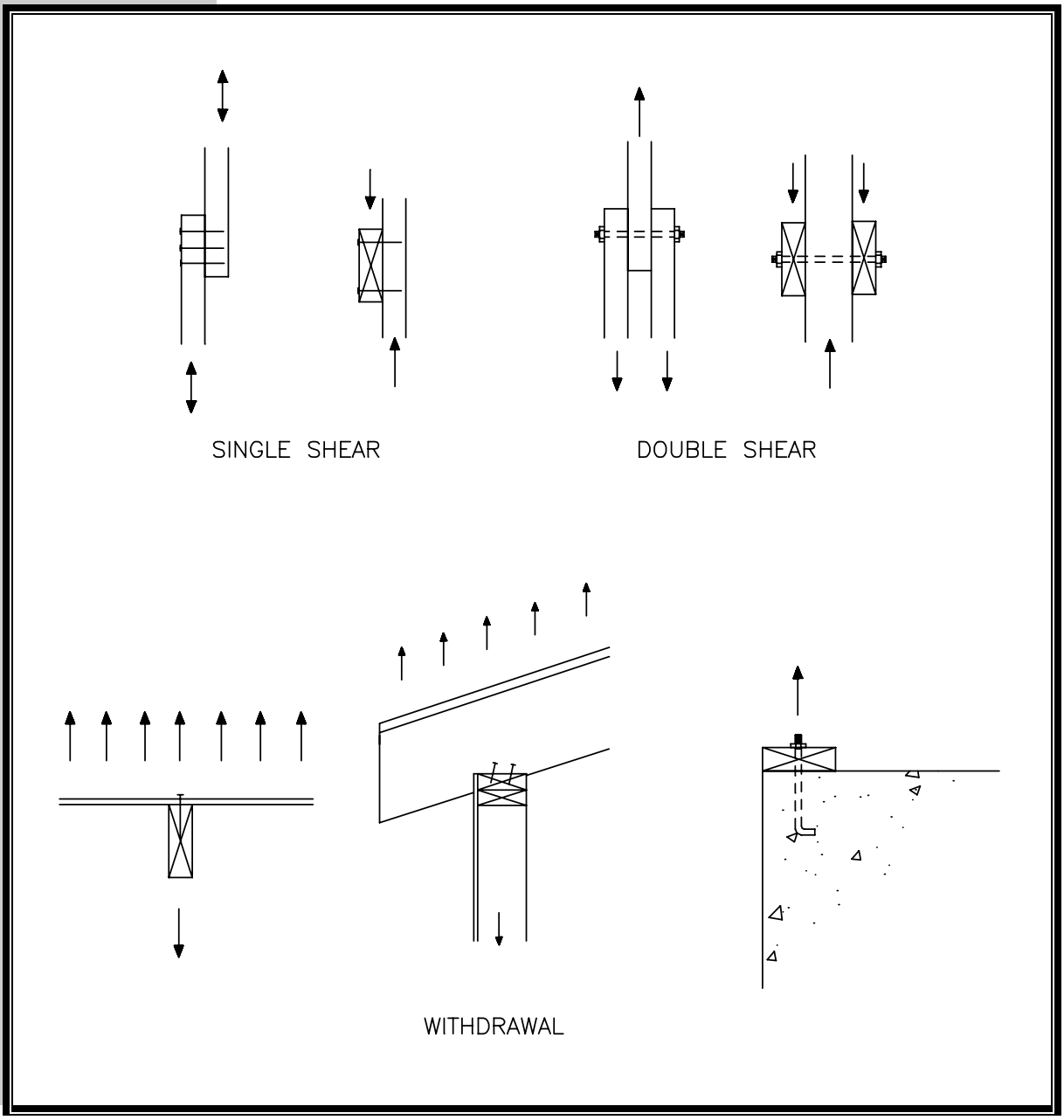
## *FIGURE 7.4 Types of Connections and Loading Conditions*




The NDS provides tabulated connection design values that use the following symbols for the three basic types of loading:

- W–withdrawal (or tension loading);
- $Z_{\perp}$–shear perpendicular to wood grain; and
- $Z_{\parallel}$–shear parallel to wood grain.

In addition to the already tabulated design values for the above structural resistance properties of connections, the NDS provides calculation methods to address conditions that may not be covered by the tables and that give more

flexibility to the design of connections. The methods are appropriate for use in hand calculations or with computer spreadsheets.

For withdrawal, the design equations are relatively simple empirical relationships (based on test data) that explain the effect of fastener size (diameter), penetration into the wood, and density of the wood. For shear, the equations are somewhat more complex because of the multiple failure modes that may result from fastener characteristics, wood density, and size of the wood members. Six shear-yielding modes (and a design equation for each) address various yielding conditions in either the wood members or the fasteners that join the members. The critical yield mode is used to determine the design shear value for the connection. Refer to NDS•Appendix I for a description of the yield modes.

The yield equations in the NDS are based on general dowel equations that use principles of engineering mechanics to predict the shear capacity of a doweled joint. The general dowel equations can be used with joints that have a gap between the members and they can also be used to predict ultimate capacity of a joint made of wood, wood and metal, or wood and concrete. However, the equations do not account for friction between members or the anchoring/cinching effect of the fastener head as the joint deforms and the fastener rotates or develops tensile forces. These effects are important to the ultimate capacity of wood connections in shear and, therefore, the general dowel equations may be considered to be conservative; refer to Section 7.3.6. For additional guidance and background on the use of the general dowel equations, refer to the NDS *Commentary* and other useful design resources available through the American Forest & Paper Association (AF&PA, 1999; Showalter, Line, and Douglas, 1999).

## 7.3.2 Adjusted Allowable Design Values

Design values for wood connections are subject to adjustments in a manner similar to that required for wood members themselves (see Section 5.2.4 of Chapter 5). The calculated or tabulated design values for W and Z are multiplied by the applicable adjustment factors to determine adjusted allowable design values, Z' and W', as shown below for the various connection methods (i.e., nails, bolts, and lag screws).

[NDS•12.3 & 7.3]

$$Z' = ZC_D C_M C_t C_g C_\Delta \quad \text{for bolts}$$

$$Z' = ZC_D C_M C_t C_g C_\Delta C_d C_{eg} \quad \text{for lag screws}$$

$$Z' = ZC_D C_M C_t C_d C_{eg} C_{di} C_{tn} \quad \text{for nails and spikes}$$

[NDS•12.2&7.3]

$$W' = WC_D C_M C_t C_{tn} \quad \text{for nails and spikes}$$

$$W' = WC_D C_M C_t C_{eg} \quad \text{for lag screws}$$