The principal method of design for wood-framed construction has historically been allowable stress design (ASD). This chapter uses the most current version of the ASD method (AF&PA, 1997), although the load resistance factored design method (LRFD) is now available as an alternative (AF&PA, 1996a). The ASD method is detailed in the *National Design Specification for Wood Construction* (NDS) and its supplement (NDS-S). The designer is encouraged to obtain the NDS commentary to develop a better understanding of the rationale and substantiation for the NDS (AF&PA, 1999).

This chapter looks at the NDS equations in general and includes design examples that detail the appropriate use of the equations for specific structural elements or systems in light, wood-framed construction. The discussion focuses primarily on framing with traditional dimension lumber but gives some consideration to common engineered wood products. Other wood framing methods, such as post-and-beam construction, are not explicitly addressed in this chapter, although much of the information is relevant. However, system considerations and system factors presented in this chapter are only relevant to light, wood-framed construction using dimension lumber.

Regardless of the type of structural element to analyze, the designer must first determine nominal design loads. The loads acting on a framing member or system are usually calculated in accordance with the applicable provisions of the locally approved building code and engineering standards. The nominal design loads and load combinations used in this chapter follow the recommendations in Chapter 3 for residential design.

While prescriptive design tables (i.e., span tables) and similar design aids commonly used in residential applications are not included herein, the designer may save considerable effort by consulting such resources. Most local, state, or national model building codes such as the *One- and Two-Family Dwelling Code* (ICC, 1998) contain prescriptive design and construction provisions for conventional residential construction. Similar prescriptive design aids and efficient framing practices can be found in *Cost-Effective Home Building: A Design and Construction Handbook* (NAHBRC, 1994). For high wind conditions, prescriptive guidelines for design and construction may be found in the *Wood Frame Construction Manual for One- and Two-Family Dwellings* (AFPA, 1996b). The designer is also encouraged to obtain design data on a variety of proprietary engineered wood products that are suitable for many special design needs in residential construction. However, these materials generally should not be viewed as simple “one-to-one” substitutes for conventional wood framing and any special design and construction requirements should be carefully considered in accordance with the manufacturer’s recommendation or applicable code evaluation reports.

# 5.2 Material Properties

It is essential that a residential designer specifying wood materials appreciate the natural characteristics of wood and their effect on the engineering properties of lumber. A brief discussion of the properties of lumber and structural wood panels follows.

## 5.2.1 Lumber

### *General*

As with all materials, the designer must consider wood's strengths and weaknesses. A comprehensive source of technical information on wood characteristics is the *Wood Engineering Handbook, Second Edition* (Forest Products Laboratory, 1990). For the most part, the knowledge embodied in the handbook is reflected in the provisions of the NDS and the NDS Supplement (NDS-S) design data; however, many aspects of wood design require good judgment.

Wood is a natural material that, as a structural material, demonstrates unique and complex characteristics. Wood's structural properties can be traced back to the material's natural composition. Foremost, wood is a nonhomogeneous, non-isotropic material, and thus exhibits different structural properties depending on the orientation of stresses relative to the grain of the wood. The grain is produced by a tree's annual growth rings, which determine the properties of wood along three orientations: tangential, radial, and longitudinal.

Given that lumber is cut from logs in the longitudinal direction, the grain is parallel to the length of a lumber member. Depending on where the lumber is cut relative to the center of a log (i.e., tangential versus radial), properties vary across the width and thickness of an individual member.

### *Wood Species*

Structural lumber can be manufactured from a variety of wood species; however, the various species used in a given locality are a function of the economy, regional availability, and required strength properties. A wood species is classified as either hardwood or softwood. *Hardwoods* are broad-leafed deciduous trees while s*oftwoods* (i.e., conifers) are trees with needle-like leaves and are generally evergreen.

Most structural lumber is manufactured from softwoods because of the trees' faster growth rate, availability, and workability (i.e., ease of cutting, nailing, etc.). A wood species is further classified into groups or combinations as defined in the NDS. Species within a group have similar properties and are subject to the same grading rules. Douglas Fir-Larch, Southern Yellow Pine, Hem-Fir, and Spruce-Pine-Fir are species groups that are widely used in residential applications in the United States.

### *Lumber Sizes*

Wood members are referred to by nominal sizes (e.g., 2x4); however, true dimensions are somewhat less. The difference occurs during the dressing stage of the lumber process, when each surface of the member is planed to its final dressed dimension after shrinkage has occurred as a result of the drying or "seasoning" process. Generally, there is a 1/4- to 3/4-inch difference between the nominal and dressed sizes of "dry" sawn lumber (refer to NDS-S Table 1B for specific dimensions). For example, a 2x4 is actually 1.5 inches by 3.5 inches, a 2x10 is 1.5