

SIXTH EDITION

# Fundamentals of Building Construction

## Materials and Methods

EDWARD ALLEN • JOSEPH IANO

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# FUNDAMENTALS OF BUILDING CONSTRUCTION



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*SIXTH EDITION*

Edward Allen and Joseph Iano

WILEY

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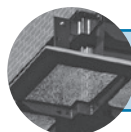
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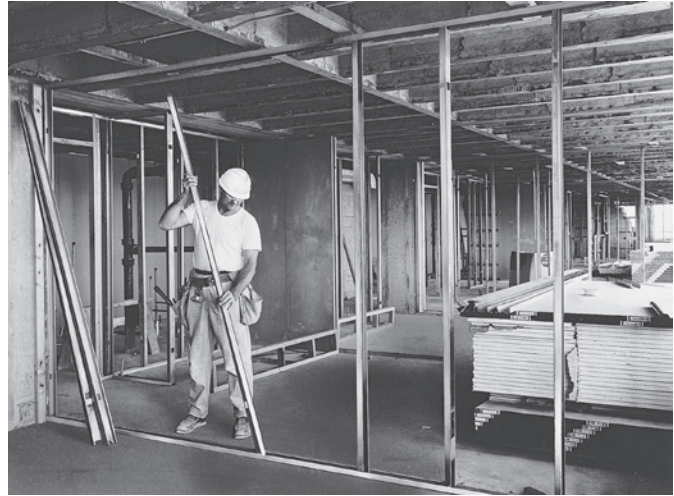
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# PREFACE TO THE SIXTH EDITION

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First published a quarter-century ago, *Fundamentals of Building Construction: Materials and Methods*, now in its sixth edition, has wrought a revolution in construction education. It has been instrumental in making a previously unpopular area of study not merely palatable but vibrant and well liked. It has taken a body of knowledge once characterized as antithetical to design excellence and made it widely recognized as being centrally relevant to good building design. It has replaced dry, unattractive books with a well-designed, readable volume that students value and keep as a reference work. It was the first book in its field to be even-handed in its coverage and profusely and effectively illustrated throughout. It was the first to release the teacher from the burden of explaining everything in the subject, thereby freeing class time for discussions, case studies, field trips, and other enrichments.

Gaining a useful knowledge of the materials and methods of building construction is crucial and a necessity for the student of architecture, engineering, or construction, but it can be a daunting task. The field is huge, diverse, and complex, and it changes at such a rate that it seems impossible ever to master it. This book has gained its preeminent status as an academic text in this field because of its logical organization, outstanding illustrations, clear writing, pleasing page layouts, and distinctive philosophy.

It is integrative, presenting a single narrative that interweaves issues of building science, materials science, legal constraints, and building craft so that the reader does not have to refer to separate parts of the book to make the connections among these issues. Building techniques are presented as whole working systems rather than component parts.

It is selective rather than comprehensive. This makes it easy and pleasant for the reader to gain a basic working knowledge that can later be expanded, without piling on so many facts and figures that the reader becomes confused or frightened away from wanting to learn about construction. Reading other texts was once like trying to drink from a fire hose; reading this one is like enjoying a carefully prepared meal.

It is empowering because it is structured around the process of designing and constructing buildings. The

student of architecture will find that it features the design possibilities of the various materials and systems. Students interested in building or managing the construction process will find its organization around construction sequences to be invaluable.

The book is necessarily complex without being complicated. It avoids the dilemma of having to expand ad infinitum over time by presenting the basic construction systems, each in sufficient detail that the student is brought to an operational level of knowledge. It deals, as its subtitle indicates, with fundamentals.

In this latest edition, we have updated and revised many portions of the text. To name a few, in Chapter 1, an expanded discussion of buildings and the environment reflects the continuing evolution and maturation of sustainable building practice. Attention to the role of the constructor and to considerations of construction management continues to receive more in-depth consideration. Many facets of foundations and sitework have been updated in Chapter 2. Chapters 3 through 7, covering wood materials and construction systems, have been extensively updated: An entirely new construction system, cross-laminated timber, is introduced; a greater emphasis is given to manufactured wood products, reflecting this trend within the industry; and the influence of the most recent energy codes and sustainability standards on the enclosure of these building systems is reflected in revised text and updated illustrations. Throughout the remaining portions of the text, new developments in materials and methods, sustainable practices, and building regulations have been incorporated. Finally, a special effort was made to update illustrations and photographs, both to ensure currency of information and to provide the greatest possible visual interest for the reader.

