycled, with up to 85 percent of the material reused for new drywall. Unpainted drywall can also be composted, replacing lime in the soil.

Indoor Air Quality (IAQ)

Air pollution problems can start with a building's materials and finishes, followed by the construction methods used to build or renovate the building. Interior designers play a major role in specifying materials that potentially contribute to indoor air pollution; they are key players in the renovation of buildings for new uses and to accommodate new ways of working.

To improve indoor air quality and prevent contamination by pollutants, a building's architect, engineers, and interior designer must work together. The interior designer can specify appropriate materials, products, and equipment, and evaluate the amount and toxicity of emissions given off during installation or use, especially where the surfaces of potentially polluting materials are exposed to the air and to people.

Maintenance requirements for cleaning processes, stain-resistant treatments, and waxing that emit pollutants may contribute to poor IAQ. When construction is complete, the interior designer should provide the building's management, users, and owners with appropriate information about maintenance requirements.

Volatile organic compounds (VOCs), chemicals that tend to evaporate at room temperature and normal atmospheric pressure (thus, are volatile) and contain one or more carbon atoms (therefore, are organic compounds), are invisible fumes or vapors. Some VOCs have sharp odors, while others are detectable only by sensitive equipment. VOCs commonly evaporate from plywood, plastic, fibers, varnishes, and coatings;

from cleaning chemicals, solvents used in paints, waxes, and petroleum fuels; and from some consumer products. Some products will off-gas VOCs for a limited period—during which the space must be ventilated—and then revert to a safe state.

Note: Not all VOCs are dangerous. Consider the scent of a rose, which is the off-gassing of a volatile organic compound.

Formaldehyde

Formaldehyde, a common VOC, is a colorless, strong-smelling gas used in the manufacture of synthetic resins and dyes, and as a preservative and disinfectant; it is present in pressed-wood products. After exposure, healthy people may have difficulty breathing, and may cough, wheeze, and feel tightness in their chests. At high levels, formaldehyde causes tearing, burning, and stinging eyes; sneezing and a tingling sensation in the nose; and soreness and dryness in the throat. The irritation persists even after removal of the source, and can temporarily heighten sensitivity to other contaminants. Formaldehyde may also increase the risk of cancer in humans, and has been clearly demonstrated to have negative effects on people with chemical sensitivities.

Formaldehyde is found in particleboard, interior laminated panels, glues, fabric treatments, and paints. Interior-grade plywood, particleboard, medium-density fiberboard (MDF), insulation, and some textiles emit it. Its effects are most severe when products are new, but they can last anywhere from a few hours to many years after installation. Fortunately, alternatives to particleboard are becoming more readily available. When formaldehyde-bearing products are used, however, they should be sealed with laminates or a liquid sealer formulated especially for formaldehyde reduction, including edges, backs, under desks or tabletops, and inside cabinets and drawers.

Table 1-4 Federal Guidelines for Recycled Content of Interior Materials

Interior Material	Recycled Material	Percent of Material's Composition
Carpet—polyester	Postconsumer Polyethylene Terephthalate (PET)	25–100%
Cement and concrete	Coal fly ash	0–40%
	Ground, granulated blast furniture slag	25–50%
Dividers: restroom and shower	Postconsumer plastic	20–100%
	Postconsumer steel	16%
Fiberboard—structural	Recovered	80%
Floor tiles	Recovered	80%
Paint	Reprocessed latex (white, pastel)	20% postconsumer
	Reprocessed latex (gray, dark)	50–99% postconsumer
	Consolidated latex	100% postconsumer
Paperboard—laminated	Postconsumer	100%
Patio blocks	Postconsumer rubber	90–100%

