



# FUNDAMENTALS OF RESIDENTIAL CONSTRUCTION

FOURTH EDITION

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EDWARD ALLEN · ROB THALLON  
ALEXANDER SCHREYER



WILEY



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Fourth Edition

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Edward Allen  
Rob Thallon  
Alexander C. Schreyer

Featuring the Drawings of  
Joseph Iano

WILEY

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# PREFACE

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## Preface to the Fourth Edition

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The book that you hold in your hands is the fourth edition of what has since its first publication in 2002 become the standard textbook on residential construction. When its preceding book, *Fundamentals of Building Construction, Materials and Methods*, was first published more than 30 years ago, it filled a void and quickly was adopted by hundreds of colleges and universities as a text for general courses in construction technology. It also precipitated immediately the first of a growing stream of requests from teachers for a companion volume that would concentrate on residential construction while retaining the qualities of the parent book. The authors were pleased to respond to those requests with *Fundamentals of Residential Construction*. This book has since grown steadily over the previous three editions and now—in its fourth edition—provides even more improvements, both in terms of content as well as its delivery. All chapters have been edited to reflect the latest in construction technology and describe traditional but also emerging methods. Content has been reorganized in a more logical fashion and the chapter on multifamily construction has been significantly expanded.

This fourth edition inherits several important traits from its predecessors: It is straightforward and readable, and it contains extensive drawings and photographs. These elements are blended on attractive pages, and, for the reader's convenience, each illustration appears on the same two-page spread as its referencing text. Retained, too, is the concern for both technical and aesthetic matters, because the authors believe that those are important for the quality of buildings and the lives of the people who inhabit them.

New to the fourth edition is a chapter on sustainability aspects of construction. Green building and sustainability have over the past years grown from an add-on to traditional design and construction practices to an integral requirement for good construction. Customers now demand high-performance houses

and building codes put more stringent energy-efficiency requirements on every construction project, large and small. The chapter on sustainability provides the reader with a thorough background on the topic, which is strengthened through updated “Green building with...” features in each chapter of the book.

With much of today's construction planning and execution based on the computer, this fourth edition features not only new Web Links sections for each chapter, but also a thorough set of digital 3D exercises. Those exercises allow the reader to virtually practice the presented construction topics and their assemblies without “getting their hands too dirty” (or wasting material). The exercises, which are linked to many locations in the chapters through sidebar icons, are easy to accomplish practices for individual or classroom use.

This fourth edition also has Alex Schreyer joining the team of the original authors, Edward Allen and Rob Thallon. Alex Schreyer, Senior Lecturer and Director of the Building and Construction Technology Program at the University of Massachusetts, is extraordinarily grateful to have been chosen by the original authors as well as the editorial team at John Wiley & Sons, to carry on the educational legacy of this book. Having this well-written, beautifully illustrated, and comprehensive tome on residential construction as a resource has allowed many students, practitioners, and laypeople to learn about our dwellings and explore in an approachable and easily comprehensible manner how they are produced. Alex intends to continue this tradition with reverence to the original intent of this book and a keen eye for current tendencies in construction.

Although all three authors teach in schools of architecture and construction, they are not mere ivory-tower academicians. Between Edward Allen and Rob Thallon, they are the architects of well over 200 constructed houses and innumerable remodeling projects. They have spent countless hours on construction sites, working with residential builders, developers, contractors, and craftspeople on the day-to-day minutiae of getting houses built.

They have both constructed houses with their own hands, from excavation to finishes. In addition, both have authored books on construction that have found enthusiastic acceptance in the building professions. Alex Schreyer adds to this a background in construction, engineering, wood science, and digital design. He is the author of “Architectural Design with SketchUp,” the main reference on this popular 3D modeling software. He is also

a researcher and sought-after speaker on various aspects of wood structural design and digital planning in construction.

The team of authors brings to the table a broad regional background that includes wintry New England, the damp but mild Pacific Northwest, as well as Canada. To extend the boundaries of their own experiences, the authors also have consulted frequently with colleagues in other regions of the United States and Canada.

## ONLINE RESOURCES

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This fourth edition of *Fundamentals of Residential Construction* comes with online resources for instructors and students, which can be found by going to [www.wiley.com/go/resconstruction4e](http://www.wiley.com/go/resconstruction4e).

A set of interactive exercises that are new to this fourth edition are linked to specific locations in the text via an icon (shown as a sample next to this paragraph). The reader is encouraged to seek those exercises out and practice constructing specific building details virtually in 3D on the computer when this would allow for a better understanding of the presented content.



As an example, in a section about window framing, there is an exercise where the framing around a window (including studs and headers) needs to be assembled by copying, placing (moving and rotating), and cutting (stretching) provided pre-modeled items.

These exercises require only minimal understanding of 3D modeling software and all of the necessary knowledge to complete them can be acquired easily by watching an introductory video (provided on the companion website). For the instructor, they provide pre-made, “hands-on” exercises that can be assigned to even large classes or as part of an online course.

# ACKNOWLEDGMENTS

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Together, Edward Allen, Rob Thallon, and Alexander C. Schreyer are very grateful to all the people at John Wiley & Sons, Inc., who have given so much of themselves to producing this book. We thank especially Publisher Amanda Miller, Editor Margaret Cummins, Developmental Editor Lauren Olesky, and Senior Production Editor Doug Salvemini. Like the quality of a house, the quality of a book is proportional to the skill and dedication of the individuals on the production team.

