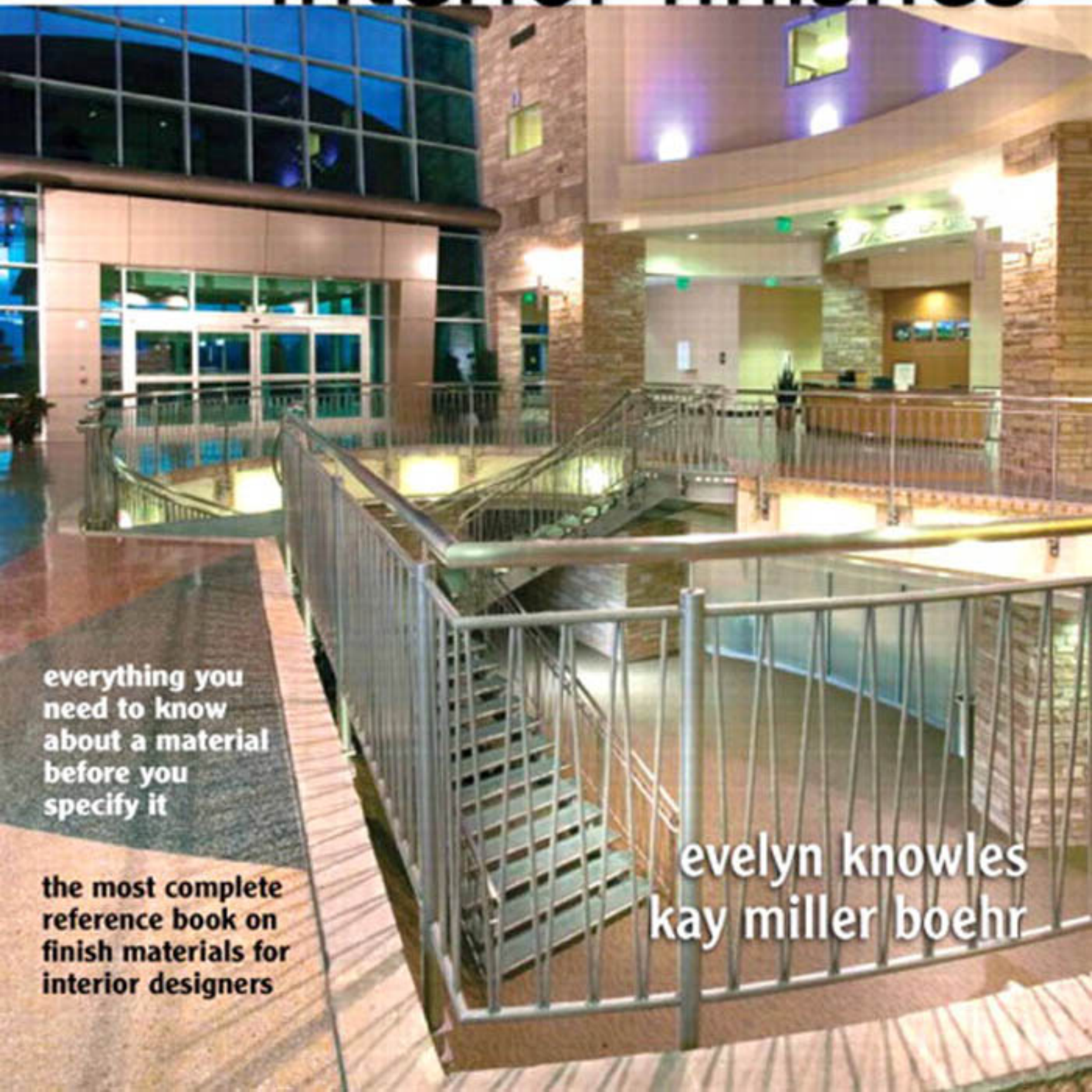
a comprehensive guide for selecting

interior finishes



everything you need to know about a material before you specify it

the most complete reference book on finish materials for interior designers

evelyn knowles
kay miller boehr

The Comprehensive Guide for Selecting Interior Finishes

This page intentionally left blank

The Comprehensive Guide for Selecting Interior Finishes

Evelyn Knowles, Ph.D., NCIDQ, IDEC, EDRA

Adjunct Professor, Environmental Studies
University of Northern Colorado, Greeley, Colorado

Kay Miller Boehr, IIDA, IDEC, registered architect

Associate Professor of Interior Design
Program Coordinator for Interior Design
Park University, Parkville, Missouri

PEARSON

Boston Columbus Indianapolis New York San Francisco Upper Saddle River
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montreal Toronto
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

Editorial Director: Vernon Anthony
Acquisitions Editor: Vernon Anthony
Associate Editor: Laura J. Weaver
Editorial Assistant: Doug Greive
Director of Marketing: David Gesell
Senior Marketing Coordinator: Alicia Wozniak
Marketing Assistant: Crystal Gonzalez
Senior Art Director: Jayne Conte
Production Manager: Laura Messerly
Manager, Rights and Permissions: Mike Lackey
Cover Designer: Karen Salzbach
AV Project Manager: Janet Portisch
Full-Service Project Management: George Jacob/Integra
Composition: Integra Software Services, Pvt. Ld.
Printer/Binder: Courier/Kendallville
Cover Printer: Courier/Kendallville
Text Font: 9/13, Frutiger

Cover photo: The interior of the Medical Center of the Rockies shows the integration of many finish materials: metal handrails, stone walls, glass windows, gypsum board ceiling, terrazzo flooring, carpet flooring on lower level, painted walls and ceiling, wood information desk, and plastic signage. Photo courtesy of Joel Eden Photography, Inc.

Credits and acknowledgments borrowed from other sources and reproduced, with permission, in this textbook appear on the appropriate page within the text. Unless otherwise stated, all artwork has been provided by the author.

