or *mud-sill anchors.* Another type of bolt sometimes used in residential construction is the *structural bolt,* which connects wood to steel or wood to wood. Low-strength ASTM A307 bolts are commonly used in residential construction as opposed to high-strength ASTM A325 bolts, which are more common in commercial applications. Bolt diameters in residential construction generally range from 1/4- to 3/4-inch, although 1/2- to 5/8-inch-diameter bolts are most common, particularly for connecting a 2x wood sill to grouted masonry or concrete.

Bolts, unlike nails, are installed in predrilled holes. If holes are too small, the possibility of splitting the wood member increases during installation of the bolt. If bored too large, the bolt holes encourage nonuniform dowel (bolt) bearing stresses and slippage of the joint when loaded. NDS•8.1 specifies that bolt holes should range from 1/32- to 1/16-inch larger than the bolt diameter to prevent splitting and to ensure reasonably uniform dowel bearing stresses.

7.2.3 Specialty Connection Hardware

Many manufacturers fabricate specialty connection hardware. The load capacity of a specialty connector is usually obtained through testing to determine the required structural design values. The manufacturer's product catalogue typically provides the required values. Thus, the designer can select a standard connector based on the design load determined for a particular joint or connection (see Chapter 3). However, the designer should carefully consider the type of fastener to be used with the connector; sometimes a manufacturer requires or offers proprietary nails, screws, or other devices. It is also recommended that the designer verify the safety factor and strength adjustments used by the manufacturer, including the basis of the design value. In some cases, as with nailed and bolted connections in the NDS, the basis is a serviceability limit state (i.e., slip or deformation) and not ultimate capacity.

A few examples of specialty connection hardware are illustrated in Figure 7.3 and discussed below.

- *Sill anchors* are used in lieu of foundation anchor bolts. Many configurations are available in addition to the one shown in Figure 7.3.
- *Joist hangers* are used to attach single or multiple joists to the side of girders or header joists.
- *Rafter clips* and *roof tie-downs* are straps or brackets that connect roof framing members to wall framing to resist roof uplift loads associated with high-wind conditions.
- *Hold-down brackets* are brackets that are bolted, nailed, or screwed to wall studs or posts and anchored to the construction below (i.e., concrete, masonry, or wood) to "hold down" the end of a member or assembly (i.e., shear wall).
- *Strap ties* are prepunched straps or coils of strapping that are used for a variety of connections to transfer tension loads.
- *Splice plates* or *shear plates* are flat plates with prepunched holes for fasteners to transfer shear or tension forces across a joint.

- *Epoxy-set anchors* are anchor bolts that are drilled and installed with epoxy adhesives into concrete after the concrete has cured and sometimes after the framing is complete so that the required anchor location is obvious.

FIGURE 7.3 Specialty Connector Hardware