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## For Edward Allen

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Edward Allen is grateful to be teamed with Rob Thallon, a gifted teacher, accomplished author, and award-winning architect of some of the loveliest, most livable houses ever constructed. He offers apologies to Dee Etzwiler and Carter and Claire Thallon for involving their husband and father, respectively, in an enterprise that kept him holed up in his office for many hours over a period of several years. He thanks Rob for sharing his vision of excellence and making this book so special. He is grateful to Joseph Iano, whose ideas and innovations for the parent book still shine in this book. And he thanks Mary M. Allen for her support and encouragement.

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## For Rob Thallon

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Rob Thallon is especially thankful to Edward Allen, his mentor and friend, for selecting him to work on this important project. He also thanks his coauthor for having been his keenest critic and most fervent champion during his previous writing projects, and he notes that their collaboration on this book has deepened his appreciation for the clarity of Edward Allen's

vision and his language. He wishes to thank the talented illustrators Mu-Yun Chang, Lisa Ferretto, Laura Houston, and Dave Bloom, who helped develop and render drawings for the original edition; and Ben Rippe and John Arnold, who contributed illustrations and organizational brilliance to the second edition. Finally, thanks and a deep appreciation to Jesse Crupper, Dee Etzwiler, and Hank Warneck, whose research, photography, and illustrations were instrumental to the quality of this third edition.

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## For Alexander Schreyer

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Alex thanks former Wiley editor Paul Drougas for originally championing this project and his joining of the original team of authors. He also thanks his colleagues Ben Weil and Ho-Sung Kim for their technical reviews and very helpful feedback on the manuscript. He also thanks his wife, Dr. Peggi Clouston, for her encouragement, support, love, and the many discussions about building, which they both feel highly passionate about. Finally, he thanks his two beautiful girls, Sophia and Mackenzie, for their patience when the manuscript was due and he had to choose to work at his computer rather than playing with them in the garden.

Alex dedicates his contributions to this book to his wife, Peggi.

Edward Allen  
*South Natick, Massachusetts*

Rob Thallon  
*Eugene, Oregon*

Alexander Schreyer  
*Amherst, Massachusetts*





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# **FUNDAMENTALS OF RESIDENTIAL CONSTRUCTION**

Fourth Edition

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# PART ONE

## Context for Building







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# THE CONTEXT FOR RESIDENTIAL CONSTRUCTION

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1

- 1.1 History
- 1.2 A Culture of Building
- 1.3 Construction Systems
- 1.4 Types of Residential Development
- 1.5 Zoning Ordinances, Building Codes, and Other Legal Constraints
- 1.6 Building Costs and Financing
- 1.7 Building a House: The Typical Process
- 1.8 MasterFormat

Review Questions

Exercises

Key Terms and Concepts

Web Links

Selected References

### 1.1 History

People have been building houses for thousands of years. These houses have provided shelter, afforded privacy, defined territory, enhanced status, and, in some cases, provided defense. The earliest houses were opportunistic uses

of naturally sheltered places like caves and were more like nests than houses. As time passed, people learned to assemble materials collected from nature to make simple freestanding structures. In many cultures, these structures have evolved into highly crafted houses that are elegant expressions of cultural patterns and

values (Figures 1.1 and 1.2). In the past 150 years, technology has afforded us conveniences such as electricity, plumbing, and automatic heating and air conditioning that have made houses, in the words of the famous architect Le Corbusier, “machines for living.” Most recently, housing in the industrialized world has

FIGURE 1.1

The Roman domus, developed more than 2000 years ago, had individual rooms for common daily functions and was built around a central courtyard that helped to cool the rooms naturally.