Library of Congress Cataloging-in-Publication Data

Knowles, Evelyn E.
The comprehensive guide for selecting interior finishes / Evelyn E. Knowles, Ph. D., NCIDQ, IDEC, adjunct professor, University of Northern Colorado, Kay Miller Boehr, IIDA, IDEC, registered architect, associate professor of interior design, program coordinator for interior design, Park University, Parkville, Missouri.
pages cm
ISBN-13: 978-0-13-512191-7
ISBN-10: 0-13-512191-4
1. Building—Details. 2. Interior decoration—Materials. 3. Interior architecture—Materials. 4. Finishes and finishing. I. Boehr, Kay Miller. II. Title.
TH2025.K58 2014
698—dc23

2012044305

10 9 8 7 6 5 4 3 2 1

PEARSON

ISBN 10: 0-13-512191-4
ISBN 13: 978-0-13-512191-7

BRIEF CONTENTS

CHAPTER 1 Introduction to Selecting Finish Materials 1

CHAPTER 2 Metals 14

CHAPTER 3 Wood 35

CHAPTER 4 Stone 64

CHAPTER 5 Concrete 83

CHAPTER 6 Gypsum and Plaster 101

CHAPTER 7 Brick 119

CHAPTER 8 Ceramics 132

CHAPTER 9 Glass 150

CHAPTER 10 Paint and Coatings 169

CHAPTER 11 Plastics 183

CHAPTER 12 Fibers and Textiles 210

This page intentionally left blank

CONTENTS

PREFACE xvii

ACKNOWLEDGEMENTS xxi

ABOUT THE AUTHORS xxiii

CHAPTER 1

Introduction to Selecting Finish Materials 1

Materials and Finishes 1

Role of the Interior Designer 2

- What Designers Need to Know about Materials 3
- Variety of Materials Used as Finishes in an Interior 3

Common Threads: An Overview of Topics in Each Chapter 4

Environmental Impact 4

- GO GREEN: LEED Standards 5

Code Requirements 5

- Sustainable Design 6
- Agencies That Develop Standards 8

Interior Finish Materials and Fire 8

- Tests Used to Test the Flame Resistance of Interior Finish Products 9

Specifying 9

- Content of a Typical Specification Section 10

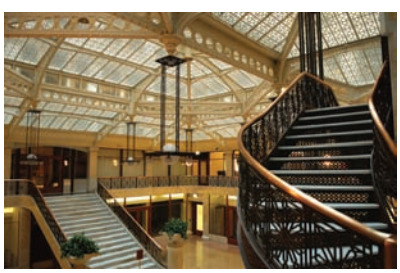
summary 11

- GO GREEN: Life Cycle Assessment: Evaluating the Material or Product 11

review questions 12

glossary of terms 13

CHAPTER 2



Metals 14

Awareness: An Overview 14

Description and Common Uses 14

Characteristics 15

Environmental Impact 15

- Properties of Metal 15
- Perforated Metal as an Interior Screening Device 16

Understanding: In-Depth Information 17

History of Metals 17

Production: How Metal Products Are Made 19

Galvanic Action 19
Metal Shapes Used in Construction 20
Types of Metal: Ferrous Metals 21
Types of Metal: Nonferrous Metals 22
Types of Metal: Alloys 23
Types of Metal: Used Primarily for Plating or Coating Other Metals 24
Alternate Forms of Metals 24
Treatments to Improve the Properties of Metals 24
Treating and Finishing Metal Products 25
Application: Using Information Regarding Interior Finish Materials 26
Code Issues 26
Case Study of Metal Used in an Interior 26
Specifying 27
Metals Used in an Interior 28
Maintenance 28
Life Cycle Costs 28
Applying Metals in an Interior 28
summary 31
review questions 32
glossary of terms 32

CHAPTER 3

Wood 35

Awareness: An Overview 35
Description and Common Uses 35
Characteristics 36
Wood Species 38
Environmental Impact 40
Properties of Wood 43
Understanding: In-Depth Information 43
History of Wood Use for Interiors 43
Production: Milling Wood 45
Types of Wood Materials Used in Interiors 46
Example of Kitchen Cabinets Made to Fit an Existing Space 50
Cherry Woodwork 52
Alternate Uses of Wood Products 55
Application: Using Information Regarding Interior Finish Materials 58
Code Issues 58
Specifying 59
Life Cycle Costs 59
Installation Methods 59

■ Wood Used in an Interior 59
Maintenance 60
■ Case Study of Wood and Wood Products 61
summary 61
review questions 62
glossary of terms 62

CHAPTER 4 **Stone 64**

Awareness: An Overview 64
Description and Common Uses 64
Characteristics 66
Environmental Impact 66
■ Properties of Natural Stone 66
■ An Example of Stone Used in a Residential Interior 67
Understanding: In-Depth Information 67
History of Stone Use in Interiors 67
Types of Stone 70
Fabrication of Stone 72
Alternate Uses of Stone 73
Application: Using Information Regarding Interior Finish Materials 75
Code Issues 75
Specifying 75
Life Cycle Costs 75
■ Stone Used in an Interior 75
Installation Methods 76
■ Case Study of Stone in a Hospital Application 76
summary 81
review questions 81
glossary of terms 81

CHAPTER 5 **Concrete 83**

Awareness: An Overview 83
Description and Common Uses 83
Characteristics 84
Environmental Impact 84
■ Properties of Concrete 84
■ Example of Concrete Used in an Interior 85
Understanding: In-Depth Information 86
History of Concrete 86
Production: How Concrete Is Made 87
Types of Concrete 90

Cementitious Products for Interiors 91
Alternate Uses of Concrete 91
Historic Uses of Concrete Blocks 92
Application: Using Information Regarding Interior Finish Materials 93
Code Issues 93
Case Study of Concrete Used in an Interior 94
Specifying 95
Maintaining 95
Life Cycle Costs 95
Concrete Used in an Interior 96
Applying Concrete in an Interior 96
Concrete Countertops 98
summary 99
review questions 99
glossary of terms 99

CHAPTER 6

Gypsum and Plaster 101
Awareness: An Overview 101
Description and Common Uses 102
Characteristics 102
Environmental Impact 104
Properties of Gypsum and Plaster 105
Understanding: In-Depth Information 105
History of Gypsum and Plaster 105
Production 107
Basecoat Plaster 108
Finish Coat Plasters 108
Gypsum Board 109
Application: Using Information Regarding Interior Finish Materials 109
Code Issues 109
Specifying 109
Gypsum Board Used in an Interior 110
Life Cycle Cost 110
Installation Methods 110
An Example of Gypsum Board Used to Cover Curved Shapes 114
Maintenance and Repair 114
An Example of Plaster Covering a Stove Vent 115
Case Study of This Material Used in an Interior Application 116
summary 117
review questions 117
glossary of terms 117

