walls tested independently. The results are reasonably consistent with those reported above. Apparently, many whole-building tests have been conducted in Japan, but the associated reports are available only in Japanese (Thurston, 1994).

The growing body of whole-building test data will likely improve the understanding of the actual performance of light-frame structures in seismic events to the extent that the test programs are able to replicate actual conditions. Actual performance must also be inferred from anecdotal experience or, preferably, from experimentally designed studies of buildings experiencing major seismic or wind events (refer to Chapter 1).

6.3 LFRS Design Steps and Terminology

The lateral force resisting system (LFRS) of a home is the “whole house” including practically all structural and non-structural components. To enable a rational and tenable design analysis, however, the complex structural system of a light-frame house is usually subjected to many simplifying assumptions; refer to Chapter 2. The steps required for thoroughly designing a building’s LFRS are outlined below in typical order of consideration:

1. Determine a building’s architectural design, including layout of walls and floors (usually pre-determined).
2. Calculate the lateral loads on the structure resulting from wind and/or seismic conditions (refer to Chapter 3).
3. Distribute shear loads to the LFRS (wall, floor, and roof systems) based on one of the design approaches described later in this chapter (refer to Section 6.4.1).
4. Determine *shear wall* and *diaphragm* assembly requirements for the various LFRS components (sheathing thickness, fastening schedule, etc.) to resist the stresses resulting from the applied lateral forces (refer to Section 6.5).
5. Design the *hold-down restraints* required to resist overturning forces generated by lateral loads applied to the vertical components of the LFRS (i.e., shear walls).
6. Determine interconnection requirements to transfer shear between the LFRS components (i.e., roof, walls, floors, and foundation).
7. Evaluate *chords* and *collectors* (or *drag struts*) for adequate capacity and for situations requiring special detailing such as splices.

It should be noted that, depending on the method of distributing shear loads (refer to Section 6.4.1), Step 3 may be considered a preliminary design step. If, in fact, loads are distributed according to stiffness in Step 3, then the LFRS must already be defined; therefore, the above sequence can become iterative between Steps 3 and 4. A designer need not feel compelled to go to such a level of complexity (i.e., using a stiffness-based force distribution) in designing a simple home, but the decision becomes less intuitive with increasing plan complexity.

The above list of design steps introduced several terms that are defined below.

Horizontal diaphragms are assemblies such as the roof and floors that act as “deep beams” by collecting and transferring lateral forces to the *shear walls*, which are the vertical components of the LFRS. The diaphragm is analogous to a horizontal, simply supported beam laid flatwise; a shear wall is analogous to a vertical, fixed-end, cantilevered beam. Chapter 2 discussed the function of the LFRS and the lateral load path. The reader is referred to that chapter for a conceptual overview of the LFRS and to Chapter 3 for methodologies to calculate lateral loads resulting from wind and earthquake forces.

Chords are the members (or a system of members) that form a “flange” to resist the tension and compression forces generated by the “beam” action of a diaphragm or shear wall. As shown in Figure 6.1, the chord members in shear walls and diaphragms are different members, but they serve the same purpose in the beam analogy. A *collector* or *drag strut*, which is usually a system of members in light-frame buildings, “collects” and transfers loads by tension or compression to the shear resisting segments of a wall line (see Figure 6.2a).

In typical light-frame homes, special design of chord members for floor diaphragms may involve some modest detailing of splices at the diaphragm boundary (i.e., joints in the band joists). If adequate connection is made between the band joist and the wall top plate, then the diaphragm sheathing, band joists, and wall framing function as a “composite” chord in resisting the chord forces. Thus, the diaphragm chord is usually integral with the collectors or drag struts in shear walls. Given that the collectors on shear walls often perform a dual role as a chord on a floor or roof diaphragm boundary, the designer needs only to verify that the two systems are reasonably interconnected along their boundary, thus ensuring composite action as well as direct shear transfer (i.e., slip resistance) from the diaphragm to the wall. As shown in Figure 6.2b, the failure plane of a typical “composite” collector or diaphragm chord can involve many members and their interconnections.

For shear walls in typical light-frame buildings, tension and compression forces on shear wall chords are usually considered. In particular, the connection of hold-downs to shear wall chords should be carefully evaluated with respect to the transfer of tension forces to the structure below. Tension forces result from the overturning action (i.e., overturning moment) caused by the lateral shear load on the shear wall. In some cases, the chord may be required to be a thicker member to allow for an adequate hold-down connection or to withstand the tension and compression forces presumed by the beam analogy. Fortunately, most chords in light-frame shear walls are located at the ends of walls or adjacent to openings where multiple studs are already required for reasons of constructability and gravity load resistance (see cross-section "B" in Figure 6.1).