*Source: Reproduced with permission of John Wiley & Sons, Inc.*

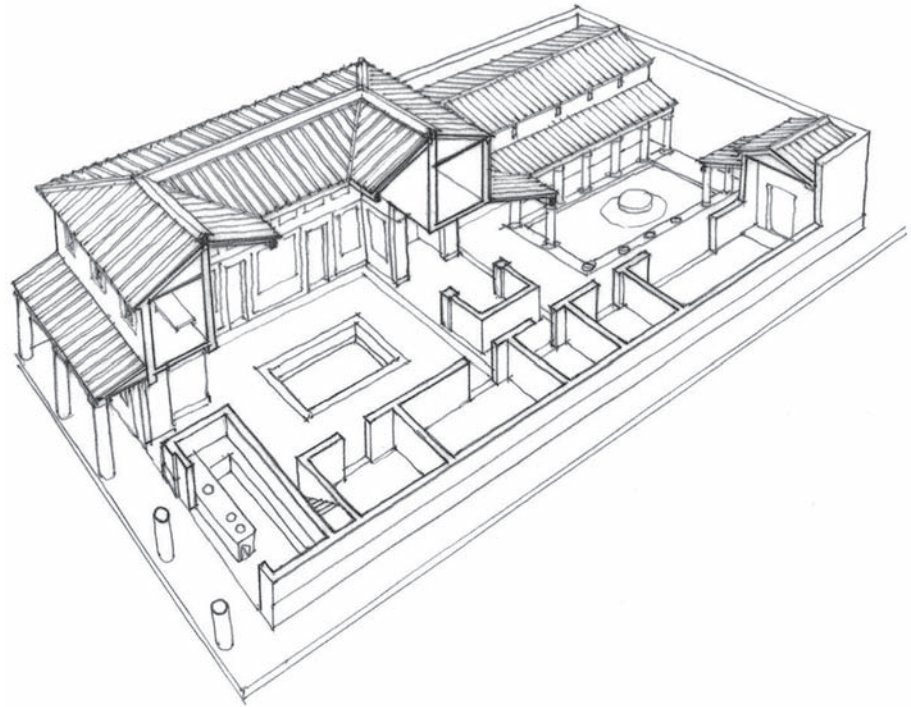
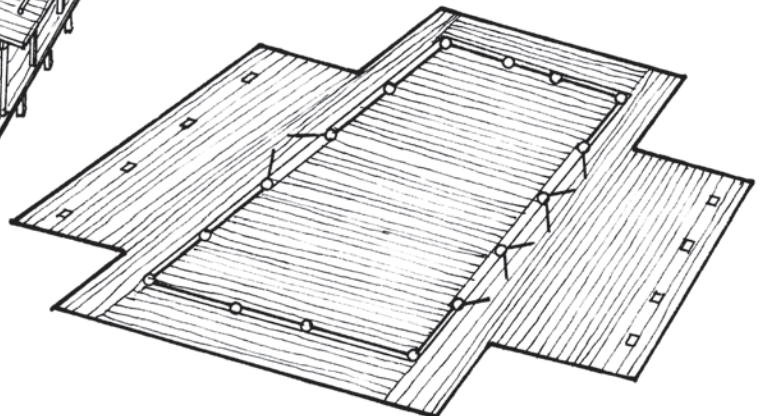
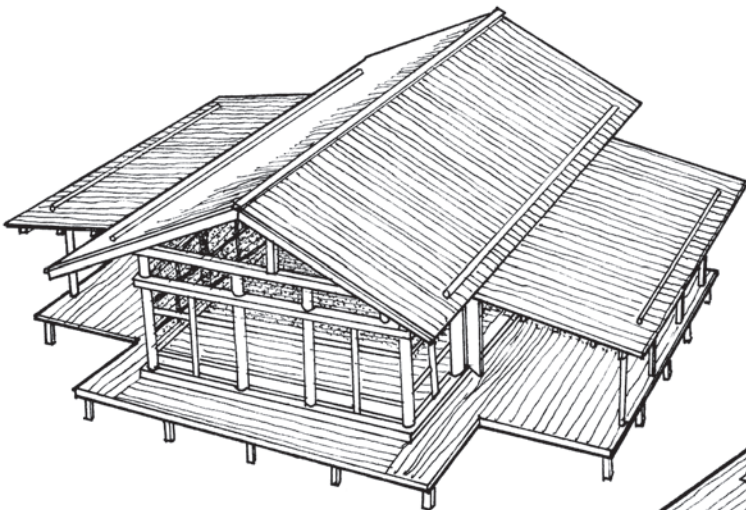


FIGURE 1.2

A traditional Japanese house from the Nara period, AD 710–784. The house had both open and closed spaces, and the enclosed indoor space had no permanent partitions. Houses such as this have influenced traditional Japanese house design and construction to the present day.

*Source: From Nishi Kazuo and Hozumi Kazuo, What Is Japanese Architecture? Kodansha International, Ltd., Tokyo, 1985*



emphasized energy conservation and efficient production. Today, residential designers have a rich history from which to draw, and residential builders have the best tools and most complete palette of quality materials with which to build that have ever existed. The challenge for this new generation of designers and builders is to sustain and improve the built environment in the face of decreasing natural resources and increasing population.

Throughout history, the forms of houses have differed from region to region. House form varies primarily in relation to climate, to available building materials and tools, and to the culture of the people being housed. The influence of climate on house form is dramatically demonstrated by the comparison of the igloo in polar regions with the open-sided palm-thatched structure in tropical zones. The forms of houses in the same climate can vary also, however, because of the use of different building materials. In Mexico, for example, the introduction of reinforced

concrete has spawned a collection of flat-roofed houses that contrast sharply with the traditional sloped roof made of timber covered with clay tiles. The culture of the people being housed also has considerable influence on house form. Native American tribes who were nomadic built dwellings such as tepees that were easily folded and transported, while rooted tribes from the same region built stationary houses of earth, stone, and wood.

The modern North American house has evolved largely from 16th-century timber-framed houses that had been developed in response to the climate, materials, and culture of northern and central Europe (Figure 1.3). Early pioneers landing on the eastern shores of North America found a new homeland rich with timber that had to be cleared to make way for development, so it was logical to use wood for the construction of new houses. The settlers soon discovered, however, that the European tradition of exposed timber frame was inadequate in the harsher climate of

the New World, so they developed an exterior skin of clapboards to protect the frame (Figure 1.4). This wooden structure and its details evolved over the years in response to changes in tools, transportation, and social norms. Other building materials and systems such as brick and stone masonry developed simultaneously but were never as prevalent in North America as the clapboard-clad, timber-framed building.