CHAPTER 7 **Brick 119**

Awareness: An Overview 119

Description and Common Uses 119

Characteristics 119

Environmental Impact 120

Properties of Brick 120

An Example of Brick Used in a Restaurant 121

Understanding: In-Depth Information 121

History of Brick Used for Buildings 121

Production of Brick 122

Brick Faces 123

Alternate Uses of Brick 124

Brick as an Art Form 126

Application: Using Information Regarding Interior Finish Materials 126

Code Issues 126

Bricks Used in an Interior 127

Specifying 127

Life Cycle Cost 127

Installation Methods 127

Maintenance 129

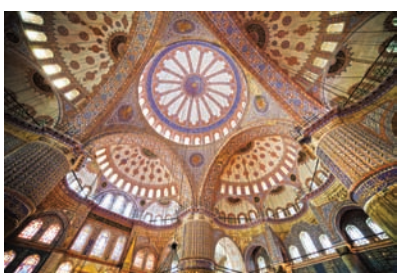
Case Study of Brick Used in a Commercial Interior Application 129

summary 130

review questions 130

glossary of terms 130

CHAPTER 8 **Ceramics 132**



Awareness: An Overview 132

Description and Common Uses 132

Characteristics 133

Environmental Impact 134

Properties of Ceramic Tiles 134

Example of Ceramics in an Application 135

Understanding: In-Depth Information 135

History of Ceramic Use in Interiors 135

Ceramic Colors 141

Production of Ceramics 141

Application: Using Information Regarding Interior Finish Materials 143

Code Issues 143

Case Study of Ceramic Tiles Used at Discovery Cove 143

Specifying 144

Life Cycle Cost 145

Installation Methods 145

■ Ceramics Used in an Interior 145
Maintenance 147
summary 148
review questions 148
glossary of terms 148

CHAPTER 9 **Glass 150**

Awareness: An Overview 150
Description and Common Uses 150
Characteristics 151
■ Properties of Glass 151
Environmental Impact 151
■ An Example of Glass Used in an Interior 152
Understanding: In-Depth Information 153
History of Glass 153
Production: How Glass Is Made 154
Types of Glass: Flat Glass 154
Types of Glass: Decorative and Art Glass 155
Alternate Uses of Glass 157
Modifications to Improve the Properties of Glass 158
Application: Using Information Regarding Finish Materials 161
Code Issues 161
■ Case Study of Decorative Glass Used in Interior Design 161
Specifying 163
Maintenance 164
Life Cycle Costs 164
Installation Methods 164
■ Glass Used in an Interior 165
Applying Glass in an Interior 165
summary 166
review questions 167
glossary of terms 168

CHAPTER 10 **Paint and Coatings 169**

Awareness: An Overview 169
Description and Common Uses 170
Characteristics 172
■ Properties of Paint and Coatings 173
Environmental Impact 173
Understanding: In-Depth Information 173
History of Use in Interiors 173
Components of Paint 174

Types of Paint and Coatings 174
Decorative Finishes 177
■ GO GREEN: Low-VOC Paint Used in a LEED Platinum Certified Project 178
Application: Using Information Regarding Interior Finish Materials 178
Code Issues 178
Specifying 179
Life Cycle Costs 179
■ Paint or Coatings Used in an Interior 179
Installation Methods 180
Maintenance 181
■ Case Study of Paint Used in an Interior Application 181
■ Case StudyRegarding Specification of Paint 181
summary 181
review questions 182
glossary of terms 182

CHAPTER 11 **Plastics 183**

Awareness: An Overview 183
Description and Common Uses 183
Characteristics 184
■ Properties of Plastics 185
Environmental Impact 185
■ GO GREEN: Plastic Recycling 187
Understanding: In-Depth Information 187
History of Plastics 187
■ Plastic Used in an Interior 188
Production: How Plastics Are Made 189
Types of Plastics 190
Application: Using Information Regarding Interior Finish Materials 194
Code Issues 194
■ Case Study of Plastic Used in an Interior 195
Specifying 196
■ Plastics Used in an Interior 198
Life Cycle Costs 198
Applying Plastics in an Interior 198
Floors 198
Walls 201
Wall Panels 202

Ceilings 203
Countertops 204
Plastic Laminate 205
Plumbing Pipes 206
summary 207
review questions 207
glossary of terms 207

CHAPTER 12 **Fibers and Textiles 210**

Awareness: An Overview 210
Description and Common Uses 210
Characteristics 211
■ **Properties of Natural Fibers 212**
■ **Properties of Synthetic Fibers 212**
Environmental Impact 212
■ **GO GREEN: Climatex Fabrics 213**
Understanding: In-Depth Information 214
History of Textiles 214
■ **Jacquard Loom 216**
Production: How Textile Products Are Made 217
Natural Fibers 217
Manufactured Fibers 218
Yarn 219
Fabrication 220
Coloring 222
Finishing 223
Design 223
Types of Fibers: Natural Fibers 223
■ **Physical Properties of Fibers 223**
Manufactured Cellulosic Fibers 225
Synthetic Fibers 226
Application: Using Information Regarding Interior Finish Materials 228
Code Issues 228
■ **Case Study of Textiles Used in an Interior 229**
Specifying 229
■ **Fibers Used in an Interior 230**
Evaluating Textiles 231
Applying Textiles in an Interior 232
Floors 232

Walls 236
Ceilings 238
Window Treatment 238
summary 239
review questions 240
glossary of terms 240

REFERENCES **241**
INDEX **250**

This page intentionally left blank

PREFACE

The authors of this book considered finish materials in terms of the physical properties of the material based on its source. Rather than categorize materials by use, as many other books on interior finish materials do, the materials in this book are categorized by their origin. For example, linoleum is in the chapter on wood because it is made from the wood and resin of trees. Another difference in this book is that sustainability is carried throughout the book and discussed in terms of the material in each chapter. In discussing the history of materials use, interiors are considered any environment manipulated to create a desired space (Huppatz, 2012). This allows the history of interior materials to go all the way back to the use of a cave for shelter.

USE OF CASE STUDIES

Interior designers reading this book will most likely be visual learners, so the information discussed is accompanied by visual images. Although a photograph starts the visual image, an example through a case study presents a long-lasting visual image to help readers remember the properties of a material. Each chapter contains case studies describing how the material met certain requirements on a project. Some of the case study requirements will discuss meeting a client's desire, meeting standards such as sustainability requirements for Leadership in Energy and Environmental Design certification of a project, or how it reduced volatile organic compounds to meet indoor air quality standards. The examples will make these issues relevant to readers who are interested in interior design.

PURPOSE

The purpose of this book is to help interior designers organize their knowledge of finish materials. Knowledge of materials is necessary for interior designers to become certified by

Visually Harmonizing Materials that Create a Unified Design is the Goal of Interior Designers
Photo courtesy of Spanjer Homes.

the National Coucil of Interior Design Qualification. Each chapter discusses one material and its properties. Since all learning builds on prior knowledge, this book starts with the basic information regarding finish materials, including common uses and characteristics for each material. When the properties of a material are thoroughly understood, a designer may come up with unique uses and applications for it. Information on how the material is produced and where the raw material was found add to the understanding of information necessary for specifying installation of the material.

