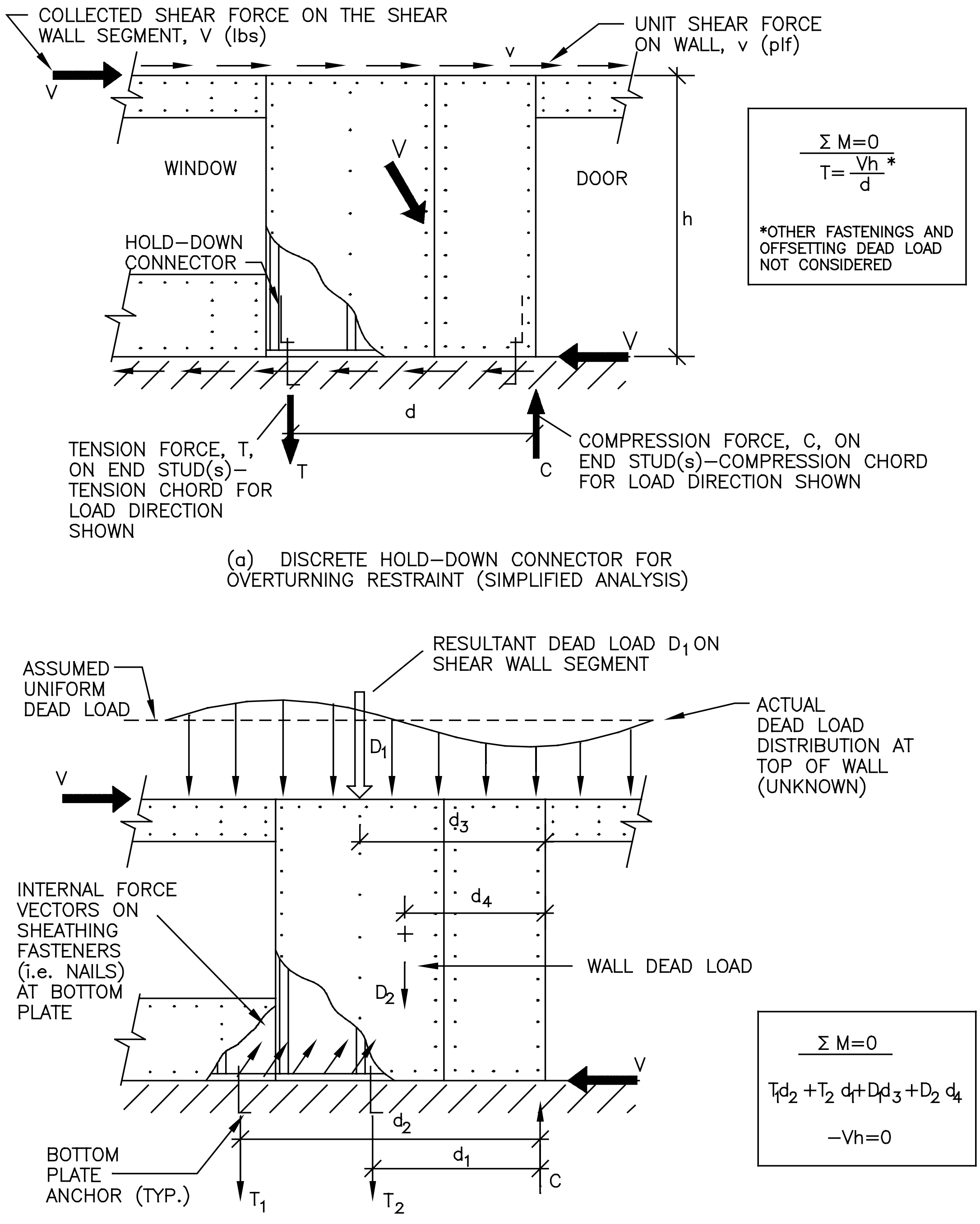
Hold-down restraints are devices used to restrain the whole building and individual shear wall segments from the overturning that results from the leveraging (i.e., overturning moment) created by lateral forces. The current engineering approach calls for restraints that are typically metal connectors (i.e., straps or brackets) that attach to and anchor the chords (i.e., end studs) of shear wall segments (see Figure 6.3a). In many typical residential applications, however, overturning forces may be resisted by the dead load and the contribution of many component connections (see Figure 6.3b). Unfortunately (but in reality), this consideration may require a more intensive analytic effort and greater degree of designer presumption because overturning forces may disperse through many “load paths” in a nonlinear fashion. Consequently, the analysis of overturning becomes much more complicated; the designer cannot simply assume a single load path through a single hold-down connector. Indeed, analytic knowledge of overturning has not matured sufficiently to offer an exact performance-based solution, even though experience suggests that the resistance provided by conventional framing has proven adequate to prevent collapse in all but the most extreme conditions or mis-applications (see Chapter 1 and Section 6.2).

Framing and fastenings at wall corner regions are a major factor in explaining the actual behavior of conventionally built homes, yet there is no currently recognized way to account for this effect from a performance-based design perspective. Several studies have investigated corner framing effects in restraining shear walls without the use of hold-down brackets. In one such study, cyclic and monotonic tests of typical 12-foot-long wood-framed shear walls with 2- and 4-foot corner returns have demonstrated that overturning forces can be resisted by reasonably detailed corners (i.e., sheathing fastened to a common corner stud), with the reduction in shear capacity only about 10 percent from that realized in tests of walls with hold-downs instead of corner returns (Dolan and Heine, 1997c). The corner framing approach can also improve ductility (Dolan and Heine, 1997c) and is confirmed by testing in other countries (Thurston, 1994). In fact, shear wall test methods in New Zealand use a simple three-nail connection to provide hold-down restraint (roughly equivalent to three 16d common nails in a single shear wood-to-wood connection with approximately a 1,200- to 1,500-pound ultimate capacity). The three-nail connection resulted from an evaluation of the restraining effect of corners and the selection of a minimum value from typical construction. The findings of the tests reported above do not consider the beneficial contribution of the dead load in helping to restrain a corner from uplift as a result of overturning action.

The discussion to this point has given some focus to conventional residential construction practices for wall bracing that have worked effectively in typical design conditions. This observation is a point of contention, however, because conventional construction lacks the succinct loads paths that may be assumed when following an accepted engineering method. Therefore, conventional residential construction does not lend itself readily to current engineering conventions of analyzing a lateral force resisting system in light-frame construction. As a result, it is difficult to define appropriate limitations to the use of conventional construction practices based purely on existing conventions of engineering analysis.

FIGURE 6.3 ***Two Types of Hold-Down Restraint and Basic Analytic Concepts***



(a) DISCRETE HOLD–DOWN CONNECTOR FOR OVERTURNING RESTRAINT (SIMPLIFIED ANALYSIS)

(b) SYSTEM OF FASTENINGS AND DEAD LOAD FOR OVERTURNING RESTRAINT AND SHEAR TRANSFER (COMPLEX ANALYSIS)