WOOD I-JOIST MANUFACTURERS ASSOCIATION

Dropped Header Design Guide

Consideration of the stability of deep beams is important to ensure proper product application. Typically, designers assume that perpendicularly framed roof or floor systems provide bracing to prevent beam buckling. However, in many parts of the country, framing practices call for "dropping" a header below the roof or floor framing and then building a short wall between the header and top plate. **Figure 1** shows a typical example of this practice – a garage door header. If beam buckling is not considered in the design of a "dropped" header, a performance problem can occur.

Review of "dropped" header applications has been conducted under uniform load, single span conditions. Based on this evaluation, the following recommendations have been developed for engineered lumber products.

In addition, provisions in this guide are based on downward uniform vertical loads only and do not account for additional effects due to lateral loads; such as, wind or seismic. The building designer is responsible for accounting for any design effects due to lateral loads.

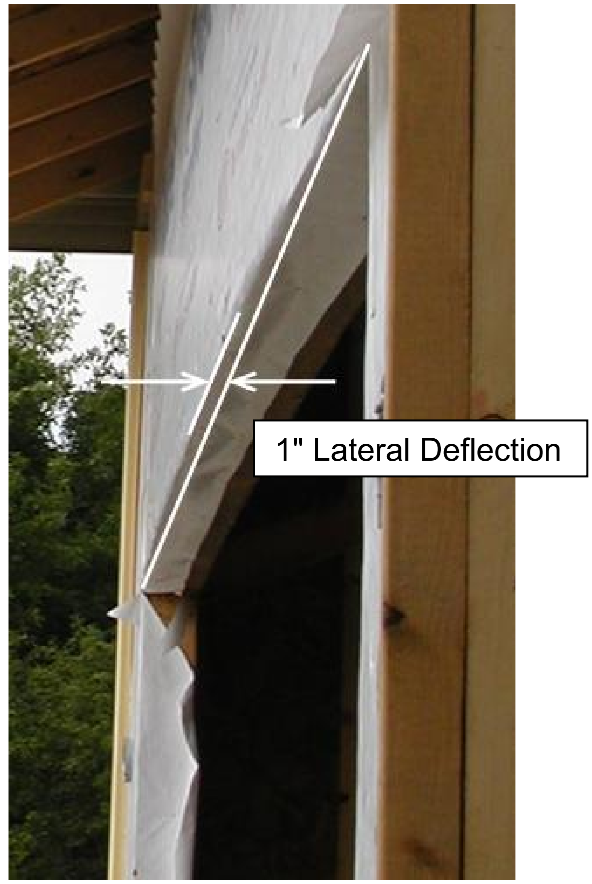

Figure 1: 2 ply 1 ¾ in. x 16 in. Buckled Garage Door Header

Fully-Braced Dropped Header Applications

Under some "dropped" conditions, a header may be assumed to be "fully-braced" and a design reduction does not need to be applied to account for buckling. These conditions are illustrated in **Figure 2**. For example, light duty headers (usually ≤ 12 in. deep), such as those over windows and sliding glass doors, may be considered fully-braced when the height of the wall above is 4 ft.-0 in. or less. The designer may also assume that deeper sections are fully-braced if designed within the constraints outlined in **Figure 2**.

Other Dropped Header Applications

Dropped headers with multiple spans, non-uniform loading, or with dimensions not addressed by **Figure 2** may also be specified by the designer. However, beam stability must be considered in their design. A design example has been provided to illustrate a beam stability calculation in accordance with the *2005 National Design Specification for Wood Construction*. A designer also has the option of detailing the header in a manner that provides the required lateral support to prevent beam buckling. **Figure 3** illustrates a single span condition where lateral support has been provided by raising the primary structural header to the level of the perpendicular framing.

