Expert Tips

Accommodating Shrinkage in Multi-Story Wood-Frame Projects

Techniques for minimizing and addressing shrinkage in light wood-frame projects.

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Photo: Pollack Shores, Matrix Residential

Wood is hygroscopic, meaning it has the ability to absorb and release moisture. As this occurs, it also has the potential to change dimensionally. Knowing how and where wood shrinks and swells helps designers detail their buildings to minimize related effects.

Wood shrinkage occurs perpendicular to grain, meaning that a solid sawn wood stud or floor joist will shrink in its cross-section dimensions (width and depth). Longitudinal shrinkage is negligible, meaning the length of a stud or floor joist will essentially remain unchanged. In multi-story buildings, wood shrinkage is therefore concentrated at wall plates, floor and roof joists, and rim boards. Depending on the materials and details used at floor-to-wall and roof-to-wall intersections, shrinkage in light-frame wood construction can range from 0.05 inches to 0.5 inches per level.

Minimizing Shrinkage

In wood-frame construction, the three variables influencing the magnitude of shrinkage are:

1. Installed moisture content (MC)
2. In-service MC or equilibrium moisture content (EMC)
3. Cumulative thickness of cross-grain wood elements

Initial MC, or MC at the time of manufacture, is typically specified on a project's structural drawings and indicated on the lumber grading stamp. In many parts of the country, the specification would read "a maximum MC of 19 percent." In order to achieve this, lumber is generally kiln dried or surface-dried. Although there are regional variations, less commonly used green lumber (S-GRN, which typically hasn't been kiln dried and has a MC above 19 percent), surface dried lumber or KD-15 (i.e., kiln dried lumber with a maximum MC of 15 percent at time of manufacture) may also be specified. Engineered wood products, including wood structural panels such as plywood and oriented strand board (OSB), glued-laminated timber (glulam) and structural composite lumber (SCL), are manufactured with lower moisture contents, in the range of 2-15 percent. Engineered wood manufacturers generally provide initial moisture contents for their products.

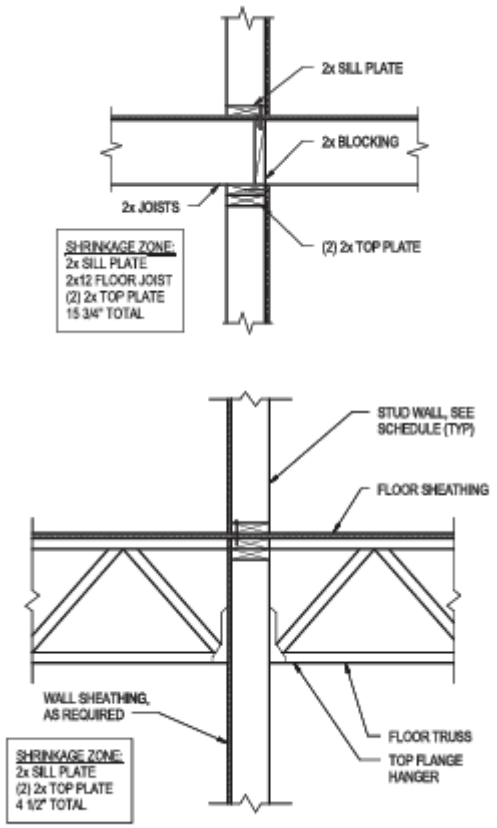
Of the significant variables affecting shrinkage, EMC is the only one largely out of the designer's control. It is heavily influenced by the building's conditioning, including temperature, relative humidity and local climatic conditions. However, a project's design and construction team can influence the two remaining variables—installed moisture content and combined thickness of the wood in cross-grain orientation.

While the initial MC of wood can be specified by the design team, it is subject to change before, during and after construction. The amount of change depends to a large degree on the protective measures taken by the contractor. To minimize moisture accumulation on site:

1. Avoid storing material where it is exposed to rain or standing water.
2. Keep unused framing materials covered.
3. Inspect building enclosure layers such as weather-resistive barriers for proper installation.
4. "Dry-in" the structure as quickly as possible.
5. Immediately remove any standing water from floor framing after rain showers.

Because wood members contribute to shrinkage cross-grain, reducing the total thickness of cross-grain wood members in the vertical load path is one way to minimize shrinkage and its effects. Traditionally, wood-frame construction has been platform-frame, where floor framing and rim or band joists bear on the top plates of supporting walls. However, switching to a semi-balloon-frame system, where only the floor sheathing bears on the lower walls and floor joists are hung from the walls, can significantly reduce per-floor and cumulative building shrinkage.

The figure below illustrates the difference. The upper platform detail has a shrinkage zone of 15.75 inches per floor, resulting in shrinkage per floor of 0.28 inches, or approximately 1.4 inches for a five-story building. The lower semi-balloon frame detail has a shrinkage zone of 4.5 inches per floor, resulting in shrinkage per floor of 0.08 inches, or approximately 0.4 inches for a five-story building. These values are based on an initial MC of 19 percent and an EMC of 12 percent.



Accommodating Shrinkage

Once shrinkage has been minimized, accommodation of the residual amounts should take place. Shrinkage accommodation typically involves consideration of how wood interacts with other building materials and building components. Other materials may exhibit significantly different shrinkage and swelling characteristics. For instance, some materials:

1. Expand due to moisture or thermal changes (brick veneer)
2. Do not shrink due to moisture change but may move with thermal changes (steel framing, and steel/cast iron/PVC piping)
3. Shrink much less (concrete masonry and cementitious veneers)

With this potential of differential movement in mind, accommodation of shrinkage includes looking at a number of areas of a multi-story building. A few examples include window sill, header and jamb flashing/sealing details, veneer transition flashing details, wood framing-to-masonry shaft wall connections, integration of mechanical/electrical/plumbing (MEP) systems in wood-frame walls, and structural connection systems such as uplift restraint.

For examples of details that can be used to accommodate this differential movement, as well as additional discussion on calculation of shrinkage in wood structures, see the WoodWorks publication: *Accommodating Shrinkage in Multi-Story Wood-Frame Structures.*