Then, in the 1840s, after more than 300 years of development, the heavy timber frame yielded its preeminence almost overnight to a new system of construction, the *wood light frame*. The emergence of the light frame was made possible by two technological developments: mass production of the inexpensive wire nail and the ability of water-powered sawmills to cut large quantities of consistently dimensioned lumber. These developments allowed the large timbers and complicated connections of the traditional timber-framed buildings to be replaced

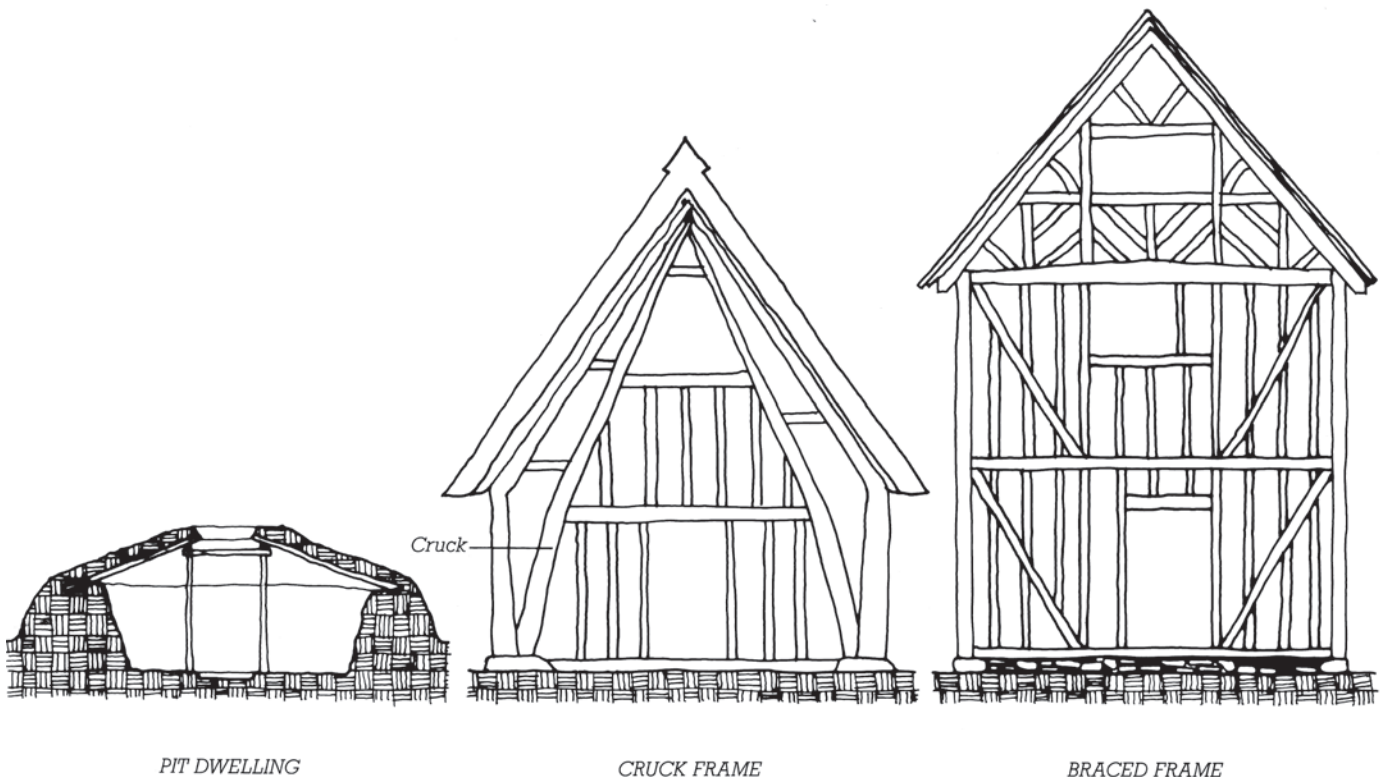


FIGURE 1.3

European timber house forms generally followed a progression of development from crude pit dwellings, made of earth and tree trunks, to cruck frames to braced frames.



FIGURE 1.4

The North American climate was more severe than the European climate, so early pioneers found a way to wrap the wooden frame with cladding, protecting it more securely from the weather than the exposed half-timbers of European houses. This example, built in Essex County, Massachusetts, is still standing.

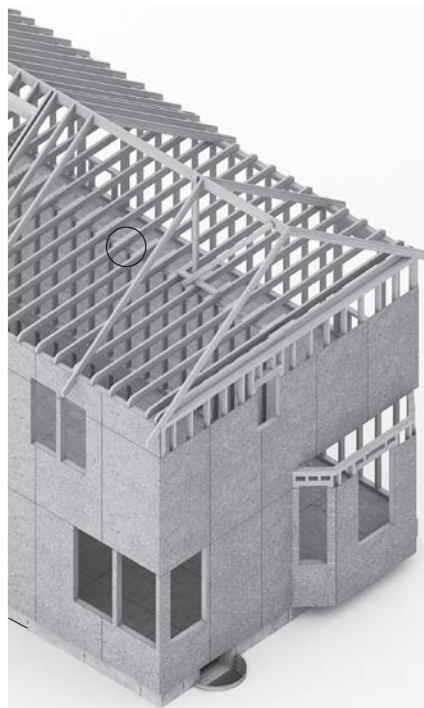
Source: Photo courtesy Library of Congress, Prints and Photographs Division, *Historic American Buildings Survey*, Reproduction Number, HABS, MASS, 5-TOP, 1–6

with numerous small structural pieces, simply connected (Figure 1.5). The advantages of the wood light frame over its predecessor are so numerous and compelling that it has dominated residential and other small-scale construction for the 150 years since its introduction, and it still shows no sign of giving way to other systems. Today, the wood light frame accounts for over 90 percent of all new site-built residential construction and is the basis for most factory-built housing as well.