We continue to take maximum advantage of the World Wide Web. The text's encyclopedic details, along with an array of additional resources for both students and instructors, are readily available via its dedicated web site ([www.wiley.com/go/constructioneducation6e](http://www.wiley.com/go/constructioneducation6e)). A Respondus test bank, PowerPoint lecture slides, *Instructor's Manual*, and more can be found there for instructors. For students, there are flashcards and interactive self-test questions, as well as SketchUp exercises and animations, which are

indicated by icons found throughout the text. Coauthor Joseph Iano's construction blog ([www.ianosbackfill.com](http://www.ianosbackfill.com)) provides an outlet for additional content and coverage of new developments in the field. The selected list of Web site addresses included in the reference section at the end of each chapter provides links to the other most relevant resources that are available on the Web, which provide starting points for students' further explorations.

The updated companion *Exercises in Building Construction* and its answer key continue to provide a unique and invaluable tool for helping students to understand the real-world application of building construction knowledge to the design and construction of buildings.

In this edition, a special thank-you goes to illustrators Heather McArthur and Terrel Broiles for their patience with the authors, perseverance in their work, and success in maintaining the high standards established by this book's previous illustrators. Alexander Schreyer also deserves mention for his contribution of interactive exercises and other supporting materials on the companion Web site.

The authors are, as always, grateful to the publisher, John Wiley & Sons, without whom the continued

improvement of this text and its supporting materials would not be possible. Amanda L. Miller, Vice President and Publisher, has for many years been a source of wisdom and support. Paul Drougas, Editor, has been invaluable for his industry knowledge, patience, and sense of humor. He remains a true friend. Lauren Olesky, Developmental Editor, and Mike New, Editorial Assistant, have been hard working and helpful through all stages of this revision. Donna Conte, Senior Production Editor, continues, as in previous revisions, to oversee the most difficult task of managing production and schedules with grace and perseverance. Diana Cisek, and too many others to name here, also deserve our thanks for their parts in helping bring this effort to fruition.

We especially offer our thanks to the many teachers, students, and professionals who have purchased and used this work. Your satisfaction is our greatest reward, your loyalty is greatly appreciated, and your comments are always welcome!

—E.A., South Natick, Massachusetts

—J.I., Seattle, Washington

A registration code to access the resources included on the Interactive Resource Center, shown on the previous page, is included with each new print copy of *Fundamentals of Building Construction, Sixth Edition*. If you've purchased another version and wish to purchase access to the Interactive Resource Center, you can go to [www.wiley.com/go/constructioneducation6e](http://www.wiley.com/go/constructioneducation6e), click on "Student Companion Site" and then "Register," which will allow you to enter a code or to purchase access if you do not have a code.