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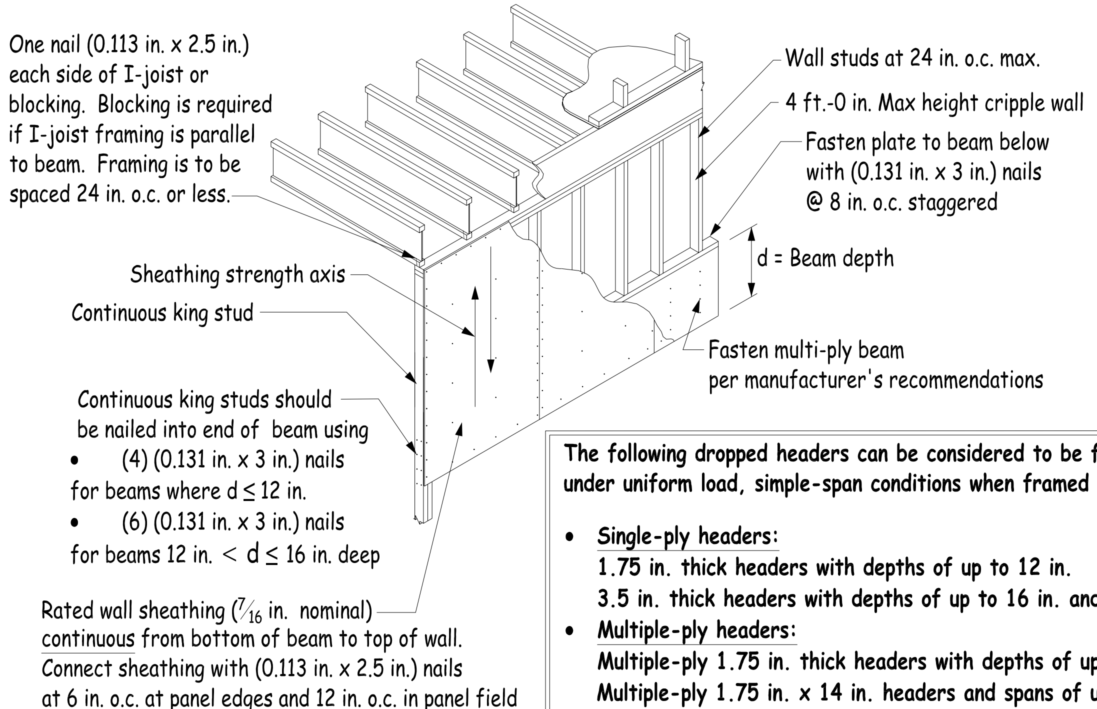

The following dropped headers can be considered to be fully-braced under uniform load, simple-span conditions when framed as shown above:

- **Single-ply headers:**
  1.75 in. thick headers with depths of up to 12 in.
  3.5 in. thick headers with depths of up to 16 in. and spans up to 18 ft.-6 in.
- **Multiple-ply headers:**
  Multiple-ply 1.75 in. thick headers with depths of up to 12 in.
  Multiple-ply 1.75 in. x 14 in. headers and spans of up to 8 ft.-6 in.

Figure 2: Dropped Header Applications That May Be Considered Fully-Braced

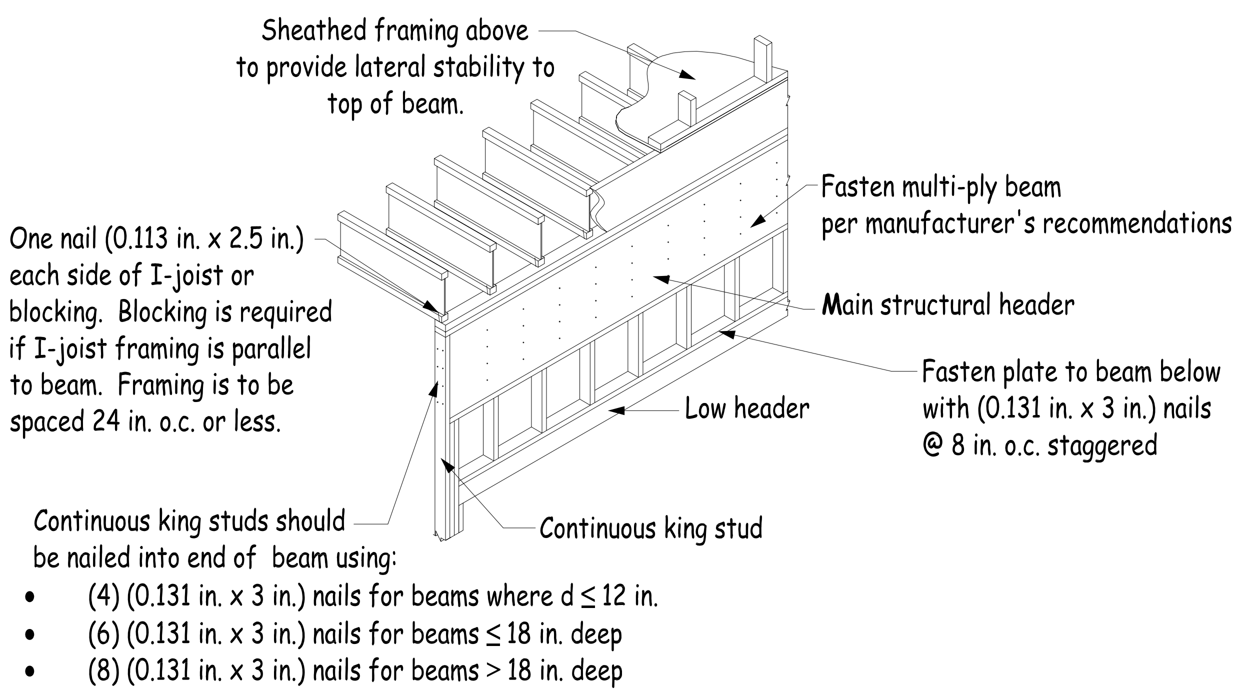

Figure 3: Fully-Braced Alternative to Dropped Header Applications

2005 NDS Calculation Example for Dropped Header Applications

Given:

- 1 ply 3½ in. x 18 in. x 18 ft.-6 in. laminated veneer lumber (LVL) garage door header with a 4 ft. - 0 in. cripple wall on top
- uniformly loaded, single span
- dry use conditions with a moisture content less than 16%
- live load conditions (C_D = 1.0)
- published bending modulus of elasticity, E, of 1,900,000 psi
- published design bending stress, F_b, of 2,500 psi at a 12 in. reference depth
- published volume adjustment, C_V, of 0.946 to adjust from a 12 in. reference depth to an 18 in. design depth.

