inches by 9.25 inches, and a 1x4 is 3/4-inch by 3.5 inches. This guide uses nominal member size, but it is important to note that the designer must apply the actual dimensions of the lumber when analyzing structural performance or detailing construction dimensions.

Based on the expected application, the tabulated values in the NDS are classified by the species of wood as well as by the nominal size of a member. Typical NDS classifications follow:

- *Boards* are less than 2 inches thick.
- *Dimension lumber* is a minimum of 2 inches wide and 2 to 4 inches thick.
- *Beams and stringers* are a minimum of 5 inches thick, with the width at least 2 inches greater than the thickness dimension.
- *Posts and timbers* are a minimum of 5 inches thick, and the width does not exceed the thickness by more than 2 inches.
- *Decking* is 2 to 4 inches thick and loaded in the weak axis of bending for a roof, floor, or wall surface.

Most wood used in light-frame residential construction takes the form of dimension lumber.

Lumber Grades

Lumber is graded in accordance with standardized grading rules that consider the effect of natural growth characteristics and "defects," such as knots and angle of grain, on the member's structural properties. Growth characteristics reduce the overall strength of the member relative to a "perfect," clear-grained member without any natural defects. Most lumber is visually graded, although it can also be machine stress-rated or machine evaluated.

Visually graded lumber is graded by an individual who examines the wood member at the mill in accordance with an approved agency's grading rules. The grader separates wood members into the appropriate grade classes. Typical visual grading classes in order of decreasing strength properties are Select Structural, No. 1, No. 2, Stud, etc. Refer to the NDS Supplement (NDS-S) for more information on grades of different species of lumber. The designer should consult a lumber supplier or contractor regarding locally available lumber species and grades.

Machine stress rated (MSR) and *machine evaluated lumber* (MEL) is subjected to nondestructive testing of each piece. The wood member is then marked with the appropriate grade stamp, which includes the allowable bending stress (F_b) and the modulus of elasticity (E). This grading method yields lumber with more consistent structural properties than visual grading only.

While grading rules vary among grading agencies, the U.S. Department of Commerce has set forth minimums for voluntary adoption by the recognized

lumber grading agencies. For more information regarding grading rules, refer to *American Softwood Lumber Voluntary Product Standard* (USDOC PS-20), which is maintained by the National Institute for Standards and Technology (NIST, 1994). NDS-S lists approved grading agencies and roles.

Moisture Content

Wood properties and dimensions change with moisture content (MC). Living wood contains a considerable amount of free and bound water. Free water is contained between the wood cells and is the first water to be driven off in the drying process. Its loss affects neither volume nor structural properties. Bound water is contained within the wood cells and accounts for most of the moisture under 30 percent; its loss results in changes in both volume (i.e., shrinkage) and structural properties. The strength of wood peaks at about 10 to 15 percent MC.

Given that wood generally has an MC of more than 30 percent when cut and may dry to an equilibrium moisture content (EMC) of 8 to 10 percent in protected environment, it should be sufficiently dried or seasoned before installation. Proper drying and storage of lumber minimizes problems associated with lumber shrinkage and warping. A minimum recommendation calls for using "surface dry" lumber with a maximum 19 percent MC. In uses where shrinkage is critical, specifications may call for "KD-15," which is kiln-dried lumber with a maximum moisture content of 15 percent. The tabulated design values in the NDS are based on a moisture content of 19 percent for dimension lumber.

The designer should plan for the vertical movement that may occur in a structure as a result of shrinkage. For more complicated structural details that call for various types of materials and systems, the designer might have to account for differential shrinkage by isolating members that will shrink from those that will maintain dimensional stability. The designer should also detail the structure such that shrinkage is as uniform as possible, thereby minimizing shrinkage effects on finish surfaces. When practical, details that minimize the amount of wood transferring loads perpendicular-to-grain are preferable.

Shrink and swell can be estimated in accordance with Section 5.3.2 for the width and thickness of wood members (i.e., tangentially and radially with respect to annual rings). Shrinkage in the longitudinal direction of a wood member (i.e., parallel to grain) is negligible.

Durability

Moisture is a primary factor affecting the durability of lumber. Fungi, which feed on wood cells, require moisture, air, and favorable temperatures to survive. When wood is subject to moisture levels above 20 percent and other favorable conditions, decay begins to set in. Therefore, it is important to protect wood materials from moisture, by:

- limiting end use (e.g., specifying interior applications or isolating lumber from ground contact);
- using a weather barrier (e.g., siding, roofing, building wrap, flashing, etc.);
- applying a protective coating (e.g., paint, water repellent, etc.);