The order of materials was chosen so that information learned about one material carries over to the next material. Materials that are often used structurally, but become the finish are first: the structural materials of Metal and Wood. Materials that are mined with a small amount of refining are next: mined materials of Stone, Concrete, Gypsum and Plaster, and Brick. This is followed by the chapter about Ceramics, which builds on the clay material used for bricks, although ceramics are refined by shape and through firing at higher temperatures. Ceramics are further refined by adding a liquid coating that becomes glass. Thus, it follows that the next chapter is Glass, which goes into more detail on the production of pure glass. Materials that are more removed from their natural elements follow: the synthetic materials of Paint and Plastics, which rely on petroleum. Last is the chapter of finishes that incorporate different materials: Fibers and Textiles. Some fibers are made from plants (cotton, linen, and rayon), some come from animals (silk and wool), and many are made from petroleum products (nylon, polyester, acetate, and olefin). Fibers and textiles are included in this book because they are often used as finish materials in interiors. This chapter will not take the place of an entire course on textiles, but it discusses them in terms of their use as finish materials.

FORMAT OF CHAPTERS

Each chapter introduces an interior finish material and contains three parts. The foundation for learning about materials is a description of the material, its common uses, and its properties, including sustainability. The second level of learning about materials includes historical use, sources where a specific material may be found, and applications for the material. The third level of learning about the material adds code issues, specifying, installation methods, and maintenance. These sections help to organize the content into areas defined by the Council for Interior Design Accreditation.

Learning Objectives

Each chapter begins with a list of specific learning objectives for the chapter.

Part I: Awareness: An Overview

Although interior designers are not responsible for the form of the building itself, or for the design of the building envelope or interior load-bearing components, it is essential for interior designers to understand how buildings are designed and constructed. In addition to having an awareness of building construction systems, readers will learn about the roles different materials play in constructing a building as well as the role that those same materials can play on an interior. Readers are therefore introduced to the material with an overview, including a description of the material and its common uses, both in building construction and as an interior finish. Included in the overview of the material is a discussion of the *properties,* or characteristics, of each material and the environmental impact of the material. Each chapter includes a feature box listing the properties of the material, emphasizing the material's sustainable properties. An example of the material used in an interior is also included.

Part I will enable readers to identify common uses of the material in an interior and introduce them to the environmental impact of the material.

Part II: Understanding: In-Depth Information

For the readers to have an *understanding*, or more thorough comprehension of the material, the text provides a review of the historical development of the material followed by a description of how the material is produced, from raw materials to various methods of producing

the final product. This portion of each chapter includes detailed information on each variation of the material as well as methods used to change or improve the properties of the material. Alternate uses and composite forms of the material are discussed as well as options for applying a finish to the material.

Part II will enable readers to explain the history of the use of a material in an interior and to describe how the material is produced.

Part III: Application: Using Information Regarding Interior Finish Materials

To appropriately specify the material for use in an interior, students must be able to evaluate the material based on the specific needs of a design project. This requires knowledge of the environmental impact of the material as well as code requirements relating to the material, installation methods, life cycle analysis, and awareness of maintenance requirements. In Part III of the text, the application of the material to various interior surfaces and components of an interior is discussed. Specification requirements unique to each material are discussed in this part. A case study of the material used in an interior enhances the students' ability to apply the material.

Part III will enable readers to describe the code requirements that affect the use of the material in an interior, analyze the environmental impact of using the material, and evaluate how well the material will meet the specific needs of a design project.

Summary

The summary for each chapter concludes with a list of websites of organizations that readers may choose to investigate for further study. These lists are not intended to be comprehensive, as many other resources are available. There are review questions at the conclusion of each chapter intended for class discussions.

Finish Materials Can Be Combined to Form a Unified Theme Carried Throughout the Project. Photo courtesy of Spanjer Homes.

Glossary

Each chapter ends with a glossary of terms found in the chapter. The meaning given is in context to the use of the term with that material. Alternate meanings may exist but not be listed.

This textbook provides information about common materials used in building construction and interiors. It provides a history of the material and its use in interiors; discusses the application of the material, and provides information that will assist the interior designer in making finish material selections. However, the pace of product development is rapid. As new materials, products, and processes are developed, older materials and processes fall out of favor. Thus, this book should be used as a foundation for further research.

INSTRUCTOR'S RESOURCES

The instructor will have access to Pearson Education's Instructor Resource Center (IRC), which will provide an Instructor's Manual and a MyTest to accompany this content. The Instructor's Manual will include projects and activities that are applied to real-world applications.

Download the Instructor Resources from the Instructor Resource Center. To access supplementary materials online, instructors need to request an instructor access code. Go to www.pearsonhighered.com/irc to register for an instructor access code. Within 48 hours of registering, you will receive a confirming e-mail including an instructor access code. Once you have received your code, locate your text in the online catalog and click on the Instructor Resources button on the left side of the catalog product page. Select a supplement, and

a login page will appear. Once you have logged in, you can access instructor material for all Prentice Hall textbooks. If you have any difficulties accessing the site or downloading a supplement, please contact Customer Service at http://247.prenhall.com.

STUDENT'S RESOURCES

eBooks. *The Comprehensive Guide for Selecting Interior Finishes* is available as a CourseSmart. *CourseSmart* is an exciting new choice for students looking to save money. As an alternative to purchasing the printed textbook, students may purchase an electronic version of the same content. With a *CourseSmart* eTextbook, students can search the text, make notes online, print out reading assignments that incorporate lecture notes, and bookmark important passages for later review. Students can also access their *CourseSmart* book on an iPad by downloading the CourseSmart App. For more information, or to purchase access to the *CourseSmart* eTextbook, visit www.coursesmart.com.

ACKNOWLEDGMENTS

We would like to give a special thank you to the reviewers of the manuscript for their input and valuable suggestions: Anthony Abbate from the Florida Atlantic University, David Butler from Florida State University, Ann Cotton from the College of DuPage, Donna Daley from the Art Institute of Philadelphia, Darlene Kness from the University of Central Oklahoma, Kimberly Morrison from the Art Institute of York Pennsylvania, and Alexander Schreyer from the University of Massachusetts.

This page intentionally left blank

ABOUT THE AUTHORS

Evelyn Everett Knowles earned both Bachelor of Science in Interior Design and Master of Architecture degrees from Kansas State University. An NCIDQ-certified interior designer since 1988, she worked in interior design and architecture firms for 10 years. She has taught interior design at Kansas State University, University of Illinois, University of Oklahoma, and Park University. Currently, Knowles is teaching Environmental Studies at the University of Northern Colorado.