FIGURE 1.5

The wood light frame uses less material and less labor to construct than does its predecessor, the timber frame.

For lateral stability, light framing relies on sheathing such as plywood applied to the exterior of the frame.



## 1.2 A Culture of Building

Houses are built within the context of the many individuals and institutions that affect their design and construction. In primitive and vernacular societies, the context was relatively local and involved few people. The head of a household might acquire a piece of land through the family, formulate a simple design based on local traditions, consult with a local builder about schedule and cost, arrange for the purchase of local building materials, and work together with the builder using traditional methods to build the house. The building of a house today in North America involves a much more complex process and many more participants. Nonetheless, all these participants are instrumental to the success of the project, and all are connected to what can be called a residential building culture—a network of people and institutions, which we will call “subcultures,” that are directly or indirectly dedicated to the production of houses. The principal subcultures are discussed in the following paragraphs and in later chapters of this book.

### 1.2.1 Contractors and Subcontractors

At the center of today’s residential building culture are the *contractors* and *subcontractors* whose job it is to construct houses. These people—carpenters, plumbers, masons, electricians, and myriad others—devote their professional lives to assembling materials in concert with one another to make houses. Their work depends on direct contributions from many other sectors of the building culture such as designers, material suppliers, and code enforcement agencies. Indirect contributions from realtors, financial institutions, educators, and publishers also play an important role in their work. Contractors and subcontractors are discussed extensively in Chapter 3.

### 1.2.2 Builders and Developers

*Builders* bring together and coordinate the numerous parts of an entire building project for the purpose of offering it for sale or rent. The builder purchases a building lot,



obtains financing, hires the designers and other consultants to produce plans, hires the contractor to do the construction, markets the project, and sells or rents it. Builders can work on one house at a time or can build large tracts of houses or large multifamily structures.

Whereas builders are the entrepreneurs who produce houses for sale, *developers* are entrepreneurs who produce building lots. Developers purchase large tracts of land, contract for the design of roads and utilities, obtain the necessary governmental permissions to develop the land, contract for the installation of roads and utilities, and sell the divided land as building lots. Developers often expand their operation to become builder/developers, and builders likewise can expand in the other direction. Nonprofit builder/developers produce affordable housing for rent or sale to low-income families or individuals. Builders and developers are discussed further in Chapter 3.



FIGURE 1.7

Large retail outlets such as this one provide one-stop shopping for professional builders and homeowners alike. Because of the large volume of building materials, tools, and books sold at these outlets, prices are usually competitive, and building professionals receive an additional discount.

Source: Photo by Rob Thallon

FIGURE 1.6

The North American wood light frame building system is now used extensively in Japan, where its resistance to earthquakes makes it most practical.

Source: Photo by Rob Thallon



FIGURE 1.8

Lumberyards play an important role in residential construction. Based on a set of building plans, an employee of the yard will estimate the quantity of lumber that is required to build a project and will furnish a competitive bid for the entire package of lumber, delivered to the building site. Yards prefer doing business with contractors who organize their work so that deliveries can be concentrated into five or six truckloads for an average-sized house.

Source: Photo by Rob Thallon

### 1.2.3 Designers and Consultants

The members of the building culture most responsible for creative solutions and communication are the *designers*. This group includes architects, building designers, engineers of several kinds, landscape architects, landscape designers, and interior designers. They are responsible for being knowledgeable about current building practices, understanding and interpreting the various codes and laws that regulate building design, having a current understanding of the availability and performance of building materials, and integrating all these factors into designs that are appreciated by their clients.

Whenever a higher degree of specialization is sought than a primary designer can provide, *consultants* are engaged who perform services for the designer in a certain specialty, such as structure, building systems and performance, code and environmental compliance, and others. The number of consultants on a project typically increases with the size of the project.

These various participants in the role of residential design are discussed further in Chapter 4.

### 1.2.4 Material Manufacturers and Distributors

There are thousands of companies, large and small, many of which operate internationally, that manufacture and sell the materials and assemblies used to construct houses. The *manufacturers* generally sell their goods wholesale to retail stores, which, in turn, sell to contractors and to the general public. Contractors, because they are frequent customers who often buy in volume, usually are offered a discount at retail outlets. Product information in both printed and electronic form is distributed to contractors and designers and is disseminated to the general public via commercial advertising in periodicals.

Building material manufacturers have also formed a large number of organizations that work toward the development of technical standards and the dissemination of information in relation to their respective products. The Western Wood Products Association (WWPA), for example,

is made up of producers of lumber and wood products. It carries out programs of research on wood products, establishes uniform standards of product quality, certifies mills and products that conform to its standards, and publishes authoritative technical literature concerning the use of lumber and related products. Associations with a similar range of activities exist for virtually every material and product used in building. All of them publish technical data relating to their fields of interest, and many of these publications are indispensable references for the architect or engineer. A considerable number are incorporated by reference into various building codes and standards.

Each upcoming chapter features the relevant associations in the Web Links section at the end of the chapter. The reader is encouraged to browse websites and download relevant information and thereby build up a reference library.

### 1.2.5 Realtors

*Realtors* are the salespeople of the building culture and play a critical role in marketing houses built for sale. They are responsible for knowing what the buying public wants in a house and for selling or renting houses as they are built. Because realtors have direct contact with consumers and are in a position to learn their desires, they are frequently queried by resourceful builders who are trying to discover new design features that will make their houses more marketable.