# How to get the most out of this text for students and instructors

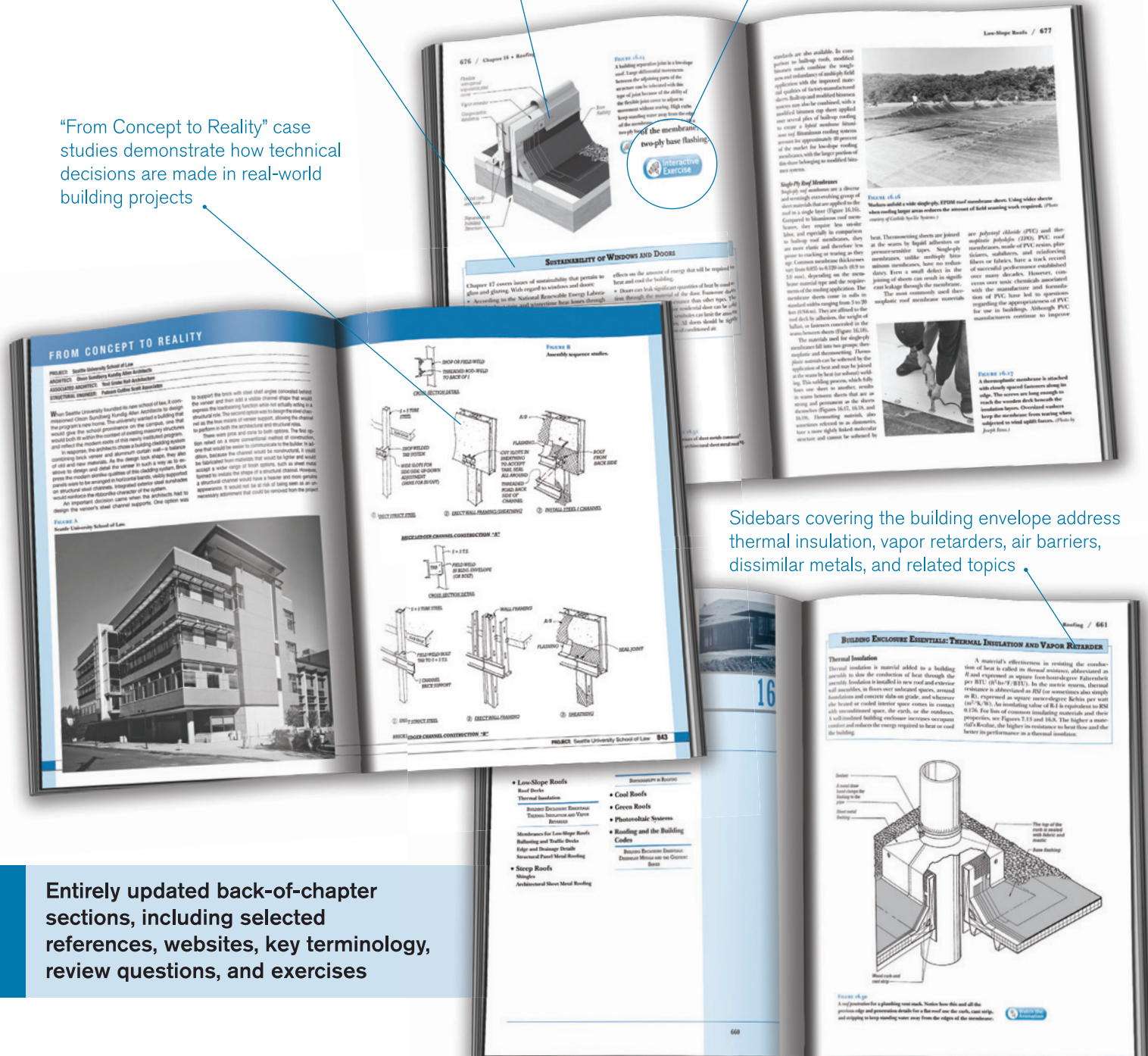
The following pages give students tools and tips on maximizing their study time using the integrated text and media within *Fundamentals of Building Construction*. Both students and instructors will appreciate the outstanding resources available to seamlessly link in class activity with lecture presentation and study time.

Sidebars addressing sustainability considerations

70 new photorealistic renderings, also available in full color as part of the Interactive Resource Center and in e-book formats

Icons indicate availability of Interactive Exercises and Animations on the online Interactive Resource Center to expand learning on difficult concepts

"From Concept to Reality" case studies demonstrate how technical decisions are made in real-world building projects



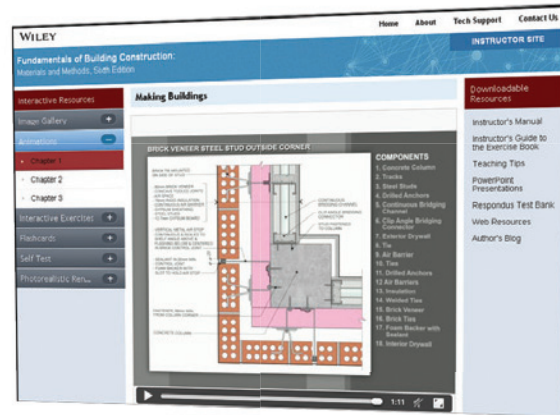
Sidebars covering the building envelope address thermal insulation, vapor retarders, air barriers, dissimilar metals, and related topics

Entirely updated back-of-chapter sections, including selected references, websites, key terminology, review questions, and exercises



# Interactive Resource Center for Students

[www.wiley.com/go/constructioneducation6e](http://www.wiley.com/go/constructioneducation6e)



**45 Interactive Exercises** tied to key concepts, including all required objects, as well as a tutorial on the basics of SketchUp and how to complete exercises—also available in standard 3D CAD format for use in other software, such as Rhino or 3ds max

**20 Animations** revealing complex construction processes, including wood light frame construction, brick veneer, and masonry wall construction, all designed to demonstrate sequencing and other concepts



**Interactive Flashcards** for learning key terms and concepts



**Interactive self-test** for learning assessment



**Supplementary image gallery** demonstrating construction operations

## Instructor Resources

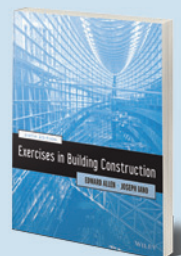
- Instructor's Manual
- Test Bank available in Respondus
- Instructor's Guide to *Exercises in Building Construction*
- Supplementary image bank
- PowerPoint presentations by chapter