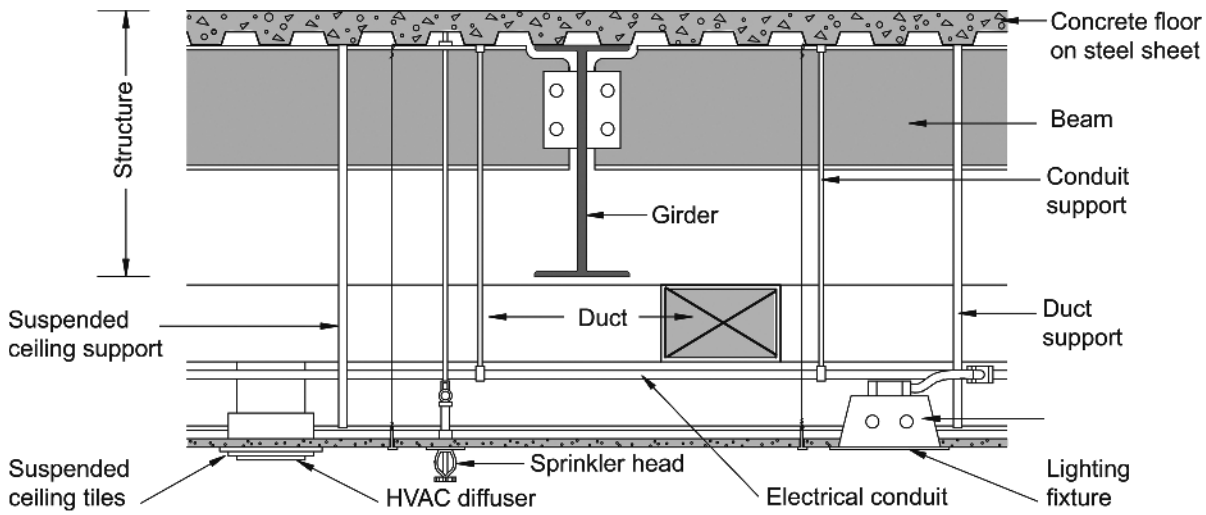

Figure 1-14 Floor/ceiling plenum

Materials Stability

The stability of materials has an impact on interior air quality over an extended period. Interior design finishes that do not produce or retain dust, and designs that limit open shelving or areas that collect dust help control VOC retention. Durable materials, such as hardwoods, ceramics, masonry, metals, glass, baked enamels, and hard plastics are generally low in VOC emissions; low-VOC paints are readily available as well. Fibers like cotton, wool, acetate, and rayon have low VOCs, but their dyes and treatments may release toxic chemicals.

The period immediately following the finishing of the building's interior is critical for VOC exposure. Aging materials before installation may help release some of the VOCs outside the space. If possible, occupancy should be delayed to allow for off-gassing from adhesives, paints, and other materials and finishes. The re-release of VOCs that have been absorbed by furnishings can be controlled by using the maximum amount of outside air ventilation possible during and following the installation of finishes and furnishings. Installed materials can be protected from collecting VOC emissions from other products by sealing them in plastic vapor barriers. Newly occupied buildings should be operated at the lowest acceptable temperatures to slow VOC emissions.

Asbestos

The inhalation of asbestos fibers over a long period of time can cause cancer, fluid in the lungs, and asbestosis, a fibrous scarring of the lungs. Asbestos is white, light gray, or light brown, and looks like coarse fabric or paper; it may appear as a dense, pulpy mass of light gray, stuccolike material applied to ceilings, beams, and columns. Up until 1975, asbestos was widely used for steam pipe and duct insulation and in furnaces and furnace parts. Before 1980, acoustic tiles and fiber-cement shingles and siding contained asbestos. Vinyl floor tiles made from the 1940s to the 1980s contain asbestos, as does their adhesive. Asbestos fibers may still be found in existing construction, especially in the insulation on heating system components and other equipment, in acoustic tiles, and in drywall joint-finishing material, and textured paint purchased before 1977. Some sprayed and troweled ceiling-finishing plaster installed between 1945 and 1973 also contains asbestos.

Most asbestos can be left undisturbed, as long as it does not emit fibers into the air. If it is not crumbling, it can be sealed with a special sealant and covered with sheet metal.

If it remains in place, it must be dealt with later during renovation or demolition. The interior designer should avoid drilling holes, hanging materials onto walls or ceilings, causing abrasion, or removing ceiling tiles below any material containing asbestos. Wrapping can repair asbestos-covered steam lines and boiler surfaces, but asbestos in walls and ceilings usually cannot be repaired, as it is difficult to keep airtight. It is possible to enclose asbestos in areas with low ceilings or small areas that are unlikely to be disturbed or damaged by water, or where the asbestos is unlikely to deteriorate. Encapsulation may cost more than removal. Removal is the only permanent solution, but if done improperly, can be more dangerous than leaving the asbestos in place. If removal is required, it should be done by a properly certified and licensed expert. Areas from which asbestos is being removed must be isolated using airtight plastic containment barriers, and kept under negative pressure with special high-efficiency particulate air (HEPA) filtration. The work site should be inspected and its air quality tested after the work is done.