New speculative houses are typically advertised and sold by realtors via a *listing agreement* under which realtors assume numerous responsibilities, including negotiating the price of the house, the terms of the sale, and the conditions of the contract, with particular attention paid to the aspect of financing. For this service, realtors are generally paid a percentage of the cost of each house sold. Large builder/developers will often create their own real estate company for the purpose of marketing and selling their own houses.

### 1.2.6 Regulatory Agencies

Building design and construction are regulated by zoning ordinances and building

codes written for the purpose of providing safe and healthy built environments. *Zoning ordinances* are local laws that divide the locality into zones and regulate such things as what kinds of buildings may be built in each zone and to what uses these buildings may be put. For example, these regulations restrict the use of buildings within residential zones so that dangerous or obnoxious activities do not get mixed in with houses. Within residential zones, the minimum size of lots, the distance a house must be from the property line, requirements for off-street parking, and maximum fence heights are typically regulated. *Building codes* are designed to ensure structural and fire safety and a healthy living environment within the house itself. The sizes of structural members, minimum standards for plumbing and wiring, minimum ceiling heights, the design of stairs and handrails, and provision for emergency escape are all examples of the regulations found in building codes. Zoning ordinances and building codes are further discussed later in this chapter.

### 1.2.7 Financial Institutions

Most residential construction projects require financial resources beyond the immediate means of the owner. Banks and other financial institutions provide capital for the projects in the form of long-term loans to qualified owners. The ability to resell a house if the owner defaults on payments is a primary concern of lending institutions, which results in them being rather risk-averse and conservative. As a result, banks may be less inclined to loan money for the purchase of houses that appear to be very different from the norm. Financial institutions are further discussed later in this chapter.

### 1.2.8 Educational and Research Institutions

Most designers and builders have some formal training from a technical school or university. Architects are required to have at least a 5-year professional degree, and most plan service drafters have taken courses in drafting and residential

construction. Many courses in both the business and the physical skills required in their specialties are offered to contractors and subcontractors. Some contractors and subcontractors are required to be licensed, and there are sanctioned courses offered by different institutions for this purpose.

In addition to providing education for the building community, universities also commonly engage in building-related research. Examples of such research are new materials and structural systems, performance of existing building methods, energetic performance of materials and systems, construction management practices, and cost of building. Often, outcomes of this research provide the market with new materials and solutions, and can inform the regulatory community about more adequate guidelines, which then make their way into building codes.

The training of residential designers is explored in Chapter 4, and that of builders and contractors is discussed in Chapter 3.

### 1.2.9 Associations

There are many associations that relate to the design and construction of houses. The *American Institute of Architects (AIA)* and the *National Association of Home Builders (NAHB)* are two of the largest such associations, and there are numerous other organizations of manufacturers, building trades, and other groups within the building culture. Their Canadian equivalents are the *Royal Architectural Institute of Canada (RAIC)* and the *Canadian Home Builders' Association (CHBA)*. Hybrid groups that include members from several disciplines also exist. For example, the International Code Council (ICC), which is responsible for writing building codes, includes architects, builders, and building code officials.

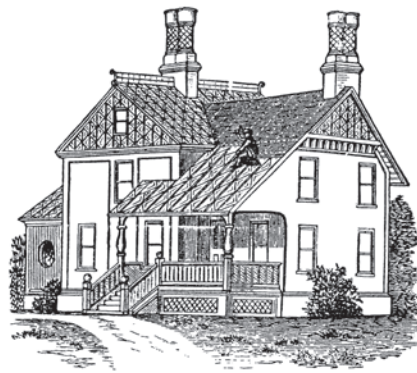
### 1.2.10 Publishers and Media

The publishing industry has long been an integral part of the residential building culture. For hundreds of years, periodicals have advertised the latest building

materials, tools, and other products (Figure 1.9). Popular magazines such as *Better Homes and Gardens*, *Sunset*, and *Home* have carried articles about design, while others such as *Builder* and *Fine Homebuilding* have focused on construction. Books and journals are devoted to a variety of related topics. Recently, there has been a proliferation of how-to books for the do-it-yourself (DIY) market, which is mirrored online and on TV. Shows like PBS's *This Old House* and cable channels like the *DIY Network* and *HGTV* deliver not only housing ideas and built examples but also education in the involved techniques to the broader public and builders alike.

Whether the motive is advertising or education, the most successful published materials come from sources with strong connections to the building culture and especially to the design and construction processes.

## METALLIC SHINGLES



make the most durable and ornamental roof in the world. The only shingle manufactured from metal that makes an absolutely tight roof. Send for full descriptive circular and new prices to

**ANGLO-AMERICAN ROOFING CO.,**  
22 Cliff Street NEW YORK.

FIGURE 1.9

Ads such as this one from the year 1882 have appeared in popular journals for as long as the journals have existed. Many modern ads refer to Web pages and/or offer free demonstration videos and downloadable material.