## Additional Format Options

- Available in eBook formats for iOS, Android, Mac and PC, Kindle, and all other eReaders and tablets, including full-color images
- Complete Access Pack including Wiley E-Text version of full text, printed Exercise Book, and access to online Interactive Resource Center
- Available in Wiley CustomSelect [www.wiley.com/college/custom](http://www.wiley.com/college/custom)

## Exercises in Building Construction

- Companion resource featuring 46 real-world construction problems, challenges students with the kind of everyday issues faced by professional architects, available in both print and e-Book formats





# FUNDAMENTALS OF BUILDING CONSTRUCTION





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# MAKING BUILDINGS

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- **Learning to Build**
- **Buildings and the Environment**
  - Sustainable Building Materials
  - Assessing Sustainable Buildings
- **The Work of the Design Professional**
  - Zoning Ordinances
  - Building Codes
  - Other Constraints
  - Construction Standards and Information Resources
- **The Work of the Construction Professional**
  - Providing Construction Services
  - Construction Scheduling
  - Managing Construction
- **Trends in the Delivery of Design and Construction Services**
  - Increasing Collaboration Among Team Members
  - Improving Efficiency in Production
  - Improving Information Management

**An ironworker connects a steel wide-flange beam to a column.**  
*(Courtesy of Bethlehem Steel Company)*

**We build because not all human activity can take place outdoors. We need shelter from sun, wind, rain, and snow. We need dry, level surfaces for our activities. Often we need to stack these surfaces to multiply available space. On these surfaces, and within our shelter, we need air that is warmer or cooler, more or less humid, than outdoors. We need less light by day, and more by night, than is offered by the natural world. We need services that provide energy, communications, and water and dispose of wastes. So, we gather materials and assemble them into the constructions we call buildings in an attempt to satisfy these needs.**

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## LEARNING TO BUILD

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This book is about the materials and methods of building construction. Throughout it, alternative ways of building are described: different structural systems, different methods of building enclosure, and different interior finishes. Each has characteristics that distinguish it from the alternatives. Sometimes a material is selected chiefly for its visual qualities, as in choosing one type of granite over another, selecting a particular color of paint, or specifying a special pattern of tile. Visual distinctions can extend beyond surface qualities. A designer may prefer the massive appearance of a masonry bearing wall building to that of a more slender exposed steel frame on one project, yet would choose the steel for another. Choices may be made for functional reasons, as in selecting a highly durable and water-resistant polished concrete instead of carpet or wood for a restaurant kitchen floor. Or, choices can be made on purely technical grounds, as, for example, in selecting a construction system that is noncombustible, so as to achieve a suitable level of building fire safety.

A building designer's choices are frequently constrained by regulations intended to protect public safety and welfare. Choices may be influenced by considerations of environmental

sustainability. And frequently, selections are made on economic grounds. Sometimes one system is chosen over another because its first cost is less. Other times the full life-cycle costs—including first cost, maintenance, energy consumption, useful lifetime, and replacement—of competing systems are compared.

In describing the major systems of building construction, this textbook presents concerns that fall into two broad categories: building performance and building construction. Performance concerns relate to the inescapable problems that must be confronted in every building: fire; the flow of heat, air, and water vapor through the building enclosure; the small, but nonetheless important, movements of the building and its parts; water leakage; acoustical performance; aging and deterioration of materials; cleanliness; building maintenance; and so on.

Construction concerns relate to the practical problems of getting a building built safely, on time, within budget, and to the required standards of quality: sequencing of construction operations for maximum productivity; optimum use of building trades; division of work between the shop and the building site; convenient and safe worker access to construction operations; effects of weather; making building components fit together; quality testing of materials and components during construction; and much more. To the novice, these matters may seem of minor consequence

when compared to the larger and often more interesting themes of building form and function. To the experienced building professional, who has seen buildings fail both aesthetically and functionally for want of attention to one or more of these concerns, these are issues that must be resolved as a matter of course to ensure a successful project outcome.

To gain a thorough knowledge of building construction, it is incumbent upon the student to go beyond what can be presented here—to other books, product literature, trade publications, professional periodicals, and especially the design office, workshop, and building site. One must learn how materials feel in the hand; how they look in a building; how they are manufactured, worked, and put in place; how they perform in service; how they deteriorate with time. One must become familiar with the people and organizations that produce buildings—the architects, engineers, materials suppliers, contractors, subcontractors, workers, inspectors, managers, and building owners—and learn to understand their respective methods, problems, and points of view. There is no other way to gain the breadth of information and experience necessary than to get involved in the art and practice of building.

In the meantime, this long and hopefully enjoyable process of education in the materials and methods of building construction can begin with the information presented in this textbook.

