Expert Tips

Beam, Column, and Beam-Column Stability Considerations

Explores bracing parameters for compression and bending members in mass timber and light-frame wood structures

The American Wood Council's National Design Specification® (NDS®) for Wood Construction requires that the design of compression members and bending members use a series of adjustment factors to determine the allowable design stress. In many cases, those adjustment factors can be taken as 1.0; however, the column stability factor, C_p, for compression members (NDS 3.7.1) and the beam stability factor, C_L, for bending members (NDS 3.3.3) are dependent on the effective length of the member (unbraced length) and require careful attention to the bracing conditions. Whether it be sheathing, blocking, diagonal members, or other means, setting the bracing parameters has a significant impact on the design of wood structures. However, questions can arise when it comes to the required force that bracing elements need to resist. This article shares specific considerations to help address common questions related to NDS language around bracing.

For wood stud walls with sheathing on one side, NDS commentary C3.6.7 says, in part, "*Experience has shown that wood structural panels, fiberboard, hardboard, gypsum board, or other sheathing materials provide adequate lateral support of the stud across the thickness when properly fastened."* It does not specify a maximum stud depth, sheathing thickness, or explicitly note fastener spacings. Since stud walls typically have combined loading conditions (bending + axial), designers may look to NDS section 4.4.1.3 to rationalize a maximum stud size where sheathing is applied to only one side:

NDS Section 4.4.1.3*: If a bending member is subject to both flexure and axial compression, the depth-to -breadth ratio shall be no more than 5 to 1 if one edge is firmly held in line. If, under all combinations of load, the unbraced edge of the member is in tension, the depth-to-breadth ratio shall be no more than 6 to 1.*

For a typical 2x stud, the 5 to 1 depth to breadth ratio would limit the actual stud depth to 7-1/2” (maximum) or a 2×8 (1-1/2” x 7-1/4” actual). So, in most cases for stud wall construction, the members will be adequately braced in the weak direction if sheathing is installed on one side. However, designers and engineers should use their judgment on a project-by-project basis and decide if supplemental blocking/bracing is warranted. Find additional commentary and insight on this topic in WoodWorks’ Expert Tip, *Requirements for Blocking/Bracing in Light-Frame Walls.*

For bending members, multiple design checks may need to be performed depending on the various load combinations. For example, a solid sawn roof joist with sheathing attached to the top side of the joist may be considered braced for positive bending (i.e., CL = 1.0). However, for negative bending—wind uplift, for example—that member would not be braced for lateral-torsional buckling (LTB), and the appropriate effective length shall be calculated from Table 3.3.3 and used to derive a CL factor (NDS Equation 3.3-6). Additional complexity may be added if that framing member is used as a collector and subject to compression loads. It is also important to note that for multi-ply members, the beam stability factor, CL, should be calculated using only 1-ply. This guidance stems from testing performed by the US Forest Products Laboratory (FPL) that found the behavior of built-up members is better aligned with multiple individual members than one solid member. This is a conservative approach but allows a simplified analysis versus attempting to model partial composite action between the plys.

For the conditions noted above, common practice to add supplemental beam bracing may be diagonal bridging or solid blocking. However, with the increasing complexity of wood structures, designers are contending with things like longer spans, multi-span conditions, and highly loaded transfer conditions. For this, a designer may seek out the actual bracing force and how that force gets transmitted into the structural system. Unfortunately, there is no formal guidance or information within the NDS or the International Building Code (IBC) on calculating the magnitude of this bracing force. NDS commentary section C4.4.1.3 says, in part, “The bracing member should have sufficient capacity to carry the additional compression load produced by the beam-column as it tends to buckle.” So, how can one evaluate the capacity of a bracing element without knowing the force it is expected to withstand?

Since there is no formal guidance on design bracing forces, it may be appropriate in some cases to leverage Appendix 6 of the AISC Specification, *Stability Bracing for Columns and Beams.* Appendix 6 provides a required bracing force as a function of axial loads for columns, moment for beams, and provides guidance for beam-column applications. While this is not a codified approach to wood structures, it could be a rational approach to design bracing members.

For multi-span beams, Table 3.3.3 in the NDS does not provide an equation to calculate an effective length. However, AWC Technical Report 14 (TR14) provides commentary on this condition and how to handle it. TR14 discusses the derivation of beam stability factors and equations for lateral torsional buckling. This goes through design examples using a Cb or equivalent moment factor (similar to structural steel design) which is a function of the moments in the beam at various locations.

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