Kay Miller Boehr earned a Master of Architecture with an emphasis in Interior Architecture from Kansas State University. After a 20-year career as an architect and interior designer, she now teaches interior design at Park University.

This page intentionally left blank

CHAPTER 1

Introduction to Selecting Finish Materials

Materials and Finishes

The primary purpose of a building is to provide shelter. To do so, a building is made up of both an enclosing structural system and interior spaces. The components of a building include *structural elements* such as foundations, columns, floors, walls, and roofs, as well as *nonstructural elements* such as interior partitions or ceilings. A **thermal envelope** encloses and protects the interior of the building. The *building envelope* may be punctured by doors and windows. Within this enclosing shell are special construction elements such as vertical circulation (stairs, ramps, and elevators) and fireplaces. The plumbing and the mechanical and electrical systems provide the necessary comforts of heating, cooling, power, water supply, and sanitation.

The structural and nonstructural building **elements** are composed of *materials* such as wood, metal, concrete, stone, and brick. In some cases, the materials, such as a brick or stone wall, are left exposed. These exposed materials then become the *finish*, and may need

The primary purpose of a building is to provide shelter.
Lloyd Smith/Shutterstock

no further treatment, or they may require a protective coating. More often, the materials that make up the building element—for example, wood studs for walls, are encased in another material, such as gypsum board, which is covered with an applied finish. When a finish is applied to a surface, the surface to which the finish is applied is called a **substrate**. Thus, an interior finish can consist of a single material or an application of a finish product to the surface of a material.

Role of the Interior Designer

In the twenty-first century, we spend the majority of our time indoors, living and working within the shelter of a building. Interior designers not only plan and shape the spaces within the building shell but they also enrich the spaces with color, texture, and pattern, as well as design details and select finishes, furnishings, and accessories. All of this is done with the goal of designing a space that is a *unified whole*, or more than the sum of its parts. This goal for cohesiveness extends to the relationship between the interior and the building shell, requiring that the interior designer be aware of building construction systems. The designer must also understand that the building is the context within which the interior is designed. While working with architects, interior designers may also influence the shape and configuration of the building shell, helping to design buildings from the inside out, with the function of the interior spaces determining the form of the building.

The building shell meets the requirements for shelter, but it is the interior that provides comfort, convenience, safety, and security. As interior designers plan and shape interior spaces, they enhance the quality of life of the individuals who live and work in them. Thus, interior designers provide functional improvement, aesthetic enrichment, and psychological enhancement to the spaces they design.

Interior designers must also be aware not only that they are designing for the client who hires them, but that their work has a much broader impact—on all the users of the space, society as whole, and the environment. **Sustainable design** is a concept that influences every decision made by the socially responsible designer. A sustainable design considers the needs of the present users of a space, but does not compromise the needs of future generations. Thus, designing sustainably means that a designer considers the three intertwined issues of the economic, social, and environmental impact of any action, especially the design of a building interior.

Additionally, interior designers are responsible for selecting the materials that make up the nonstructural elements of the interior space and the finishes that are applied to these elements. According to the 2011 Standards of the Council for Interior Design Accreditation, or **CIDA**, the accrediting body for interior design programs at colleges and universities, students in interior design "have an awareness of a broad range of materials and products [and an awareness of] their typical fabrication and installation methods and maintenance requirements." According to CIDA, students should be "able to select and apply appropriate materials and products on the basis of their properties and performance criteria, including ergonomics, environmental attributes and life-cycle costs" (CIDA, Standard 11).

Because the work of interior designers affects the health, safety, and welfare of the public, many states regulate the practice of interior design. In 2012, 27 states, including the District of Columbia and Puerto Rico and eight Canadian provinces, have enacted some type of legislation that regulates either the use of the title "Interior Designer" or the practice of interior design. The National Council for Interior Design Qualification (**NCIDQ**) develops and administers the examination that certifies that an interior designer has the "knowledge and experience to create interior spaces that are not just aesthetically pleasing, but also functional and safe" (www.NCIDQ.org). After meeting the required combination of education and experience, one must pass the NCIDQ to be considered a professional interior designer by professional interior design organizations, employers, state regulators,

and the general public. The NCIDQ certification examination includes questions about finish materials. This textbook is designed to give interior designers information they need to successfully qualify as professionals. Questions that relate to materials and finishes are found in the NCIDQ test Sections 1 and 3, as shown here:

NCIDQ Section 1

Knowledge of and skill in the application of:

- Code requirements, laws, standards, and regulations, including accessibility guidelines
- Sustainable design practices

Knowledge of and skill in:

- Selection, specification, use, and care of furniture, fixtures, and equipment, including window treatments and textiles
- Selection, specification, use, and care of interior finishes and materials—for example, acoustics, life safety considerations, performance, and properties
- Procurement
- Cost estimating
- Sourcing and research as related to manufacturers' and vendors' information

What Designers Need to Know about Materials

- Be aware of the broad range of materials and finish products that are available.
- Select and apply appropriate materials and finish products on the basis of their **properties** or physical characteristics, which will determine how the product will perform.
- Know how the use of the materials will affect the acoustics of the space. Absorbent materials will help deaden the sound, making spaces less noisy. Reflective materials will add to the noise level of a space, which may be desirable in some instances. Some materials will help slow the passage of unwanted sound from one space to another.
- Consider the life cycle cost of selected materials, which include the required durability of all materials.
- Be aware of the environmental impact of the selected materials.
- Understand the typical fabrication and installation methods for materials and finish products.
- Know and understand maintenance requirements for finish products.
- Be aware of the resources that are available for obtaining information about products and materials.
- Evaluate materials for their function, aesthetics, and appropriateness for a given use.

Variety of Materials Used as Finishes in an Interior

The dining commons of this high school in Lawrence, Massachusetts, illustrates the variety of materials that are often used in an interior.

- *Plastics* include the quartz-based vinyl tile used to create a colorful pattern on the floor as well as a resilient vinyl base.
- *Concrete* walls are constructed of both split-faced and ground-faced concrete masonry units.
- To absorb some of the sound in the room, a fiberglass *textile* is wrapped around acoustical panels. Suspended from the ceiling are custom fabric-wrapped acoustical tile "clouds."
- *Metal* used in the space includes exposed steel column, beams, and ductwork.
- *Gypsum board* surfaces as well as the exposed metals are *painted*.
- The abundant natural light is made possible by the use of *glass*.
- *Wood* is used for built-in cabinetry.