Note: Values for E, F_b, and C_v depend on the beam type and manufacturer. Values given here are for example purposes only.

Find:

- The maximum allowable uniform load based upon lateral-torsional buckling constraints per the *2005 National Design Specification for Wood Construction*

Variables:

b = beam width (in.)

d = beam depth (in.)

l_u = laterally unsupported span length of bending member (in.)

l_e = effective span length of bending member (in.) (2005 NDS; Table 3.3.3)

R_B = slenderness ratio of bending member

E'_{min} = adjusted modulus of elasticity for beam stability (2005 NDS, Appendix D, Equation D-4)

F_{bE} = Euler-based critical buckling design value for bending members (psi)

F_b^* = reference bending stress multiplied by all applicable adjustment factors (psi)

C_L = NDS beam stability factor

COV_E = assumed coefficient of variation for modulus of elasticity

Calculations:

Since this 3½" wide single-ply header exceeds the 16 in. depth outlined in **Figure 2**, it cannot be assumed to be fully-braced. The NDS analysis, based on an unbraced length equal to the header clear span, would proceed as follows:

b = 3.5 in.

d = 18 in.

l_u = 18 ft.-6 in. = 222 in.

l_u / d = 222 in./18 in. = 12.3

$l_e = 1.63\ L_u + 3d$ = 1.63(222 in.) + 3(18 in.) = 415.9 in. (L_u/ d > 7, single span/uniform load)

$$R_B = \text{slenderness ratio} = \sqrt{\frac{\ell_e d}{b^2}} = \sqrt{\frac{415.9\text{in.} \times 18\text{in.}}{(3.5\text{in.})^2}} = 24.72$$

COV_E = 11%

$E'_{min} = E[1 - 1.645COV_E](1.03)/1.66 = 1.9(10^6\text{ psi})[1 - 1.645(0.11)](1.03)/1.66$ = 965,600 psi

$$F_{bE} = \frac{1.20E'_{min}}{R_B^{\ 2}} = 1{,}896\text{ psi}$$

$F_b^* = F_b(C_D)$ = 2,500 x 1.0 = 2,500 psi (See Note 3 below)

F_{bE}/F_b^* = 1,896 psi / 2,500 psi = 0.76

$$C_L = \frac{1+\left[F_{bE}/F_b^*\right]}{1.9} - \sqrt{\left[\frac{1+\left(F_{bE}/F_b^*\right)}{1.9}\right]^2 - \frac{\left[F_{bE}/F_b^*\right]}{0.95}} = \frac{1+0.76}{1.9} - \sqrt{\left[\frac{1+(0.76)}{1.9}\right]^2 - \frac{0.76}{0.95}} = 0.68$$

$F_b' = F_b \times C_L$= 2,500 psi x 0.68 = 1,711 psi (See Note 3 below)

$M_{max} = F'_b \times S$ = 1,711 x (3.50 in. x (18 in.)^2 / 6) = 323,341 in.-lb.

Maximum uniform load = <u>630 lbs/ft</u>.

<u>Notes:</u>

1. Because this beam falls outside the provisions of **Figure 2**, it must be designed for lateral stability per the 2005 NDS and the un-braced beam length is taken as the beam clear span. Based on the assumption that the short wall above the header does not provide lateral bracing to the header, the moment capacity is reduced by 32% when compared to the moment capacity of a fully-braced header.

(Additional Notes Continued on Next Page)

2. This header could alternatively be considered as fully-braced if detailed as illustrated in **Figure 3**. It should be noted that if C_L were to be calculated per the 2005 NDS for many conditions that meet the constraints of **Figure 2**, the resulting C_L adjustment would be less than one. However, the "fully-braced" provisions in **Figure 2** of this guide consider the bracing contributions from additional framing elements such as wall sheathing, wall plates, and king stud connections that are neglected in a traditional NDS C_L calculation.

3. For this example, the volume factor, C_V, used to adjust to an 18 in. design depth from a 12 in. reference depth is 0.946 (review manufacturers' literature for applicable C_V calculation). Per Section 8.3.6 of the 2005 NDS, F_b^* is not modified by C_V since $C_v \leq 1.0$. For clarification on the proper application of C_V, see http://www.awc.org/wood-design/2006/09/application-of-volume-factor-cv-for.html. In addition, since C_L is less than C_V, only C_L is used to modify the allowable design bending stress, F_b'.

4. The preceding example addresses bending stress and beam stability. A complete beam design needs to consider other factors including alternative load combinations, horizontal shear, bearing stress, deflections, etc.