Source: From *Builder* and *Wood-Worker*, Vol. XVIII, Chas. D. Lakey, New York, 1882

## 1.3 Construction Systems

For the past 150 years, most houses in North America have been built using wood light frame construction, which is the most flexible of all building systems. There is scarcely a shape it cannot be used to construct, from a plain rectilinear box to cylindrical towers to complex roofs with dormers of every description (Figure 1.10). Since it first came into use, wood light framing has served to construct buildings in styles ranging from reinterpretations of nearly all the historical fashions to uncompromising expressions of every architectural philosophy of the last 100 years. It has assimilated without difficulty a succession of technical improvements in building: gas lighting, electricity, indoor plumbing, central heating, air conditioning, thermal insulation, prefabricated components, and electronic communications.

Wood light frame buildings are easily and swiftly constructed with a minimal investment in tools. Many observers of the building industry have criticized the supposed inefficiency of wood light frame construction, which is carried out largely by hand methods on the building site, yet it has successfully fought off competition from industrialized building systems of every sort, partly by incorporating their best features, to remain the least expensive form of durable construction for houses and even multistory, multifamily buildings.

However, wood light frame construction has its deficiencies: If ignited, the unprotected frame burns rapidly; if exposed to dampness, it can decay. It expands and contracts by significant amounts in response to changes in humidity, sometimes causing chronic difficulties such as cracking plaster, sticking doors, and buckling floors. The framing itself is so unattractive to the eye that it is seldom left exposed in a building. These problems can be controlled, however, by appropriate design (e.g., with a covering of gypsum board that increases fire resistance), using adequate materials (e.g., using engineered wood products instead of solid wood to reduce swelling) and careful workmanship. There is no arguing with success: Frames made by the monotonous repetition of wooden joists, studs, and rafters are likely to



FIGURE 1.10

The Carson House, built in 1885 in the Queen Anne style for a lumber baron in Eureka, California, is one of the most elaborate residential forms ever built and stands as a testament to the versatility of the wood light frame.

Source: Courtesy of University of Oregon Visual Resources Collection. Original photography by Michael Shellenbarger

remain the number one system of building in North America for a long time to come. The wood light frame system is described in detail in Chapters 8 to 22.

If 90 percent of all site-built residential construction consists of light wood frame, the remaining 10 percent is divided among several other residential construction systems. In some regions of the South, loadbearing masonry is the dominant system. Throughout the continent, other systems such as timber frame, light-gauge steel frame, insulating concrete forms, insulated masonry, and panelized construction are

used in significant numbers of dwellings. These systems are important for their roles in developing new materials and building methods and for inducing innovation in the dominant wood light frame system. These less common systems are discussed in Chapters 23 to 27.

The *manufactured housing* industry factory-builds entire houses as finished boxes, often complete with furnishings, and trucks them to prepared foundations where they are set in place and made ready for occupancy in a matter of hours (Figures 1.11, 1.12, and Chapter 23). If the house

is 14 feet (4.27 m) or less in width, is constructed on a rubber-tired frame, and is completely finished in the factory, it is known as a *mobile home*. If the house is wider than this or is more than one story high, it is built in two or more completed sections that are joined at the site and is known as a *sectional home* or *modular home*. Some manufacturers employ hybrid approaches where, for example, the utility-heavy bathrooms and kitchens are produced as boxes and all other walls are panelized single-wall segments, complete with windows, finishes, and siding.

Modular and mobile homes are sold at a fraction of the price of conventionally constructed houses. This is due in part to the economies of factory production and mass marketing, and in part to the use of components that are lighter and less costly and, therefore, of substantially shorter life expectancy. At prices that more closely approach the cost of conventional on-site construction, however, many companies manufacture modular housing to the same standards as conventional construction. Manufactured housing is an important component of the housing industry but is highly specialized. Because the units are made in a factory rather than at the site, the designs are strongly driven by considerations of production and transport, and their construction process is somewhat different from that of site-built housing.



FIGURE 1.11

This manufactured house was trucked to the site in sections, which were joined together as they were placed on the site-built concrete foundation. The garage will be built at the site because garages, having no framed floors, are difficult to transport and are economical to frame on-site. Manufactured houses account for approximately 25 percent of all new housing in the United States.

Source: Photo by Rob Thallon

#### 1.4 Types of Residential Development

At the present time, single-family houses are built in the United States at a rate of about 620,000 new units per year—less than half of the totals reached in recent peak years. Those single-family detached (freestanding) dwellings comprise approximately 70 percent of all residential buildings. An additional 28 percent are units within large multifamily structures (5 and more units), and the remaining 1 percent are in buildings with 2 to 4 units (2014 data, see Figure 1.13). Most new housing is built at the site, but about 60,000 manufactured houses (representing about 10 percent of the total, in 2013 figures) are built in factories and shipped to the site each year (Figure 1.14). Remodeling of existing houses is more difficult to quantify because it includes projects that range in scope from a new window to an addition larger than the original house. However, it is clear that remodeling is a substantial component of the residential construction industry. The U.S. Census Bureau estimates that residential remodeling in the United States in 2014 accounted for \$135 billion in economic activity, about 36 percent of the value of all new residential construction (Figure 1.15).

In Canada in the year 2014, more than 189,000 units were built, 40 percent of which were single-family detached houses.



FIGURE 1.12

Manufactured housing is typically single-story construction, but some companies produce two-story models. This house was set on the foundation within a matter of hours, but it took weeks for the site crew to add the porch, finish the trim, connect the utilities, and complete the painting.

