should apply (refer to Table 5.4), along with a live load deflection limit of $\ell/240$ (refer to Table 5.6). Large openings or especially heavy loads may require stronger members such as engineered wood beams, hot-rolled steel, or flitch plate beams. Refer to *Cost-Effective Home Building: A Design and Construction Handbook* for economical framing solutions to reduce header loads and sizes (NAHB, 1994).

Headers are generally designed to support all loads from above; however, typical residential construction calls for a double top plate above the header. When an upper story is supported, a floor band joist and sole plate of the wall above are also spanning the wall opening below. These elements are all part of the resisting system. Recent header testing determined whether an adjustment factor (i.e., system factor or repetitive member factor) is justified in designing a header (HUD, 1999). The results showed that a repetitive member factor is valid for headers constructed of only two members as shown in Table 5.4 and that additional system effects produce large increases in capacity when the header is overlaid by a double top plate, band joist and sole plate as shown in Example 5.7. Consequently, an overall system factor of 1.8 was found to be a simple, conservative design solution. That system factor is applicable to the adjusted bending stress value, F_b', of the header member only. While this example covers only a very specific condition, it exemplifies the magnitude of potential system effect in similar conditions. In this case, the system effect is associated with load sharing and partial composite action. The above adjustment factor is not currently recognized in the NDS.

Refer to Table 5.8 for recommended allowable bending stress adjustment factors for use in the specific header design conditions related to the discussion above. For other conditions, refer to Table 5.4. Example 5.7 demonstrates the design approach for a typical header condition.

TABLE 5.8 *Recommended System Adjustment Factors for Header Design*

Header Type and Application[1]	Recommended C_r Value[2]
2x10 double header of No. 2 Spruce-Pine-Fir	1.30[3]
Above header with double top plate, 2x10 floor band joist, and sole plate of wall located directly above.[4]	1.8

Notes:
[1]For other applications and lumber sizes or grades, refer to the C_r factors in Table 5.4 of Section 5.2.4.2.
[2]Apply C_r in lieu of Section 5.1.3 (Table 5.4) to determine adjusted allowable bending stress, F_b'.
[3]Use $C_r = 1.35$ when the header is overlaid by a minimum 2x4 double top plate without splices.
[4]Refer to Example 5.7 for an illustration of the header system.

Headers are not required in nonload-bearing walls. Openings can be framed with single studs and a horizontal header block of the same size. It is common practice to use a double 2x4 or triple 2x4 header for larger openings in nonload-bearing walls. In the interest of added rigidity and fastening surface, however, some builders use additional jamb studs for openings in nonload-bearing walls, but such studs are not required.

5.5.5 Columns

Columns are vertical members placed where an axial force is applied parallel to the longitudinal axis. Columns may fail by either crushing or buckling. Longer columns have a higher tendency than shorter columns to fail due to buckling. The load at which the column buckles (Euler buckling load) is directly related to the ratio of the column's unsupported length to its depth (slenderness factor). The equations provided in Section 5.3 are based on the NDS•3.7.1 provisions regarding the compression and stability of an axial compression member (i.e., column) and thus account for the slenderness factor.

Figure 5.6 illustrates three ways to construct columns using lumber. *Simple columns* are columns fabricated from a single piece of sawn lumber; *spaced columns* are fabricated from two or more individual members with their longitudinal axes parallel and separated with blocking at their ends and mid-point(s); *built-up columns* are solid columns fabricated from several individual members fastened together. Spaced columns as described in the NDS are not normally used in residential buildings and are not addressed here (refer to NDS•15.2 for the design of spaced columns).

Steel jack posts are also commonly used in residential construction; however, jack post manufacturers typically provide a rated capacity so that no design is required except the specification of the design load requirements and the selection of a suitable jack post that meets or exceeds the required loading. Typical 8-foot tall steel jack posts are made of pipe and have adjustable bases for floor leveling. The rated (design) capacity generally ranges from 10,000 to 20,000 lbs depending on the steel pipe diameter and wall thickness.

Simple columns are fabricated from one piece of sawn lumber. In residential construction, simple columns such as a 4x4 are common. The equations in Section 5.3 are used to design simple columns as demonstrated in Example 5.8.

Built-up columns are fabricated from several wood members fastened together with nails or bolts. They are commonly used in residential construction because smaller members can be easily fastened together at the jobsite to form a larger column with adequate capacity.

The nails or bolts used to connect the plys (i.e., the separate members) of a built-up column do not rigidly transfer shear loads; therefore, the bending load capacity of a built-up column is less than a single column of the same species, grade, and cross-sectional area when bending direction is perpendicular to the laminations (i.e., all members bending in their individual weak-axis direction). The coefficient, K_f, accounts for the capacity reduction in bending load in nailed or bolted built-up columns. It applies, however, only to the weak-axis buckling or bending direction of the individual members and therefore should not be used to determine C_p for column buckling in the strong-axis direction of the individual members. (Refer to NDS•15.3 for nailing and bolting requirements for built-up columns.)

The above consideration is not an issue when the built-up column is sufficiently braced in the weak-axis direction (i.e., embedded in a sheathed wall assembly). In this typical condition, the built-up column is actually stronger than a solid sawn member of equivalent size and grade because of the repetitive member