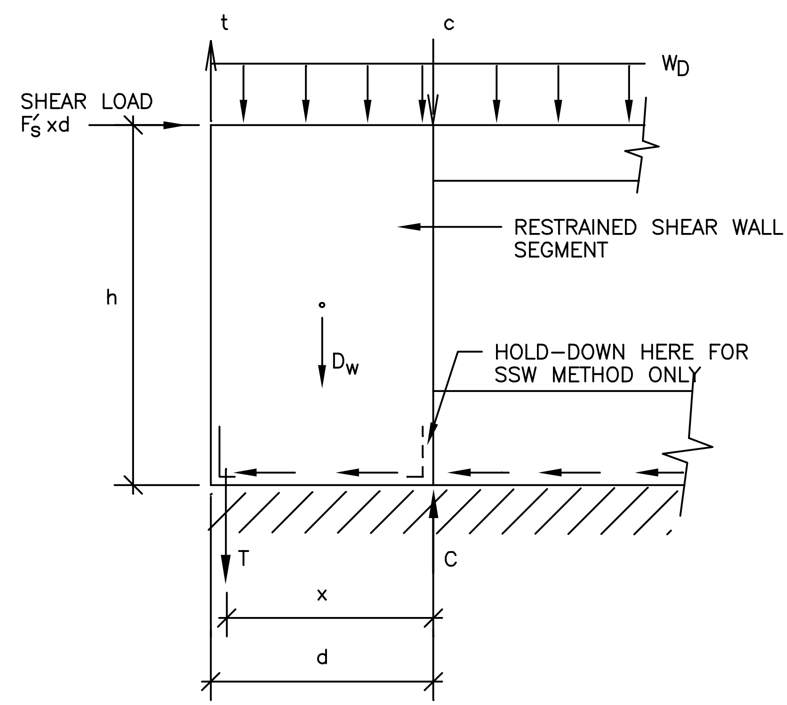
through deep bending action of the wall to have a full effect on the uplift forces occurring at the end of the segment, particularly when it is rigidly restrained from uplifting. This effect also depends on the stiffness of the construction above the wall that "delivers" and distributes the load at the top of the wall. The assumptions necessary to include the restraining effects of dead load is no trivial matter and, for that reason, it is common practice to not include any beneficial effect of dead load in the overturning force analysis of individual shear wall segments.

FIGURE 6.6 ***Evaluation of Overturning Forces on a Restrained Shear Wall Segment***



For a more simplified analysis of overturning forces, the effect of dead load may be neglected and the chord forces determined as follows using the symbols defined as before:

$$T = C = \left(\frac{d}{x}\right) F'_s\, h \qquad \text{Eq. 6.5-7c}$$

Any tension or compression force transferred from shear wall overturning forces originating above the wall under consideration must be added to the result of Equation 6.5-7c as appropriate. It is also assumed that any net wind uplift force is resisted by a separate load path (i.e., wind uplift straps are used in addition to overturning or hold-down devices).

For walls not rigidly restrained, the initiation of overturning uplift at the end stud (i.e., chord) shifts an increasing amount of the dead load supported by the wall toward the leading edge. Thus, walls restrained with more flexible hold-down devices or without such devices benefit from increased amounts of offsetting dead load as well as from the ability of wood framing and connections to disperse some of the forces that concentrate in the region of a rigid hold-down device. However, if the bottom plate is rigidly anchored, flexibility in the hold-down device can impose undesirable cross-grain bending forces on the plate due to uplift forces transferred through the sheathing fasteners to the edge of the bottom plate. Further, the sheathing nails in the region of the bottom plate anchor experience greater load and may initiate failure of the wall through an “unzipping” effect.

The proper detailing to balance localized stiffness effects for more even force transfer is obviously a matter of designer judgment. It is mentioned here to emphasize the importance of detailing in wood-framed construction. In particular, wood framing has the innate ability to distribute loads, although weaknesses can develop from seemingly insignificant details. The concern noted above has been attributed to actual problems (i.e., bottom plate splitting) only in severe seismic events and in relatively heavily loaded shear walls. For this reason, it is now common to require larger washers on bottom plate anchor bolts, such as a 2- to 3-inch-square by 1/4-inch-thick plate washer, to prevent the development of cross-grain tension forces in bottom plates in high-hazard seismic regions. The development of high cross-grain tension stresses poses less concern when nails are used to fasten the bottom plate and are located in pairs or staggered on both sides of the wood plate. Thus, the two connection options above represent different approaches. The first, using the plate washers, maintains a rigid connection throughout the wall to prevent cross grain tension in the bottom plate. The second, using nails, is a more “flexible” connection that prevents concentrated cross-grain bending forces from developing. With sufficient capacity provided, the nailing approach may yield a more “ductile” system. Unfortunately, these intricate detailing issues are not accommodated in the single seismic response modifier used for wood-framed shear walls or the provisions of any existing code. These aspects of design are not easily “quantified” and are considered matters of qualitative engineering judgment.

Finally, it is important to recognize that the hold-down must be attached to a vertical wall framing member (i.e., a stud) that receives the wood structural panel edge nailing. If not, the hold-down will not be fully effective (i.e., the overturning forces must be “delivered” to the hold-down through the sheathing panel edge nailing). In addition, the method of deriving hold-down capacity ratings may vary from bracket to bracket and manufacturer to manufacturer. For some brackets, the rated capacity may be based on tests of the bracket itself that do not represent its use in an assembly (i.e., as attached to a wood member). Many hold-down brackets transfer tension through an eccentric load path that creates an end moment on the vertical framing member to which it is attached. Therefore, there may be several design considerations in specifying an appropriate hold-down device that go beyond simply selecting a device with a sufficient rated capacity from manufacturer literature. In response to these issues, some local codes may require certain reductions to or verification of rated hold-down capacities.