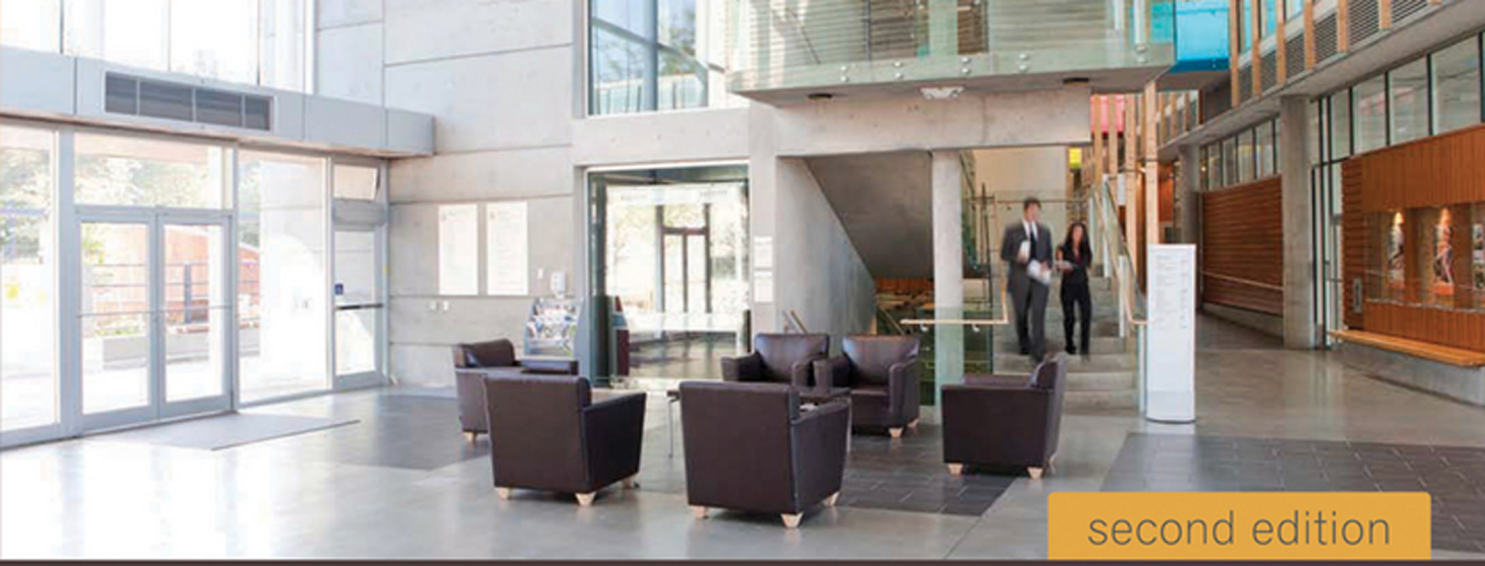

second edition

materials for INTERIOR ENVIRONMENTS

CORKY BINGGELI, ASID

WILEY

Materials for Interior Environments

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SECOND EDITION

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Preface

The materials used in interior environments—their composition, forms, characteristics, cost, uses, and effect on human health and the environment—encompass an immense, diverse, and constantly changing body of knowledge. *Materials for Interior Environments* was written as a guide to learning about these materials, with the emphasis on clarity and comprehensiveness.

The enormous amount of detail needed to describe interior finish materials can be daunting. The Second Edition provides carefully researched, updated, and organized information on basic material types and their applications. With color throughout and over 550 new illustrations, this book is informative and inspirational for both students and design professionals.

Part I Design Considerations begins in Chapter 1 with a discussion of the properties involved in selecting interior materials: functional criteria, the constraints of codes, human factors, and cost estimating. Chapter 2 focuses on sustainable design principles, codes and standards, materials, and product certification systems. Chapter 3 addresses existing building interiors, historic buildings, and hazardous existing materials.

Part II Interior Materials looks at each basic group of materials with a review of its design context, its types and sources, and its impact on human health and on the environment. Chapter 4 covers concrete and cement-based materials. Stone, masonry, and concrete masonry units are addressed in Chapter 5. Glass and ceramics are covered in Chapter 6, wood and wood products in Chapter 7, and plaster and gypsum board in Chapter 8. Chapter 9 is devoted to metals, and Chapter 10 to synthetic materials.

Part III Finish Comparisons allows the reader to compare different materials with each other in respect to specific applications. Chapter 11 covers paints and coatings. Fibers, textiles, and leather are addressed in Chapter 12. Chapter 13 is devoted to floor finishes, Chapter 14 to wall and window finishes, and Chapter 15 to ceiling finishes. Chapter 16 discusses the use of materials for millwork, casework, and furnishings.

