- Tables 12.3A and B. Nailed wood-to-wood, single-shear (two-member) connections with the same species of lumber using box or common nails, respectively.
- Tables 12.3E and F. Nailed metal plate-to-wood connections using box or common nails, respectively.

The yield equations in NDS•12.3 may be used for conditions not represented in the design value tables for Z. Regardless of the method used to determine the Z value for a single nail, the value must be adjusted as described in Section 7.3.2. As noted in the NDS, the single nail value is used to determine the design value.

It is also worth mentioning that the NDS provides an equation for determining allowable design value for shear when a nailed connection is loaded in combined withdrawal and shear (see NDS•12.3.8, Equation 12.3-6). The equation appears to be most applicable to a gable-end truss connection to the roof sheathing under conditions of roof sheathing uplift and wall lateral load owing to wind. The designer might contemplate other applications but should take care in considering the combination of loads that would be necessary to create simultaneous uplift and shear worthy of a special calculation.

7.3.4 Bolted Connections

Bolts may be designed in accordance with NDS•8 to resist shear loads in wood-to-wood, wood-to-metal, and wood-to-concrete connections. As mentioned, many specialty "bolt-type" fasteners can be used to connect wood to other materials, particularly concrete and masonry. One common example is an epoxy-set anchor. Manufacturer data should be consulted for connection designs that use proprietary fastening systems.

The design shear value Z for a bolted connection is typically determined by using the following tables from NDS•8:

- Table 8.2A. Bolted wood-to-wood, single-shear (two-member) connections with the same species of lumber.
- Table 8.2B. Bolted metal plate-to-wood, single-shear (two-member) connections; metal plate thickness of 1/4-inch minimum.
- Table 8.2D. Bolted single-shear wood-to-concrete connections; based on minimum 6-inch bolt embedment in minimum f_c = 2,000 psi concrete.

The yield equations of NDS•8.2 (single-shear joints) and NDS•8.3 (double-shear joints) may be used for conditions not represented in the design value tables. Regardless of the method used to determine the Z value for a single bolted connection, the value must be adjusted as described in Section 7.3.2.

It should be noted that the NDS does not provide W values for bolts. The tension value of a bolt connection in wood framing is usually limited by the bearing capacity of the wood as determined by the surface area of a washer used underneath the bolt head or nut. When calculating the bearing capacity of the wood based on the tension in a bolted joint, the designer should use the small bearing area value C_b to adjust the allowable compressive stress perpendicular to grain $F_{c\perp}$ (see NDS•2.3.10). It should also be remembered that the allowable compressive stress of lumber is based on a deformation limit state, not capacity; refer to Section 5.2.3 of Chapter 5. In addition, the designer should verify the tension capacity of the bolt and its connection to other materials (i.e., concrete or masonry as covered in Section 7.4). The bending capacity of the washer should also be considered. For example, a wide but thin washer will not evenly distribute the bearing force to the surrounding wood.

The arrangement of bolts and drilling of holes are extremely important to the performance of a bolted connection. The designer should carefully follow the minimum edge, end, and spacing requirements of NDS•8.5. When necessary, the designer should adjust the design value for the bolts in a connection by using the geometry factor C_ρ and the group action factor C_g discussed in Section 7.3.2.

Any possible torsional load on a bolted connection (or any connection for that manner) should also be considered in accordance with the NDS. In such conditions, the pattern of the fasteners in the connection can become critical to performance in resisting both a direct shear load and the loads created by a torsional moment on the connection. Fortunately, this condition is not often applicable to typical light-frame construction. However, cantilevered members that rely on connections to “anchor” the cantilevered member to other members will experience this effect, and the fasteners closest to the cantilever span will experience greater shear load. One example of this condition sometimes occurs with balcony construction in residential buildings; failure to consider the effect discussed above has been associated with some notable balcony collapses.

For wood members bolted to concrete, the design lateral values are provided in NDS•Table8.2E. The yield equations (or general dowel equations) may also be used to conservatively determine the joint capacity. A recent study has made recommendations regarding reasonable assumptions that must be made in applying the yield equations to bolted wood-to-concrete connections (Stieda, et al., 1999). Using symbols defined in the NDS, the study recommends an R_e value of 5 and an R_t value of 3. These assumptions are reported as being conservative because fastener head effects and joint friction are ignored in the general dowel equations.

7.3.5 Lag Screws

Lag screws (or lag bolts) may be designed to resist shear and withdrawal loads in wood-to-wood and metal-to-wood connections in accordance with NDS•9. As mentioned, many specialty “screw-type” fasteners can be installed in wood. Some tap their own holes and do not require predrilling. Manufacturer data should be consulted for connection designs that use proprietary fastening systems.

The withdrawal strength of a lag screw (inserted into the side grain of lumber) is determined in accordance with either the empirical design equation below or NDS•Table 9.2A. It should be noted that the equation below is based on single lag screw connection tests and is associated with a reduction factor of 0.2 applied to average ultimate withdrawal capacity to adjust for load duration and safety. Also, the penetration length of the lag screw L_p into the main member does