---

**Go into the field where you can see the machines and methods at work that make the modern buildings, or stay in construction direct and simple until you can work naturally into building-design from the nature of construction.**

**—Frank Lloyd Wright, “To the Young Man in Architecture,” 1931**

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## BUILDINGS AND THE ENVIRONMENT

In constructing and occupying buildings, we expend vast quantities of the earth's resources and generate a significant portion of its environmental pollution. Buildings account for 30 to 40 percent of the world's energy consumption and carbon dioxide gas (CO<sub>2</sub>) emissions. In the United States, buildings consume approximately 35 percent of this country's energy, 65 percent of its electricity, 12 percent of its potable water, and 30 percent of its raw materials. Building construction and operation together are responsible for roughly 40 percent of U.S. total greenhouse gas emissions and a third of its solid waste stream. Buildings are also significant emitters of particulates and other air pollutants. In short, building construction and operation cause many forms of environmental degradation and place a heavy burden on the earth's resources.

One simple definition of *sustainability* is building to meet the needs of the present generation without compromising the ability of future generations to meet their needs. By consuming irreplaceable fossil fuels and other nonrenewable resources, by building in sprawling urban patterns that cover extensive areas of prime agricultural land, by using destructive forestry practices that degrade natural ecosystems, by allowing topsoil to be eroded by wind and water, by generating substances that pollute water, soil, and air, and by generating copious amounts of waste materials that are eventually incinerated or buried in the earth, we have been building in a manner that will make it increasingly difficult for our children and grandchildren to meet their needs for communities, buildings, and healthy lives.

Sustainable building construction demands a more symbiotic relationship between people, buildings, communities, and the natural environment. Sustainable buildings—in both their operation and construction—

must use less energy, consume fewer resources, cause less pollution of the air, water, and soil, reduce waste, discourage wasteful land development practices, contribute to the protection of natural environments and ecosystems, provide healthier interiors for building occupants, and minimize adverse social impacts.

The practice of sustainable design and construction, also called *green building*, continues to mature. The understanding of the interplay between buildings and the environment has deepened and standards for sustainability continue to evolve. Interest in and adoption of green building has broadened among public agencies, private owners, and building occupants. The design and construction industry has become more skillful at applying green practices, and sustainable building is becoming more integrated with mainstream practice. As a result, sustainable building performance is improving while the premium in cost and effort to design and construct such buildings in comparison to conventional buildings is declining or disappearing completely.

### Sustainable Building Materials

Building sustainably requires access to information about the environmental impacts of the materials used in construction. For example, when selecting a material, the designer must ask: Does its manufacture depend on the extraction of nonrenewable resources, or is it made from recycled or rapidly renewable materials? Is additional energy required to ship the material from a distant location, or is it produced locally? Does the material contain toxic ingredients or generate unhealthful emissions, or is it free of such concerns? To enable meaningful decision making, reliable product information must be readily available to all the parties involved in the selection of materials for sustainable building design.

A series of international standards, designated as ISO 14020, distinguish

three types of *environmental labels* that define expectations for comprehensiveness and reliability of sustainable materials and product information:

- *Type I Ecolabels* are independent, third-party certifications of environmental performance. Their accuracy and comprehensiveness are intended to ensure that the information provided is unbiased, relevant, and reliable.
- *Type II Self-Declared Environmental Claims* are provided directly by product manufacturers, without independent verification. They may also be more limited in scope than Type I labels. Type II labels may provide useful information, but users must employ their own judgment in evaluating the appropriateness of these products for a particular application.
- *Type III Environmental Impact Labels* provide the most comprehensive assessments of products and their environmental impacts on a comprehensive life-cycle basis. However, they do not in themselves provide environmental ratings or judgments—it is up to the user to interpret the data for this purpose. The information in Type III labels is independently verified, but the label itself may be prepared by the product manufacturer.

An example of a Type I Ecolabel is Green Seal Standard GS-11 for Paints and Coatings. Green Seal is a not-for-profit, independent organization that develops sustainability standards and certifications. For a paint or coating product to be certified to the GS-11 standard, it must:

- Meet minimum performance requirements, such as adhesion, ease of application, hiding power, washability, and fade resistance
- Be free of highly hazardous ingredients (for example, carcinogens)
- Not exceed permitted amounts for other less hazardous ingredients such as volatile organic compounds (a class of chemicals that contribute to air pollution and can act as irritants to building occupants)

- Be sold with instructions to the end user for safe application and responsible methods of disposal

By relying on this Green Seal certification, the paint specifier can easily and confidently identify environmentally responsible products from which to choose, without having to perform in-depth investigations of individual products.