FIGURE 1.1 The Dining Commons at Lawrence High School in Lawrence, Massachusetts, designed by Flansburgh Architects, Boston, Massachusetts. Photograph courtesy of Heidi Jandris and A. Jandris & Sons, Inc.—New England CMU manufacturer

NCIDQ Section 3

Knowledge of and skill in analyzing and synthesizing programmatic information

- Sustainable design practices
- Interior finishes and materials

Common Threads: An Overview of Topics in Each Chapter

Each material that is used by a designer must be evaluated for its environmental impact, the code requirements and other regulations to be considered in its selection, and the effect the material has on accessibility. Once a material is evaluated and selected for a project, the designer must be able to document that selection so the project can be properly built using the appropriate materials and finishes. Because each of these issues is a factor in selecting any material, the following overview will aid in the understanding of the discussion topics in each chapter.

ENVIRONMENTAL IMPACT

According to Edward Mazria, founder of Architecture 2030, an organization established to address the climate change crisis, buildings have a greater negative impact on the environment than does transportation or industry. Buildings are responsible for nearly half of the energy consumed in the United States and nearly half of the carbon emissions that contribute to global warming. Thus, designers of buildings have the greatest potential to solve the problems that are causing the rapid depletion of natural resources and global climate change.

A conscientious designer will analyze the environmental impact of the product he or she selects. Although most manufacturers claim that their products are "green," a careful evaluation of each product is necessary. Multiple factors must be considered in the decision-making process, and choices may be based on balancing the various options with the requirements for each project. Fortunately, several organizations and entities provide guidance and, in some cases, certification of specific products used in an interior. The mission of the *GREENGUARD Environmental Institute* is to "protect human health and quality of life by enhancing indoor air quality and reducing people's exposure to chemicals and other pollutants." A GREENGUARD-certified product meets stringent chemical emission standards. *FloorScore* was developed by the Resilient Floor Covering Institute (RFCI) in conjunction with *Scientific Certification Systems* (SCS) to test and certify hard-surface flooring and flooring-adhesive products for compliance with indoor air-quality emissions. *Greenseal* certifies a wide variety of products. A Greenseal certification considers the impact of the product on health and the environment. These certification agencies often refer to standards set by the *International Organization for Standardization (ISO)*, which sets standards for products based on criteria that have global relevance. In the United States, the *Environmental Protection Agency (EPA)* is the federal organization charged with protecting human health and the environment, and, as such, writes regulations related to environmental issues.

Each of the preceding agencies provides certification that will assist in designing a sustainable interior or building and achieving **LEED** certification. The United States Green Building Council (USGBC), a nonprofit organization established in 1998, created a rating system that assesses the sustainability of the "design, construction and operation of buildings and neighborhoods," known as LEED, or Leadership in Energy and Environmental Design. As of 2012, LEED has acknowledged the unique requirements for different types of buildings, and includes LEED for Homes, Existing Buildings, Commercial Interiors, New

GO GREEN LEED Standards

- ***Sustainable Sites*** Included in this standard are such issues as determining where to build, the connection of the building to its surroundings, and the way the land is treated.
- ***Water*** This standard includes issues such as the source of water used in the building and where the water goes when it leaves the building. It can cover everything from runoff to the type of plumbing fixtures selected.
- ***Energy and Atmosphere*** Not only does this standard address the types of heating and cooling systems used but it also includes the power sources and the type of appliances selected.
- ***Materials and Resources*** Interior designers have the greatest opportunity to contribute to this standard due to their responsibility for selecting interior materials and finishes. Considerations include the origin of the material and the distance the material must be transported, as well as the quality of materials selected. Subtopics in this standard include:

  Source reduction and management
  Toxic material source reduction
  Construction waste management
  Optimized use of alternative materials
  Optimized use of indoor-air-quality–compliant products
  Sustainable cleaning products
  Occupant recycling
  Additional toxic material source reduction
  Recycled content

- ***Indoor Air Quality*** This standard not only addresses the issue of irritating or toxic gasses in an interior, usually caused by **volatile organic compounds**, but also addresses the quality of life of the occupants by considering access to daylight and views, thermal comfort, and the right to breathe clean air.
- ***Innovation in the Design Process*** "Extra credit" points are available for an innovative design that goes above and beyond requirements or solves a problem in a new way.

Construction, Core and Shell, and LEED for Schools, Health Care, and Retail. LEED for neighborhoods is in development. After passing an examination in a specific category, individuals can become LEED Accredited Professionals or Green Associates, and thus can assist design firms and building owners in the process of designing a building or interior that is in compliance with LEED. Buildings that are designed to comply with LEED standards may be awarded a certificate that reflects the level of compliance, from basic LEED compliance through LEED Silver, Gold, or Platinum based on the number of points received for meeting each standard. LEED is becoming a requirement for buildings that receive government funding from the local to the federal level. The organization is continually being evaluated and revised, but the six overarching categories of analysis remain consistent.

The environmental impact of a material used to construct and finish a building can be evaluated by referring to a measurement of its ***embodied energy***, a complex system of determining how much nonrenewable energy is used throughout the life cycle of the material. *Indirect embodied energy* measures the energy used to produce the material, including processing, manufacturing, and related transportation. *Direct embodied energy* measures the energy used to transport materials to the site and the energy used during construction. *Recurring embodied energy* measures the energy used during the lifetime of the material, including the energy required to repair, restore, or replace the material. The numbers are expressed in megajoules (MJ) or gigajoules (GJ) per unit of weight or area. The numbers for individual materials vary based on the location of the project, and they may be used to compare the environmental impact of different materials.

CODE REQUIREMENTS

Interior designers must understand and apply government regulations that affect the way they design. These regulations include zoning ordinances, building codes, and the Americans with Disabilities Act. Some jurisdictions have incorporated environmental requirements into their local regulations. For instance, some publically funded buildings may be required to meet LEED standards.

Sustainable Design

MARIPOSA VET CLINIC

Approximately 600 locally harvested straw bales are used as a highly effective insulation infill between the post and beam structure of the Mariposa Veterinary clinic in Lenexa, Kansas. A 10-inch thick structural insulated panel (SIP) roof with 48-inch overhangs shelters the walls from the rain and shades interior spaces from the summer sun. Careful orientation on the site and strategically placed windows allow the building to take advantage of passive solar heating in the winter and natural day-lighting throughout the year. Native plantings conserve water, and a series of rain gardens planted with native sedges provide storm water detention and treatment. Interior finish materials visible in this photograph include a stained concrete floor that acts as a thermal mass, absorbing heat during the day and radiating it into the interior at night; plastered walls covering the straw bales; and the exposed structure of the ceiling, including the glulam (glued laminated timber) beams and the particle board of the structural insulated panel.

