

are cautioned about using programs in a *blackbox* approach. Any program should be adequately documented and sufficient output should be provided so that results can be verified by hand solutions. The emphasis throughout this book is on understanding the design criteria. Modern spreadsheet and computer-aided design software can be effective tools in design. With such an application, the user can tailor the solution to meet a variety of goals.

When determining the strength of a wood beam, it is important to understand the nature of the stresses. Longitudinal stresses are parallel to the length of the member and are parallel to the grain of the wood. This is a common beam design problem, and it is the general subject of this section. See Example 6.1. However, bending stresses across the grain (Fig. 6.1b) are not. The designer needs to recognize this situation. It has been noted that wood is relatively weak in *tension perpendicular to grain*. Whether the cross-grain tension stress is caused by a direct tension load or by loading that causes cross-grain bending, cross-grain bending should generally be avoided.

## 6.1 Bending in Wood Members

### Longitudinal Bending Stresses—Parallel to Grain

The bending stress in a wood beam is parallel to the grain. The free-body diagram in Fig. 6.1a shows a *typical beam* cut at an arbitrary point. The internal forces and moment  $M$  are required for equilibrium. The bending stress diagram shows the stresses developed by the moment are longitudinal stresses, and they are *parallel to grain*. Bending is shown about the strong or  $x$  axis of the beam.

### Cross-Grain Bending—Not Allowed

Fig. 6.1b shows a concrete wall connected to a wood horizontal diaphragm. Lateral force is transferred from the wall through the *wood ledger* by means of an anchor bolt and nailing.

Figure 6.1b indicates that the ledger cantilevers from the anchor bolt to the diaphragm. Figure 6.1c is an FBD showing the internal forces at the anchor bolt and the diaphragm. The bending stresses in the ledger are *across the grain* (as opposed to being parallel to the grain). Wood is very weak in cross-grain bending and tension. This connection is introduced at this point to illustrate a cross-grain bending problem. Reference bending design values for wood design are given in Table 6.1 for bending stresses only.

If failures in some ledger connections of this type, cross-grain bending stresses are not permitted by the IBC for the anchorage of seismic forces. Under existing conditions, designs should generally avoid stressing wood in tension across the grain.

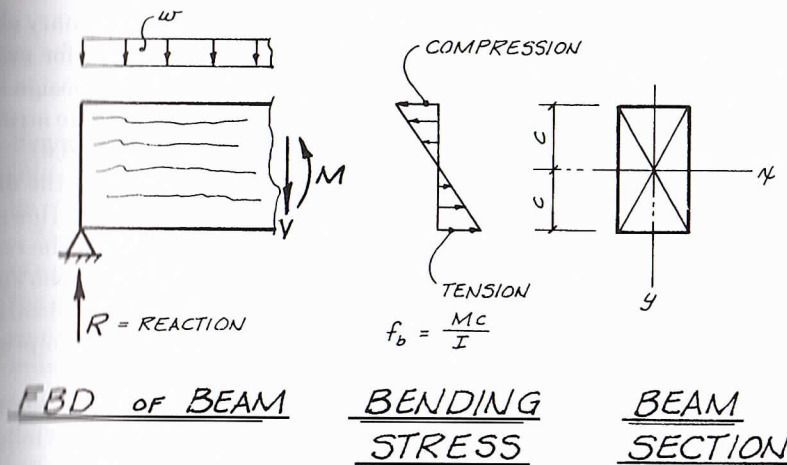


Figure 6.1a Bending stress is parallel to grain in the usual beam design problem.

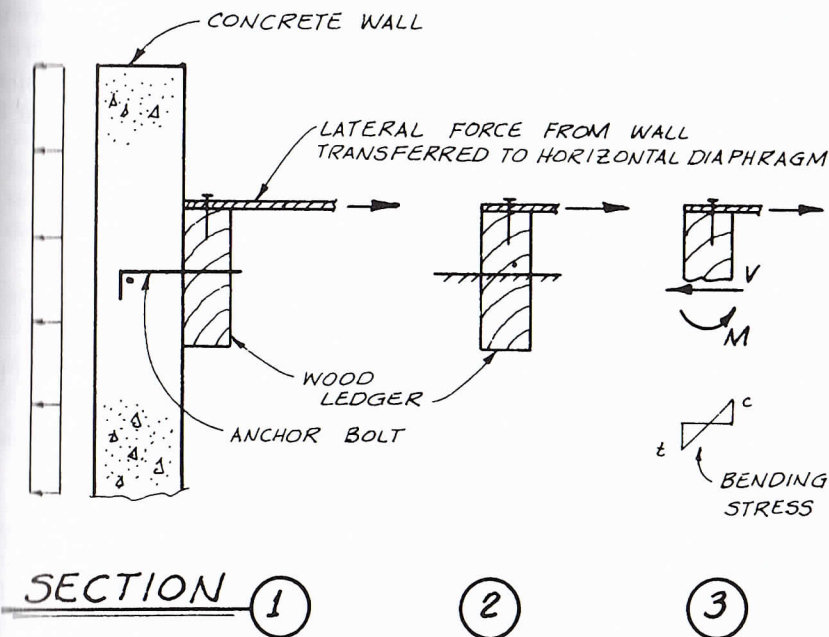


Figure 6.1b Cross-grain bending in a wood member should be avoided.

It should be noted that the use of a wood ledger in a building with concrete or masonry walls is still a common connection. However, additional anchorage hardware is required to prevent the ledger from being stressed across the grain. Anchorage for this type of connection is covered in detail in Chap. 15.