Recycled materials content is an example of product information that is often provided in the form of a Type II Self-Declared Environmental Claim. That is, this information is usually reported directly by the product manufacturer, without third-party verification. This places more burden on the user of that information to determine its applicability. For example, the LEED® rating system (discussed later in this section) calculates recycled materials content as the sum of postconsumer content (materials recycled after use) plus one-half of preconsumer content (materials recycled during manufacturing). When relying on a Type II claim to determine recycled content for possible LEED credit, the designer must verify that the manufacturer's content claims accurately correspond to this standard's calculation method. At present, in North America, Type I and II environmental labels are the types in most common use.

An example of Type III labeling is the Western Red Cedar Association's Typical Red Cedar Decking Product Declaration. This 10-page document describes this product's material characteristics and quantifies—in detail—the environmental impacts of the product throughout its life. For example, for every 100 square feet of decking harvested, milled, trucked to the construction site, installed, maintained through its useful life, and then disposed of at the end of its life, this declaration reports the following impacts:

- 2,500,000 BTU (2600 MJ) of energy consumed

- 0.1 gallons (0.3 liters) of fresh water consumed
- 180 lb (80 kg) of nonhazardous waste generated

Additional information in the report quantifies materials consumption, *global warming potential* (total contribution to global warming), smog production, ozone depletion, acidification and eutrophication potential, and more. Information about the standards to which this information is prepared and independent verification of the reported results are also included. This document does not, in itself, provide an environmental rating of the product. But it can be used, for example, in comparing Western red cedar to some other decking material, such as recycled plastic decking, to assess the relative environmental consequences of choosing one of these materials over the other.

Not all sustainable product information necessarily fits neatly into one of these three label types. But considerations of comprehensiveness, independence, and relevance of information are appropriate to the review of building materials data from any source.

### *The Material Life Cycle*

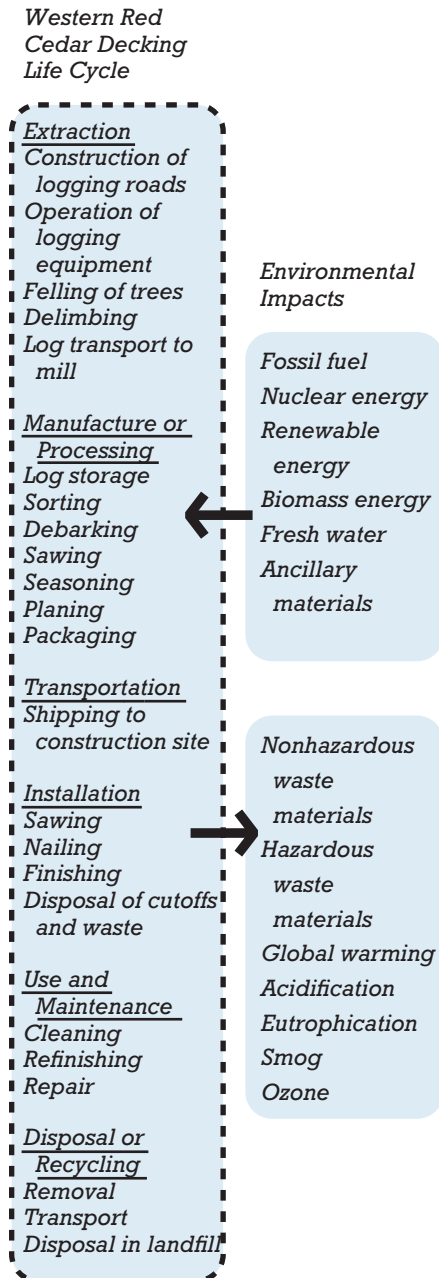
To most fully account for the environmental effects of a building material, its effects on the environment must be considered throughout its life cycle. This begins with raw materials extraction, continues with production and use, and finishes at end of life when a material is disposed of or put to an entirely new use. Such a *life-cycle analysis (LCA)* or *cradle-to-grave analysis* is considered the most comprehensive method for describing and quantifying environmental impacts associated with building materials. Through each life-cycle stage, environmental impacts are tallied: How much fossil fuel, electricity, water, and other materials are consumed? How much solid waste, global warming gasses, and other air and water pollutants

are generated? The total of all these impacts describes the environmental footprint of the material. As noted earlier in this section, this type of comprehensive life-cycle analysis is an essential part of a Type III Environmental Impact Label (Figure 1.1).