As a textbook, *Materials for Interior Environments* provides students with both an introduction to the different types of materials and the information needed to compare alternatives. For the design professional, it serves as a reference for information on properties, environmental impact, and human health and safety, and as a source of suggestions for design solutions. This Second Edition has been carefully tailored to meet these needs.

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Acknowledgments

The structure of *Materials for Interior Environments* derives from the organization of a course I taught with Rachel Pike, ASID, at Wentworth Institute of Technology, Boston. Rachel's extensive knowledge and formidable organizational skills helped me put this very broad range of subject matter into usable form.

The comments of the proposal reviewers were very helpful in shaping the Second Edition. My thanks go out to reviewers Valerie L. Settles of the University of Central Oklahoma, Meghan Woodcock of Savannah College of Art and Design, and Anubhuti Thakur of California State University, Northridge. I also want to thank Christina Oliver, ASID, who brought me up to date on cost estimating practices for residential projects.

The team at Wiley has helped me refine the content and format for the Second Edition. They include my editor, Paul Drougas, and his able editorial assistant Michael New, senior production editor Nancy Cintron, copy editor Stewart Smith, and marketing manager Sharon Kucyk.

As always, my husband Keith Kirkpatrick provided feedback and made sure I was properly fed. He, along with my cats Spif and Brindle, helped me shift my somewhat obsessive focus with occasional breaks and laughter.

Part I

Design Considerations

Finish Selection and Specification 1

There are thousands of products available for use in interior environments, and each has its assets and disadvantages. The process of selecting the right interior material for the job is sometimes bewildering. The purpose of this book is to serve as a guide for designers to learn about, evaluate, and select 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 appearance, they consider its acoustic properties and light reflectance. The material's shape, texture, proportion, and scale are related to the balance and symmetry of the space and the harmony of the design. Whether or not 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 (Figure 1.1).

Figure 1.1: Materials in Trinity Church Undercroft, Boston, Massachusetts

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

Interior materials 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. They check details of product manufacture and installation for exposed sharp edges and shatter resistance. Electrically conductive materials are selected where static

electricity is likely to cause a painful shock or affect electronic equipment. Materials that are likely to become very hot or cold require insulation from contact. Where potentially dangerous chemicals are in use, materials are selected to protect both surfaces and people. Designers should avoid materials that expose people to harmful chemicals or unsafe conditions during manufacturing, delivery, installation, use, or disposal, or that degrade **indoor air quality (IAQ)**.

Designers 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 for light, moderate, or heavy use by their manufacturer.

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.

Describing the Properties of Materials

Color: property dependent on the quality and quantity of light; one or more innate colors, and possibly other colors if processed
Durability: ability to resist destructive forces, retain original appearance, and continue to function as intended
Elasticity: resiliency or flexibility; the ability to return to initial form after deformation
Form: the three-dimensional quality defined by length, width, and depth; may be linear, planar, or block-like
Plasticity: ability to be formed or shaped; allowing 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
Texture: relative smoothness or roughness of a surface; may be large- or small-scale
Workability: the ease of altering a material from its primary form

FUNCTIONAL CRITERIA

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

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 it will break if struck hard by a fist, causing cuts and bleeding. It is important to keep in mind that safety concerns change over time; when asbestos was introduced to prevent the spread of fire, its effect on human health was not clearly understood or was not considered.

Durability involves evaluating a material for its ability to stand up to its intended use. Materials may be rated for their resistance to abrasion. Some materials will melt when they come in contact with a heat source; others will deteriorate from contact with alcohol or acetone. Water will damage or weaken some materials, while others will dry out in low humidity. The preparation of the underlying **substrate** and the use of proper installation procedures affect the durability of a material, as does its finish.

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 is more likely to induce lingering. Materials that carry heat away from the human body may be welcome in a tropical climate but can feel unpleasantly cold to the touch elsewhere. The texture of a floor becomes critical for those who spend their workday on their feet.

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 are performing the maintenance.

Fire resistance is such an important topic that designers often limit their initial material 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.

The acoustic properties of interior materials affect the acoustic quality of a space by absorbing or reflecting sound within it, and by transferring sound from one space to another (Figure 1.2).

Within a space, a sound generated from one location will spread out and away from its source; this is referred to as **diffusion** (Figure 1.3). It continues to spread and gradually becomes weaker, which is called **attenuation** (Figure 1.4), until it is either absorbed or reflected by an intervening material. In some spaces, a designer will want sound to be reflected and spread 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, while the flooring material is generally the least important in terms of sound absorption.