Lead

Lead was present in most paint in the United States until it was banned in 1978 by federal law (it had been banned in most other countries decades earlier). Until 1985, pipes and solder also contained lead, as did gasoline, and it was commonly found in dust and soil near roads.

Lead is a neurotoxin that is especially damaging to fetuses, infants, and young children, and can cause learning disabilities, nausea, trembling, and numbness in the arms and legs. Children ingest and inhale lead-based paint chips or dust by playing on floors and other dusty surfaces and then putting their hands in their mouths or noses. Lead particles are suspended in the air or settle on surfaces such as carpets, which can release the particles back into the air when disturbed. Lead accumulates in the body over time, and lead poisoning has become the number-one health hazard to children under the age of seven. Lead exposure has been implicated in attention deficit disorder, impaired hearing, reading and learning disabilities, delayed cognitive development, reduced IQ scores, mental retardation, seizures, convulsions, coma, and death. In adults, lead exposure can cause high blood pressure; and occupational exposure has been implicated in kidney disease.

Houses built prior to 1950 are likely to contain paint with high levels of lead. Lead-based paint is in three-quarters of U.S. homes built prior to 1975, amounting to nearly 60 million private homes. The woodwork and walls of many homes were painted with lead-based paints. This residential exposure accounts for 80 to 90 percent of total lead exposure; therefore, it is critical that old lead paint be identified and removed, or sealed in an approved manner. Old pipes and solder should also be replaced.

An interior designer is in a position to advocate for the proper handling and disposal of lead paint by a licensed contractor. If the lead-based painted surfaces are clean and intact, and there is no cracking, peeling, blistering, or flaking, they can sometimes be encapsulated with a coating applied in liquid form that provides a flexible, impact-resistant barrier. Encapsulation is the most economical and simplest procedure, and does not require hazardous waste removal or the relocation of building occupants.

HISTORIC PRESERVATION, RESTORATION, AND ADAPTIVE REUSE OF MATERIALS

By keeping older buildings in usable condition and protecting their original use or finding a new one, communities create a sense of continuity and cultural richness. While the exterior appearance of a building in many communities is regulated by law to maintain a prescribed historic appearance, the interior is permitted to be changed to accommodate new uses and evolving tastes. In these cases, the interior designer has the option of working with existing interior elements or installing a totally new interior into the historic building shell.

The following four approaches to the preservation of historic buildings are regulated in the United States by government entities, including the Secretary of the Interior, the National Historic Preservation Fund, and the *National Register of Historic Places*.

- *Preservation* focuses on retaining and repairing as much of an existing property as possible. The subject of a preservation effort is often a building, or parts of a building, with significant historical value. Details from more than one historic period may be preserved, showing how the building has changed over time. Existing materials are preserved wherever possible by cleaning and, sometimes, by coating surfaces. Paints are matched to original colors, although modern formulations are used. The interior designer's role in preservation involves conducting careful historic research and providing expert advice. The accuracy of the preservation is a major concern, as the client is often a museum, a preservation society, or a private owner of a valuable landmark property.

Figure 1-15 Wallpaper conservation. Carolyn Frisa conserves historic wallpaper in the Henry James suite at the Mount, home of writer Edith Wharton, Lenox, Massachusetts.
Photo by David Dashiell, the Mount.

- *Restoration*, in contrast, seeks to depict a specific period of time. The focus is on the period of greatest cultural, historical, and architectural significance. Original components from the desired period are either uncovered or accurately copied, and details from other periods are removed. The goal is an accurate depiction of the building at a specific moment in history. (See color plate C-1, Paint color restoration.)
- *Reconstruction* supplements original elements from a specific historical period, with new construction imitating the original. New methods and materials may be used to re-create a historically significant period. Reconstruction often seeks to maintain, with historic accuracy, a neighborhood that reflects a period from the past.
- *Rehabilitation* attempts to retain elements of a building's history, cultural environment, and architectural character while altering or expanding the existing property to accommodate new needs or uses. Repairs, alterations, and additions compatible with contemporary use are permitted, such as accommodations for ductwork or an elevator. Rehabilitation, it is important to point out, runs the risk of altering subtle but important relationships of proportion and detail.