FIGURE 1.2 Mariposa Veterinary Clinic in Lenexa, Kansas, Designed by Rothers Design Build. Photograph courtesy of Rothers Design Build

SLOCUM CENTER

The Slocum Center, the first LEED Gold orthopedic center in the United States, was designed by the Neenan Company in Fort Collins, Colorado. Design strategies that helped achieve LEED certification included:

- Sustainable site development
- Water-use reduction, including installing low flow and dual flush toilets
- Energy efficiency, including occupancy sensors and participation in a wind program
- Building exterior designed to reduce heat gain, taking into consideration the building orientation, sunshades, low-emissivity glazing, and strategies for natural lighting

Material selection played a large role in achieving the LEED certification. There was an overall goal of reducing plastic products made of PVC. Linoleum and carpet tile were used as well as eco-polymeric sheet flooring. Other materials used in construction and as finishes include:

- Local brick
- Certified woods (including particle board)
- Recycled steel
- White TPO (thermoplastic) single-ply roof, an alternative to PVC (polyvinyl chloride) roofing
- Low VOC (volatile organic compounds) paints, flooring, and walk-off mats

FIGURE 1.3 Slocum Center for Orthopedic and Sports Medicine, LEED Gold, by Neenan Architects, Annie Lilyblade, Interior Designer and Medical Planner. Courtesy of The Neenan Company, LaCasse Photography

Zoning ordinances are locally created regulations that are used to control the type of development that may occur in a defined area or zone. They regulate land use and address such issues as the location of a building on the site, the allowed use of the building depending on its location, the height and size of a building, and the number of parking spaces required. Zoning ordinances are not based on life safety issues, but are planning tools that may control the character of a neighborhood, protect environmentally sensitive areas, and/or conserve open space.

Building codes are regulations that help protect the health, safety, and welfare of the occupants by setting minimum standards for construction materials and methods, as well as setting standards for design and construction that protect the building occupants from hazardous conditions. The development of building codes was instigated by disasters, usually fires, that resulted in deaths to occupants. Each serious disaster led to a strengthening in codes, including the September 11, 2001, bombings of the World Trade Center in New York, which has led to more stringent construction and safety requirements for tall buildings. Architects and interior designers are professionally obligated to design buildings and interiors that meet code requirements.

The most commonly adopted building code in the United States is the International Building Code, or IBC. However, the interior designer must first check with the local jurisdiction to determine which code is being used. Not all jurisdictions have adopted the IBC, and/or there may be specific modifications to the code to reflect the conditions of the locality. For instance, NFPA 101 is a life safety code established by the National Fire Protection Association that may be adopted as a stand-alone code or in conjunction with another code. In addition, building codes are supported by specialty codes such as fire codes, residential codes, and electrical, mechanical, and plumbing codes. Environmental regulations, such as requirements for sustainable design, may be adopted by a specific jurisdiction and incorporated into a local building code. In some jurisdictions, publicly funded buildings must meet LEED standards.

The Americans with Disabilities Act (ADA) is a federal civil rights law ensuring that people with disabilities have equal access to places of employment, state and local government services, public transportation, public accommodations and commercial facilities, and communication services. The ADA is not a building code, but local jurisdictions have generally adopted ADAAG, the Americans with Disabilities Act Accessibility Guidelines, as part of their building codes. Although ADAAG is the most stringent accessibility code, other similar accessibility guidelines—such as the original accessibility standards, ANSI 117.1—may be adopted by individual jurisdictions. Federal buildings are covered under the Architectural Barriers Act (ABA), which has standards similar to the ADA. The Americans with Disabilities Act is concerned with allowing access to buildings, and interior finishes become an issue if they create a barrier to accessibility.

To design a space that meets building codes, the designer must know the occupant type, occupant load, and building construction type. The **occupant type** is a category based on the risk associated with the type of use of the building; it determines an allowable number of people (per square foot) that can safely occupy a building or the space within a building. For example, a restaurant may be categorized as "assembly without fixed seats" and has a higher occupant count (15 square feet per person) than a business occupancy, which allows 100 square feet per person. The **occupant load** is determined by dividing the size of the space in square feet by the number of occupants allowed per square foot. The **building construction type** is based on the level of combustibility of the materials used to construct the building, both exterior and interior, and is used to determine the allowable height and floor area of the building. The occupant type, occupant load, and construction type are used together to determine design criteria such as allowable use of construction materials on both the interior and exterior of a new building and on any interior construction in an existing building. This information is used to guide the selection of materials used for construction assemblies; the design of fire barriers; the selection and placement of finish materials, doors, and windows; and the selection and placement of furniture.

Agencies That Develop Standards

- ***National Fire Protection Association (NFPA)*** Established in 1897, the NFPA's stated mission is to "reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training and education." The NFPA establishes standards for life safety that are incorporated into all building codes, as well as developing its own stand-alone life safety code.
- ***American National Standards Institute (ANSI)*** This institute is a private not-for-profit organization established in 1918. It "promotes and facilitates voluntary consensus standards and conformity assessment systems." The American National Standards Institute approves and organizes the standards developed by other organizations, developing standards when an industry group or government agency commissions the organization to do so. The institute is the U.S. representative to the International Organization for Standardization.
- ***American Society of Testing and Materials International (ASTM International)*** The ASTM was founded in 1898 as an organization that writes standards, but does not test or certify products. It develops and delivers international voluntary consensus standards. Among the categories of standards written by ASTM International are newly developed sustainable design standards.
- ***Underwriters' Laboratory (UL)*** Underwriters' Laboratory is an agency that has tested and approved products since 1894. It tests hundreds of products in construction, building materials, systems, and assemblies to protect occupants from fire and life safety hazards.

Building codes base most of their requirements on an established set of *standards*, voluntary testing procedures that determine whether a product or material is compliant. Standards are not regulations, and testing is voluntary. However, when standards are incorporated into a building code, materials or products that are specified or assemblies that are designed must meet the pertinent standard.

INTERIOR FINISH MATERIALS AND FIRE

Building codes are not limited to regulations related to preventing the loss of life in fires, but it was disasters such as the Triangle Shirtwaist Factory fire in New York City in 1913 (145 young women died) and the Cocoanut Grove nightclub fire in Boston in 1942 in which 492 people died that led to stronger fire and life safety codes. The goal is to construct buildings using methods and materials that help prevent fires from starting. If a fire starts, the strategy is to ensure early detection (such as from fire alarms) and suppression (such as from extinguishers or sprinklers) and/or to contain the fire long enough for occupants to evacuate, as well as to allow firefighters enough time to bring in equipment and fight the fire. Many building materials and finish materials will burn, and some finishes, such as flammable coatings, can actually start fires. Once started, combustible materials can serve as fuel, feeding the fire and allowing the flame to spread. Smoke is often more dangerous to occupants than flames, obstructing vision in addition to causing injuries from smoke inhalation. In addition, some finish materials emit toxic fumes when they burn. Thus, the key is confining the fire to the location in which it starts, while providing a safe path of exit for the occupants. Finish materials must not contribute to the spread of fire or allow flashover from one burning material to another flammable material.