The concept of embodied energy also derives from life-cycle analysis. *Embodied energy* is the sum total of energy consumed during the material's life cycle. Because energy consumption tends to correlate with the consumption of nonrenewable resources and the generation of greenhouse gasses, it is easy to assume that materials with lower embodied energy are better for the environment than others with greater embodied energy. However, in making such comparisons, it is important to be sure that functionally equivalent quantities of materials are considered. For example, a material with an embodied energy of 10,000 BTU per pound is not necessarily environmentally preferable to another with an embodied energy of 15,000 BTU per pound, if 2 pounds of the first material are required to accomplish the same purpose as 1 pound of the second. The types of energy consumed for each material, such as fossil, nuclear, or renewable, should be considered, as impacts differ from one energy source to another. Differences in the life span of materials must also be accounted for.

Embodied energy and other life-cycle effects may sometimes be calculated for only a part of the material life cycle. A *cradle-to-gate analysis* begins with materials extraction but extends only as far as when the material leaves the factory, excluding the effects of transportation to the building site, installation, use, maintenance, and disposal or recycling. In other cases, data may be reported from cradle to the construction site. Though less comprehensive, such analyses can in many cases still provide a useful basis for comparison between products. For example, for most materials, the difference in



**FIGURE 1.1**

Life-cycle analysis of Western red cedar decking. The underlined life-cycle stages (Extraction, Manufacture or Processing, etc.) are applicable to any building construction material LCA. The activities listed under each stage here are specific to the example of Western red cedar decking. For other materials, other activities would be listed. The right-hand column lists the types of environmental impacts associated with this material, both resources consumed (such as energy and water) and pollutants and wastes emitted (such as global warming gasses and nonhazardous waste). Though not included here, the LCA also quantifies these impacts so that one material can be readily compared with another.

*Embodied carbon* refers to the total carbon-related greenhouse gas emissions associated with a building material.

While life-cycle analysis represents the most comprehensive materials assessment method currently available, it does not necessarily address all environmental impacts. LCA of wood products, for example, does not capture the loss of biodiversity, decreased water quality, or soil erosion caused by poor forestry practices. These concerns are better addressed by sustainable forestry certification programs. As another example, although global warming potential is quantified in materials LCA, its ultimate consequences for ecosystems and wildlife populations are not described.

### ***Unhealthy and Toxic Materials***

Life-cycle analysis does not fully address human health impacts of materials used in the construction of buildings. For example, although LCA may describe a material's contribution to various forms of air pollution, it will not account for the increase in incidence of asthma or shortening of life expectancy that may result therefrom. To address such concerns, green building

programs explicitly discourage the use of materials known to contain harmful ingredients or that generate such ingredients as byproducts of their manufacturing, use, or disposal.

As an example, historically, formaldehyde commonly has been used as an ingredient in binders and adhesives for many kinds of manufactured wood products. However, this chemical is now a recognized carcinogen and associated with a variety of additional adverse human health impacts. As a consequence, the use of materials with added formaldehyde in buildings is discouraged, and where such materials must be used, strict limits are set on acceptable formaldehyde emission levels. Lead, cadmium, and asbestos are other examples of once-common ingredients that are now discouraged or banned from use in building materials due to their toxicity. These and other examples are discussed in more detail throughout this book.

### **Assessing Sustainable Buildings**

In the United States, the most widely applied system for evaluating building sustainability is the U.S. Green Building Council's Leadership in Energy and Environmental Design, or *LEED®*, rating system. LEED for New Construction and Major Renovation groups sustainability goals into eight broad categories addressing areas such as site selection and development, energy efficiency, conservation of materials and resources, and others (Figure 1.2). Within each category are mandatory *prerequisites* and optional *credits* that contribute points toward a building's overall sustainability rating. Depending on the total number of points achieved, four levels of sustainable design are recognized, including, in order of increasing performance, Certified, Silver, Gold, and Platinum. The LEED rating system is voluntary. It is used when adopted by a private building owner or mandated by a public building agency.

embodied energy between a cradle-to-cradle and cradle-to-construction site analysis is small, as most of the energy expenditure occurs prior to the material's installation, use, and disposal.

The concept of embodied effects can also be applied to any other measured input or output from a material life-cycle analysis. For example, *embodied water* refers to the fresh water consumed as a consequence of building with a particular material.