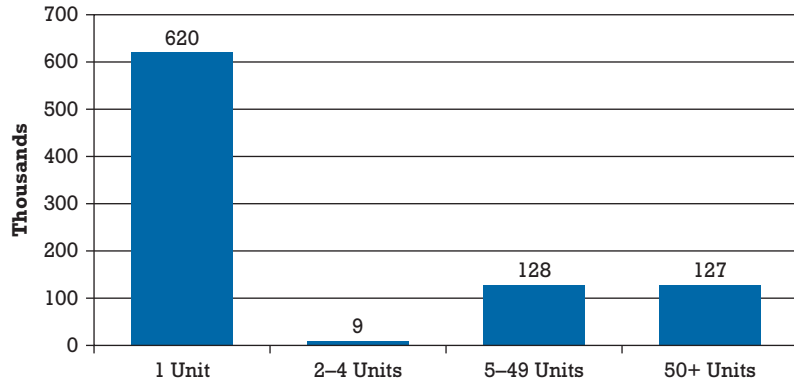
Source: Courtesy of Fischer SIPS, Louisville, Kentucky



## 12 Part One • Context for Building

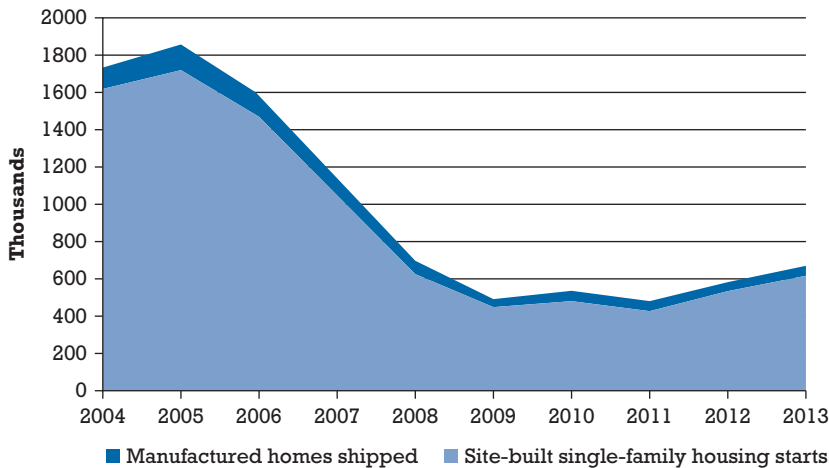
Houses are built for a number of different reasons, depending principally on who pays for their construction (Table 1.1):

- Many are built for personal use and are financed from start to finish by the future owner. Houses in this category are virtually always single-family detached dwellings, although a few are condominium units within larger buildings.
- Houses may also be built for profit, either to be sold or to be rented by entrepreneurial housing developers. This activity is called *speculative building* and accounts for more than half of all housing units built each year. Speculative houses built for sale are most likely to be detached dwellings, whereas speculative rental housing is usually consolidated into large buildings.

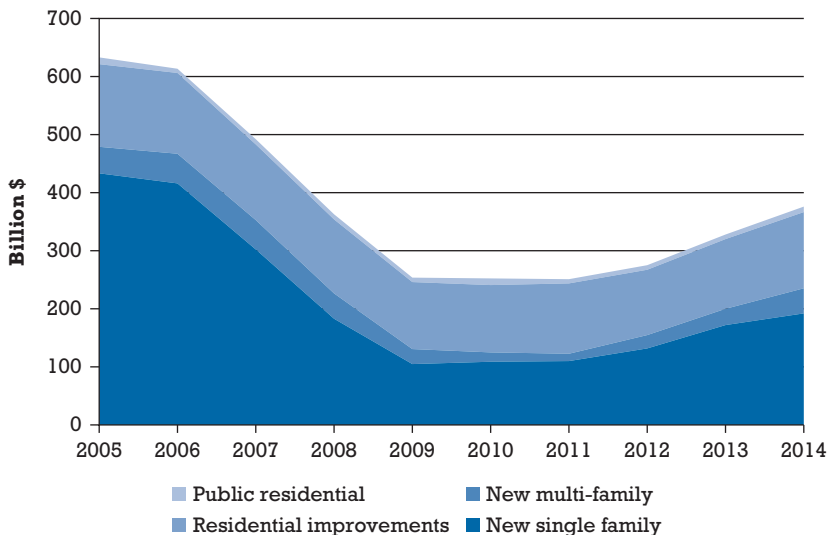


**FIGURE 1.13**  
2014 U.S. housing production measured in thousands of units, broken down by the number of separate dwelling units per building.

Source: U.S. Census Bureau, *Characteristics of Housing*. [www.census.gov/construction/chars/pdf/c25ann2014.pdf](http://www.census.gov/construction/chars/pdf/c25ann2014.pdf)



**FIGURE 1.14**  
New site-built single-family housing starts vs. manufactured-home shipments.  
Source: *Manufactured Housing Institute*. [www.manufacturedhousing.org/lib/forcedownload.asp?filepath=/admin/template/subbrochures/396temp.pdf](http://www.manufacturedhousing.org/lib/forcedownload.asp?filepath=/admin/template/subbrochures/396temp.pdf)



**FIGURE 1.15**  
Annual value of construction put in place: new housing units vs. improvements. Residential construction accounted for 38 percent of all construction in the United States in 2014.  
Source: U.S. Census Bureau, *Annual Value of Construction Put in Place in the U.S.* [www.census.gov/construction/c30/historical\\_data.html](http://www.census.gov/construction/c30/historical_data.html)