As determined by the use and construction type of a building, *means of egress* (exits, exit access corridors, and doors and windows as components of exitways) must be designed and built to provide barriers to smoke and flame. This involves designing floors, walls, and ceilings as *assemblies* of components that are rated based on the length of time they can resist fire. Ductwork and other penetrations must have fire stops and dampers. Finishes must pass tests to ensure that they resist flames and will not contribute to the development of smoke. The priority in a fire is to evacuate occupants before the building burns. Thus, corridor assemblies are rated by the time that they will withstand smoke and flame, usually one or two hours. Interior designers not only have to understand the methods required for the rated construction assemblies but also the flammability of finish materials applied to the surface of walls, floors, and ceilings, as well as window treatments, furniture, applied trim, and other potentially flammable objects in a space.

Testing Products for Flame Resistance

Testing agencies such as Underwriter's Laboratory will test the fire resistance of an assembly of components used to construct a wall, for instance. An **assembly** refers to the components of a structure, wall, or enclosure, combined and rated as a unit. A door assembly would include the door, frame, hardware, and window glass.

Interior finish materials are tested by a variety of smaller-scale flame tests. The finish material is usually tested on top of the substrate to which it will be applied. The results of the tests are used to rate the material—for instance, Class A, B, or C for wallcovering, or Class I

or II for flooring. The various standards organizations have written these tests into their standards, and they are thus incorporated into building codes.

SPECIFYING

In order to communicate the design of a space or building so the project can be priced, permitted, and built, the designer prepares a set of **contract documents** that include construction drawings and specifications. The codes officials working for the local jurisdiction review these documents for compliance with all applicable codes and regulations before issuing a *permit* to build the project. The documents also serve as the basis of a contract between the owner and the general contractor, as well as a guide for construction.

A **specification** is the written portion of the contract documents that describes the material or the product to be used, the quality of the product or material, and the installation or construction methods to be used. For some small projects, specification information may be incorporated into the set of drawings, but for larger projects, specifications are prepared as a separate written document or *Project Manual*. Interior designers may also write separate specifications for *furniture, fixtures, and equipment (FF&E)* to be issued, not to the general contractor, but to vendors who will supply the FF&E after the construction is complete. Interior designers and architects write standards into a specification, selecting and specifying products that have been tested for their compliance with codes and performance standards, and requiring evidence that the products used meet the standards.

Architectural specifications are formally structured documents, and have traditionally been based on CSI (Construction Specifications Institute) Masterformat, although other formats are similar. CSI Masterformat specifications are written so that the specifications writer can choose from options for each category of information. Information is included to guide the designer in the decision-making process. The CSI Masterformat specification package includes a *General Conditions* section that gives instructions to the bidder related to the entire project, such as definitions, responsibilities of each party involved, requirements for using the site, and processes for determining completion of work and receiving payment. The specification is then divided into divisions for each type of product or material. Interior designers are often given the responsibility for writing or gathering information for a specifications writer—specifically for the divisions related to interior finish materials and components of an interior, such as Division 9: Finishes. Specifications may require the submittal of evidence that products meet performance standards—for example, tear strength standards for vinyl, citing specific ASTM and ANSI standards or industry standards.

Tests Used to Test the Flame Resistance of Interior Finish Products

- ***Steiner Tunnel Test*** The *Steiner Tunnel Test* is used to test the flame spread and smoke development of finishes used on walls, columns, or ceilings. Using the manufacturer's recommended adhesive, a sample of the material to be tested is adhered to the type of substrate to which it will be applied when installed. This sample is mounted on the ceiling of a 25-foot-long tunnel-like apparatus called the *Steiner Tunnel.* A flame is applied at one end with a consistent draft blown through the tunnel. The distance the flame spreads before going out is measured and used to determine the *flame spread rating*. At the same time, a photoelectric cell at the opposite end of the tunnel measures the smoke that develops to determine the *smoke development rating*. The ratings are determined by comparing the measurements with two common materials: glass reinforced cement board, which is given a rating of zero, and red oak flooring, which is given a rating of 100. Materials that have lower flame spread ratings mean that the flame does not spread too quickly; therefore they allow people more time to evacuate and are given a higher rating. Materials that have higher ratings for smoke development will not allow enough visibility for occupants to get out. Both ratings must be acceptable for the product to earn a Class A, B, or C rating, with Class A being the best.
- ***Radiant Panel Test*** The *Radiant Panel Test* is used to evaluate flooring materials, including carpet, hardwood, and resilient flooring. Flooring is not generally a contributing factor in fires, but if the material is used in a means of egress it must be tested. A sample of the entire flooring assembly, including pad if it is to be used, is adhered to a substrate and placed on the bottom of the test chamber. The flooring is preheated with a radiant panel set at a 30-degree angle from the flooring, and then the flooring is exposed to a gas burner. If the flame ignites the flooring, the distance of the charred mark is measured when the flame goes out, and the radiant heat energy at the extent of the burned area is measured. The formula for determining the result is called *critical radiant flux*. Flooring materials are rated Class I, most flame resistant, and Class II, less flame resistant.
- ***Methenamine Tablet Test*** Since 1971, all carpets sold in the United States have had to pass the *Methenamine Tablet Test* or the "pill test." Carpet in a chamber is covered with a metal plate with an 8-inch circle cut out of the middle. The methenamine pill, replicating a slow-burning cigarette, is placed in the center of the circle, on the carpet. The pill ignites the carpet, and when it extinguishes itself, the distance from the burn to the edge of the metal is measured. If the burn extends to within an inch of the metal, the carpet fails. All carpets and large rugs that do not pass this test are labeled flammable.
- ***Room Corner Test*** Carpets or carpet-like looped textiles that are used on a wall as well as expanded vinyl wallcoverings are tested using a *Room Corner Test*. This test uses a full-sized room, with the wallcovering applied partially to two walls. A flame source is placed in the corner of the room that has wallcovering attached. The wall is exposed to flame at two different heat levels. If the wallcovering ignites, the height of the burn is measured. A duct outside the room collects and measures concentrations of gasses, as well as smoke velocity and temperature. The Room Corner Test measures the distance the flame travels, flashover potential, and smoke produced. Nontextile wallcoverings and ceiling material are tested in a similar fashion.

(*continued*)