Figure 1-16 The Earle Theatre, Washington, DC. Now known as the Warner Theatre, this performance space was thoroughly documented with photographs and drawings for its restoration in 1992.

Rehabilitation of Historic Building Interiors

Focus on:
- Portions significant to its historic, architectural, and cultural values
- Floor plans and interior spaces that define overall historical characteristics
- Size, configuration, relationships, and proportion of rooms and corridors
- Relationships of special features to spaces

Avoid:
- Dividing historically important spaces
- Making new cuts in floors and ceilings
- Dividing spaces horizontally with new floors or mezzanines
- Dropping ceilings below ornamental ceilings
- Changing room proportions
- Furring out perimeter walls for insulation
- Removing paint and plaster from traditionally finished surfaces
- Painting previously unpainted millwork
- Using destructive paint removal processes
- Using harsh cleaning agents

Retain, preserve, and repair:
- Columns, doors, fireplaces, and mantels
- Cornices, baseboards, paneling, hardware, and flooring
- Lighting fixtures and elevator cabs
- Stair locations and configurations
- Wallpaper, plaster, paint, stenciling, marbling, graining
- Visible building mechanical system elements
- Use of period colors
- Deteriorated decorative plasterwork

Figure 1-17 The actual composition of a wall in an existing building is sometimes unknown until demolition begins, as is the case here. Discrete removal of outer layers can provide a glimpse of what is behind.

Figure 1-18 Adaptive reuse of mill building, Lowell, Massachusetts. The steel columns, heavy wood beams, brick floor and walls, and wood plank ceiling of this building can be incorporated into designs for a variety of new uses.

In contrast to those four approaches, *renovation* and *adaptive reuse* of existing buildings are less concerned with historic accuracy.

- Buildings are renovated for many reasons, but principally to correct existing problems of structure or use. Design elements may be inconsistent with the historic period, and new materials may be used. Renovation may strive to create a period style while accommodating current needs and methods. Many upgrades of existing buildings fall into this category, which is not considered to be historic by government agencies.
- Adaptive reuse seeks to change the function of a building into something not intended for the original structure. Many times, buildings that have become obsolete are slated for adaptive reuse in order to extend their useful lives. The key elements of adaptive reuse are (1) the change from the building's original function and (2) adaptation to a new use. By adapting an existing structure to a new use, demolition is unnecessary.

According to "Rehabilitating Interiors in Historic Buildings" (Preservation Brief 18, National Park Service, U.S. Department of the Interior), by H. Ward Jandl, the process of historic interior preservation begins with the identification, retention, repair, and protection of a building's floor plan, the arrangement of its spaces, its features, and the applied finishes that define its historical character and purpose. After assessing the alterations that have already been made, as well as any deterioration the building has undergone, the degree of change appropriate to a project can be determined. Existing fabrics and original floor plans may reveal which alterations were added and where historical features are covered up but not destroyed. Identifying which walls and architectural features have been removed helps to establish the history of the building. Greatly altered spaces might not be worth returning to their original condition. If a building's history is important and well recorded, it may be possible to reconstruct its interior. The documentation of existing conditions includes photographing interior features and preparing measured floor plans prior to beginning any rehabilitation.

Historically preserved buildings must comply with contemporary building, life safety, and fire codes. However, when compliance would damage distinctive interior features, it may be possible to obtain a code compliance variance. The entire process benefits from close cooperation with code officials, building inspectors, and fire marshals.

Historic preservation construction usually involves a team of highly skilled, experienced, and specialized workers. State historic preservation officers and local preservation organizations can help a designer locate workers with established reputations. Information on preservation techniques can be found in the Association of Preservation Technology's *APT Bulletin* and in *The Old House Journal.*

CONCLUSION

Interior designers share in the responsibility to use resources wisely, to create buildings that support human and environmental health and safety, and to respect the architectural history of the buildings on which they work. Whether a project is very large or quite small, the interior designer benefits from an awareness of the impact it will have on the environment, the welfare of its users, and the nature of the community of which it is part.