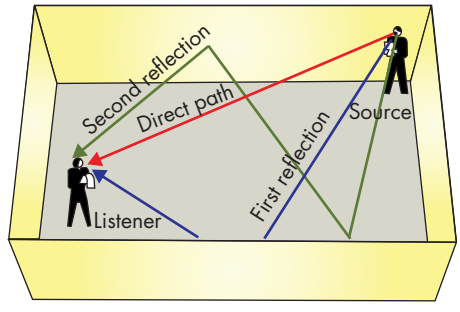

Figure 1.2: Reflected sound

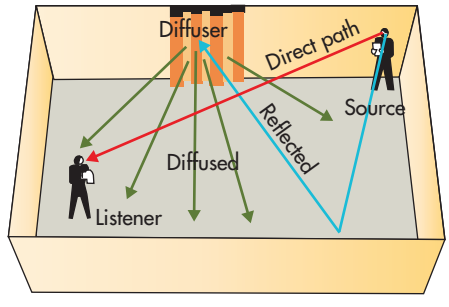

Figure 1.3: Sound diffusion

The sound of footfalls and chairs scraping on a hard-surfaced floor can add a considerable amount of noise to a space. **Impact noise**—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 via the building structure to another location (Figure 1.5).

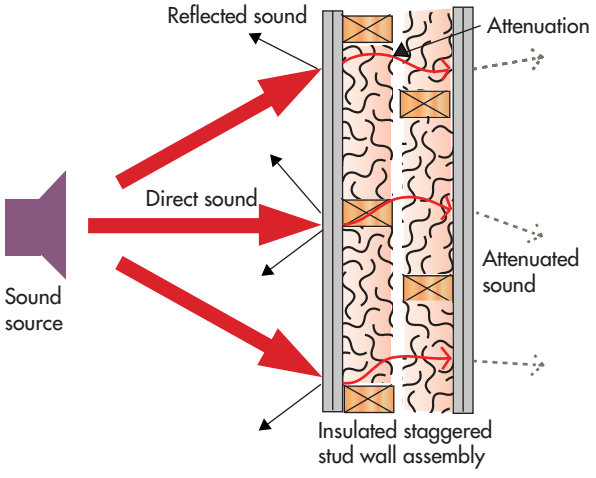

Figure 1.4: Sound attenuation

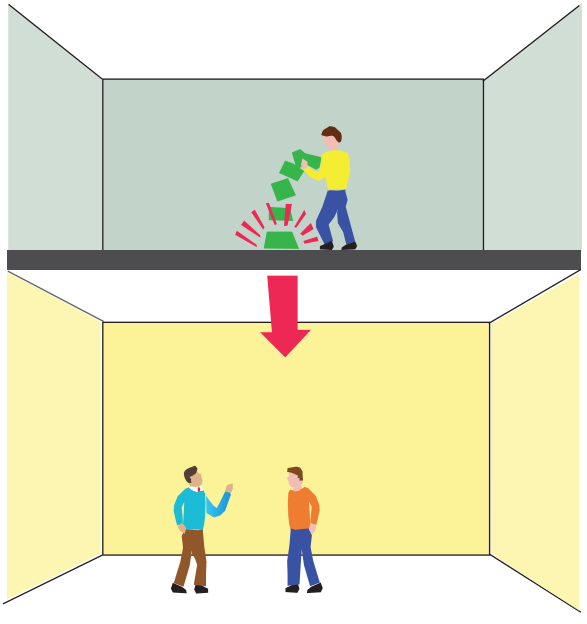

Figure 1.5: Impact noise transmission

Some materials tend to block the transfer of sound. These include large amounts of sound-absorbent material as well as 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. Certain panel materials will pick up the vibration of a sound wave and amplify it, much like the head of a drum.

HEALTH AND SAFETY CODES

Interior designers share in the responsibility to create buildings that support human health and safety. Whether a project is large or small, the interior designer benefits from an awareness of the impact it will have on the welfare of its users and the community of which it is part.

Building Codes

Before starting to select the finishes and furniture for a project, a designer determines which codes are applicable. The International Code Council (ICC) publishes the International Codes (I-Codes). The International Building Code® (IBC) or codes based on it have been widely accepted throughout the United States. Other I-Codes with provisions related to interior materials include:

- International Residential Code for One- and Two-Family Dwellings® (IRC)
- International Existing Building Code® (IEBC) (also chapters on existing buildings in other codes)
- International Green Construction Code® (IGCC)

The C3-Codes, published by the National Fire Protection Association (NFPA), are newer than the IBC and not as widely adopted. NFPA 5000® Building Construction and Safety Code is a C3-Code relevant to interior materials.

Note: Code information in this text is meant for general reference only; see *The Codes Guidebook for Interiors* by Sharon Koomen Harmon, IIDA, and Katherine E. Kennon, AIA, published by John Wiley & Sons, for more detailed information.

