6-1. INTRODUCTION

Structural members stressed primarily in bending are called beams. Horizontal beams of dimension lumber, such as 2 × 8s, used repetitively in bending are usually referred to as joists, whereas large beams that support other beams are called girders. Beam sections are generally chosen on the basis of bending and then checked for other possible failure modes. Beam failure could be a result of bending, shear, lateral buckling, bearing, deflection under service loads, or deflection from creep or ponding. Beam design consists of selecting a species, grade, and cross-sectional dimensions to prevent any of these types of failure from occurring.

Some of these failures might be catastrophic, while others might affect only aesthetics or serviceability. This chapter will discuss each of these failure modes in the sequence in which they would normally be considered.

Beam sections are specified by nominal dimensions, but cross-sectional properties such as area and section modulus are always based on actual dimensions. Unless bending moment due to self-weight is trivial, one must include beam weight as a load on the beam. In this case, the specific gravities given in Appendix Table C-1 will be helpful.

6-2. DESIGN FOR FLEXURE—LATERALLY SUPPORTED BEAMS

If not braced to prevent their compression surface from moving sidewise, wood beams may buckle laterally due to instability. Fortunately, most wood beams and joists are braced at close enough intervals along their compression face that lateral buckling is prevented. If this is the case, then the full modified allowable bending stress may be used.

Lateral support may be provided by blocking (short pieces of dimension lumber cut to fit between joists), or cross bracing called bridging, as shown in Fig. 6-1. The diagonal bridging members are sometimes light-gauge metal, but are more often cut from wood 1 × 3s or 1 × 4s for material economy. Bridging not only keeps the joists upright (prevents rotation), but also helps distribute loads to adjacent joists so that the repetitive-member value of \( F_b \) may be used. Lateral support can be provided by well-nailed plywood sheathing or by nailing one-inch nominal boards (subfloor) diagonally over the joists. Commercial metal hangers, besides providing a bearing seat, can also prevent the ends of beams from rotating.

The NDS (1) lists minimum requirements for lateral support to permit using the full modified bending allowable stress. These requirements, developed from past experience, are:

1. If the ratio of depth to thickness (based on nominal dimensions) of the beam is not more than 2 to 1, no lateral support is required.
2. If the ratio is 3 or 4 to 1, the ends must be held in position to prevent rotation.
3. If the ratio is 5 to 1, one edge must be held in line for its entire length.
4. If the ratio is 6 to 1, full-depth bridging or blocking must be installed at not over 8-ft centers. There are two alternatives to this: (a) Both edges must be held in line, or (b) the ends must be held in position to prevent...

rotation and also the full length of the compression edge of the member must be laterally supported by subflooring or sheathing.

**Design Procedure**

Sawn-timber beams are designed by working (allowable) stress design. The computed extreme fiber stress \( f_b = \frac{M}{S} = \frac{Mc}{I} \) must not exceed the modified allowable bending stress:

\[
f_b \leq F_b \quad (6-1)
\]

In this equation and other equations to follow, the symbol for allowable stress \( F_b \) indicates the particular allowable stress **including all applicable modifications**. Some of these modifications (discussed in Chapter 4) are size factor, load-duration modification, moisture content modification, and fire-retardant modification. Others are spelled out by footnotes to Tables B-3 and B-4. In bending-moment calculations for simple beams, the span is to be taken as the distance center-to-center of required bearing areas.

Should there be a notch in a bending member, the section modulus at that location should be reduced accordingly for calculating flexural stress. The notch depth must not exceed one-sixth the depth of the member. Notches should be avoided, especially on the tension side of the member (except at the ends), and must not be located in the middle one-third of the span where bending moment is the greatest.

The steps in the design procedure are as follows:

1. Estimate the size factor, \( C_r \) (discussed in Section 4-10); recall that it applies only to \( F_b \).
2. Estimate beam weight per foot.
3. Solve for actual maximum bending moment.
4. Determine which load combination controls the design, and solve for section modulus required.
5. Choose a trial section.
6. Verify weight per foot, \( C_r \), moment, and section modulus required.
7. Recycle as needed.
8. After selecting a section for bending, check for shear, deflection, and bearing (if required).

**Form Factor**

For circular and diamond-shaped beams, there is a modification to the allowable bending stress called the form factor, \( C_f \). Early experiments showed that a circular log can support the same load as a square beam of the same cross-sectional area, even though the circular log has a section modulus only \( 1/1.18 \) times as large. A square beam loaded diagonally to its face can support the same allowable load as if it were loaded perpendicular to a face. Consequently, a circular beam has \( C_f = 1.18 \) and a diagonally loaded square beam has \( C_f = 1.414 \). The allowable bending stress is multiplied by this factor. Use the section properties of the actual circle or diamond cross section.

**Decking**

Tongued-and-grooved (T & G) decking, used for floors and roofs, is another type of wood