# LEED for New Construction and Major Renovation

## Project Checklist

Project Name

Date

Y ? N

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 1 Integrative Process	1
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			<b>Location and Transportation</b>	Possible Points:	16
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 1 LEED for Neighborhood Development Location		16
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 2 Sensitive Land Protection		1
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 3 High Priority Site		2
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 4 Surrounding Density and Diverse Uses		5
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 5 Access to Quality Transit		5
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 6 Bicycle Facilities		1
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 7 Reduced Parking Footprint		1
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 8 Green Vehicles		1

			<b>Sustainable Sites</b>	Possible Points:	10
<b>Y</b>	<input type="checkbox"/>	<input type="checkbox"/>	Prereq 1 Construction Activity Pollution Prevention		Required
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 1 Site Assessment		1
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 2 Site Development--Protect or Restore Habitat		2
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 3 Open Space		1
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 4 Rainwater Management		3
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 5 Heat Island Reduction		2
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 6 Light Pollution Reduction		1

			<b>Water Efficiency</b>	Possible Points:	11
<b>Y</b>	<input type="checkbox"/>	<input type="checkbox"/>	Prereq 1 Outdoor Water Use Reduction		Required
<b>Y</b>	<input type="checkbox"/>	<input type="checkbox"/>	Prereq 2 Indoor Water Use Reduction		Required
<b>Y</b>	<input type="checkbox"/>	<input type="checkbox"/>	Prereq 3 Building-Level Water Metering		Required
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 1 Outdoor Water Use Reduction		2
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 2 Indoor Water Use Reduction		6
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 3 Cooling Tower Water Use		2
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 4 Water Metering		1

			<b>Energy and Atmosphere</b>	Possible Points:	33
<b>Y</b>	<input type="checkbox"/>	<input type="checkbox"/>	Prereq 1 Fundamental Commissioning and Verification		Required
<b>Y</b>	<input type="checkbox"/>	<input type="checkbox"/>	Prereq 2 Minimum Energy Performance		Required
<b>Y</b>	<input type="checkbox"/>	<input type="checkbox"/>	Prereq 3 Building-Level Energy Metering		Required
<b>Y</b>	<input type="checkbox"/>	<input type="checkbox"/>	Prereq 4 Fundamental Refrigerant Management		Required
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 1 Enhanced Commissioning		6
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 2 Optimize Energy Performance		18
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 3 Advanced Energy Metering		1
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 4 Demand Response		2
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 5 Renewable Energy Production		3
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 6 Enhanced Refrigerant Management		1
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Credit 7 Green Power and Carbon Offsets		2

			<b>Materials and Resources</b>	Possible Points: 13
<b>Y</b>		Prereq 1	Storage and Collection of Recyclables	Required
<b>Y</b>		Prereq 2	Construction and Demolition Waste Management Planning	Required
		Credit 1	Building Life-Cycle Impact Reduction	5
		Credit 2	Building Product Disclosure and Optimization - Environmental Product Declarations	2
		Credit 3	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
		Credit 4	Building Product Disclosure and Optimization - Material Ingredients	2
		Credit 5	Construction and Demolition Waste Management	2
			<b>Indoor Environmental Quality</b>	Possible Points: 16
<b>Y</b>		Prereq 1	Minimum Indoor Air Quality Performance	Required
<b>Y</b>		Prereq 2	Environmental Tobacco Smoke Control	Required
		Credit 1	Enhanced Indoor Air Quality Strategies	2
		Credit 2	Low-Emitting Interiors	3
		Credit 3	Construction Indoor Air Quality Management Plan	1
		Credit 4	Indoor Air Quality Assessment	2
		Credit 5	Thermal Comfort	1
		Credit 6	Interior Lighting	2
		Credit 7	Daylight	3
		Credit 8	Quality Views	1
		Credit 9	Acoustic Performance	1
			<b>Innovation</b>	Possible Points: 6
		Credit 1	Innovation	5
		Credit 2	LEED Accredited Professional	1
			<b>Regional Priority</b>	Possible Points: 4
		Credit 1	Regional Priority: Specific Credit	1
		Credit 2	Regional Priority: Specific Credit	1
		Credit 3	Regional Priority: Specific Credit	1
		Credit 4	Regional Priority: Specific Credit	1
			<b>Total</b>	Possible Points: 110
<b>Certified 40 to 49 points   Silver 50 to 59 points   Gold 60 to 79 points   Platinum 80 to 110</b>				

**FIGURE 1.2**

**The LEED-NC v4 Project Checklist.** (Courtesy of U.S. Green Building Council.)

The process of achieving LEED certification for a building begins at the earliest stages of project conception, continues throughout the design and construction of the project, and involves the combined efforts of the owner, design team, builder, subtrades, and materials suppliers. Its successful implementation

requires a high level of cooperation among all of these parties. During this process, the achievement of individual credits is documented and submitted to the Green Building Council, which then makes the final certification of the project's LEED compliance after construction is completed.

The Green Building Council has also developed related rating systems for other types of construction, including existing buildings, commercial interiors, building core and shell construction, schools, retail building, healthcare facilities, homes, and neighborhood development. Through affiliated organizations, LEED is also