Occupancy Classifications

Occupancy classifications were developed to address risk factors associated with specific types of building use. They consider the way a space is used: the amount of finish materials, upholstered furniture, and other flammable contents; and the concentration and characteristics of occupants, among other things. The **occupant load**—the number of people that is assumed to safely occupy a space or building—is closely related to the occupancy classification. Interior materials–related code issues affected by occupancy include accessibility requirements, finish and furniture selection and placement, and means of egress.

Building Construction Types

Building construction types are classified by building codes according to their resistance to fire. Building elements rated in hours include bearing and non-bearing walls and partitions and floor

construction and secondary members. Building types and elements are important considerations when adding walls, finished ceilings and ceiling elements, doors, and interior glazing.

Materials and material assemblies are rated based on their fire resistance (ease of ignition, length of burn, flame spread, and heat generation). Most products are classified as either noncombustible, fire-resistant, limited combustible, or combustible. Fire-resistant and limited combustible materials may be combined with other materials in rated assemblies. Some combustible materials are allowed in rated spaces with proper installation.

Noncombustible materials will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. They are used to prevent substantial fire spread, and do not contribute to fire. Fire-resistant materials will delay the spread of fire for a designated time period. They can prevent or retard passage of heat, hot gases, or flames. Limited combustible materials do not meet noncombustible material requirements, and do have some capacity to burn. Combustible materials will ignite and continue to burn when the flame source is removed.

Means of Egress Issues

Means of egress is defined as a continuous and unobstructed path of travel from any point in a building to its exterior or a public way. Both horizontal and vertical passageways, including doorways, corridors, stairs, ramps, enclosures, and intervening rooms, are included. Requirements tend to become stricter as the occupant moves toward the exit.

Compartmentation

Compartmentation involves the separation of various areas of a building to control fire and smoke by wall, floor, and ceiling assemblies, which may be required to be fire-rated, smoke-rated, or both. Fire-rated assemblies include fire walls, fire barriers, horizontal assemblies, and fire partitions. Smoke barriers and smoke partitions may also be required in some cases. The combination of walls, floor, and ceiling together creates a compartment or enclosure.

There are two basic types of tests for fire-rated wall and floor/ceiling assemblies. Fire-resistance tests evaluate how long an assembly will contain a fire, retain its own structural integrity, or both. Other tests measure how a material contributes to the dangerous elements of a fire such as heat, smoke, combustion products, and flame spread.

Sound Transmission

Codes address efforts to prevent airborne sound transmission between specific types of spaces, such as hotel rooms, dormitory rooms, or apartment units. These requirements for specific **sound transmission coefficient (STC)** levels affect the selection of materials and their use in assemblies. The IBC requires that walls, partitions, and floor/ceiling assemblies separating dwelling units from each other or from public areas limit sound transmission and impact noise.

Residential Codes

Historically, building codes have focused on commercial, institutional, and multiple-occupancy residential buildings rather than on single- or two-family residential buildings. However, most fires occur in

smaller residential buildings. According to the NFPA, 92 percent of all civilian structure fire deaths in 2010 resulted from home structure fires, with cooking the leading cause of fires and home fire injuries. Smoking is also a major cause of civilian home fire deaths.

Tip: For more information on home fires, see www.NFPA.org

International Residential Code

The ICC has developed a residential code, the International Residential Code (IRC), which is required by many jurisdictions and referenced in some other I-Codes and standards. The IRC specifies both the types of materials and requirements for proper construction for foundations, floors, walls (including interior walls), ceilings, and roofs. It includes provisions relating to floor finishes, shower and bath area finishes, wall and ceiling finishes and trims, wood finishes, and mattresses. Other codes and standards may also apply to residential projects. (Table 1.1).

Other Regulations and Standards

Other provisions relating to interior materials include federal regulations and state and local codes. Standards are often referenced by building codes, the federal government, or a code jurisdiction. There are also optional industry standards that can be specified.

Federal Regulations

The federal government regulates the building of its own facilities, including federal buildings, Veterans Administration hospitals, military facilities, and other buildings built with federal funds. Government

Table 1.1: Residential Codes and Standards

Code	Comments
International Residential Code (IRC)	Single- and two-family homes, duplexes, and townhouses
ICC 700, National Green Building Standards (NGBS or ICC 700)	Used with IRC; requirements for resource, water, energy efficiency, and indoor environmental quality
ASHRAE/IESNA 90.2, Energy-Efficient Design of New Low-Rise Residential Buildings	Energy efficiency standard
International Energy Conservation Code (IECC)	Includes chapter on residential buildings
Fair Housing Accessibility Guidelines (FHAG)	Accessibility requirements