Technical Q & A

Minimum Required Bearing

Confusion about required bearing width is addressed.

by Jim Vogt, P.E.

Metal plate connected wood trusses are often used in applications where they bear directly on top of a structural wood support such as a beam or lumber top plate. One of the many design parameters evaluated by the Truss Designer is whether or not the truss has adequate bearing at each support. Using the maximum reaction force for the assumed loading conditions and the allowable compression value for the species and grade of the lumber used in the truss, the required bearing width for each bearing location is calculated and compared with the assumed width provided in the Construction Documents for the project.[1] The required bearing width must be less than or equal to the assumed bearing width, or the truss design software will warn that the truss design is insufficient.

Based on questions received from architects, engineers, building code officials, contractors and even some truss technicians, it is apparent that some confusion exists as to what this bearing width actually represents. This article will review the analysis used to determine required bearing width and provides a reference table for evaluating the bearing strength of select species of lumber typically used for plate material in walls.

Question

How is the bearing width on the Truss Design Drawing determined and does it account for the material used to support the truss?

Answer

The bearing widths included on the Truss Design Drawing are evaluated using the properties of the lumber in the truss, not the material used to support the truss. This is because the Truss Designer has control over the species and grade of lumber to be used in the truss, but not for the support. The minimum required bearing width is calculated by dividing the maximum reaction force at the bearing by the adjusted compression stress of the lumber. For trusses designed to bear on the narrow or wide face of the truss chord, compression perpendicular to grain ($F_{c\perp}$) is used.

$F_{c\perp}$ varies by species and, in a few instances, the grade of lumber. Tabulated values for $F_{c\perp}$ are provided in the Supplement to the National Design Specification® (NDS®) for Wood Construction titled, "Design Values for Wood Construction," published by the American Forest & Paper Association. The value of $F_{c\perp}$ used to evaluate bearing width is derived by multiplying the tabulated value by applicable adjustment factors[2] including Wet Service (C_M), Temperature (C_t), Incising (C_i), and Bearing Area (C_b).

C_M accounts for the reduction in compression perpendicular to grain strength that wood experiences when subjected to elevated moisture contents. A factor of 0.67 is applied for "wet service" conditions in which the moisture content of the lumber is assumed to exceed 19 percent for extended periods of time and a factor of 1.0 is applied for "dry service" conditions where the moisture content is assumed to remain below 19 percent. C_M is taken as 1.0 for typical residential and light commercial applications.

C_t adjusts the strength properties of the wood based on in-service moisture conditions and elevated temperatures. C_t is taken as 1.0 for typical residential and light commercial applications.

C_i accounts for the strength reducing effects caused by incising. Incising is a process used to help increase the retention and penetration of preservative treatments in certain species of wood and consists of punching small incisions or slits in the surface of the wood prior to treating. Incising has not been shown to have an adverse effect on $F_{c\perp}$, and is taken as 1.0.

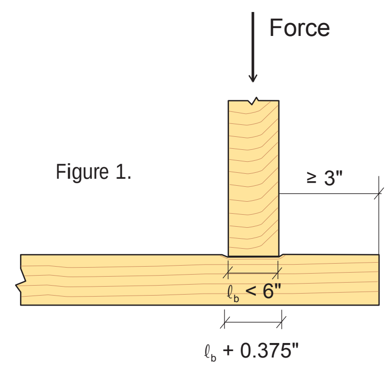

Figure 1.

C_b is an adjustment used to account for the additional wood fibers that resist the applied load after the member becomes slightly indented (See Figure 1). C_b is calculated using the following equation and is applicable only to bearings less than six inches in length and at least three inches from the end of the member.

$$C_b = \frac{l_b + 0.375}{l_b}$$

Where: l_b is the bearing length (in.) measured parallel to grain.

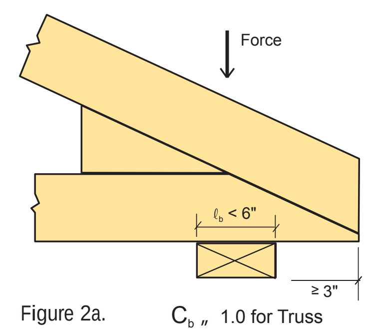

Figure 2a.

The C_b adjustment only applies to trusses that bear on supports that are less than six inches wide and are located at least three inches from the ends of the truss (See Figure 2a). Similarly, the C_b adjustment would only apply to the supporting wood plate or beam if the width of the truss is less than 6" and the truss is located at least 3" from the end of the supporting member (See Figure 2b).

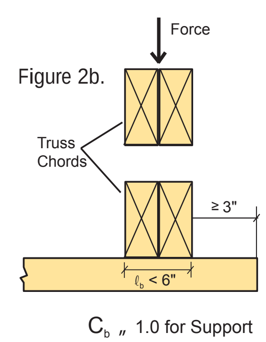

Figure 2b.

Example

The end of a bottom chord bearing, 3-ply roof girder truss bears on top of a 2x4 exterior wood wall in a single family residence. The bottom

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at a glance

- The required bearing length provided on the Truss Design Drawing is based on the lumber used in the truss.
- The bearing area for the wood wall or beam may need to be increased to prevent crushing of these members.
- Table 1 includes the maximum allowable reaction load that selected species of lumber used as wall plates can resist without excessive crushing.

[1] A provision has been proposed for the next edition of ANSI/TPI 1, *National Design Standard for Metal Plate Connected Wood Truss Construction* that will also evaluate the lateral stability of the truss heel at the bearing location when determining truss bearing requirements. This provision is not discussed in this article since the next edition of ANSI/TPI 1 has not been approved.

[2] A provision has been proposed for the next edition of ANSI/TPI 1, to include an adjustment that accounts for the reinforcement effect of the metal connector side plates (i.e., C_{plate}). This potential adjustment factor is not discussed in this article since the next edition of ANSI/TPI 1 has not been approved.

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chords of the girder consist of 2400f – 1.8E 2x10 Southern Pine lumber and the top wall plate is No 2 SPF. The maximum reaction force is 12,000 lbs. What is the minimum required bearing for this truss and the wall plate?

The Minimum Required Bearing Area (A) = Reaction Force (R) ÷ the Adjusted Compression Perpendicular to Grain Stress ($F_{c\perp adj}$),
i.e., $A_{req.} = R \div F_{c\perp adj}$

For the Girder Truss:

$$R = 12{,}000 \text{ lbs}$$

$$F_{c\perp adj} = F_{c\perp} \times C_M \times C_t \times C_i \times C_b,$$

where:

$F_{c\perp} = 805 \text{ lbs/in}^2$ (from Table 4C Footnotes of NDS Supplement for 2400f – 1.8E Southern Pine),

C_M, C_t and C_i = 1.0 and C_b = 1.0, since the bearing wall is located within 3 inches from the end of the truss.

Therefore,

$$A_{req} = 12{,}000 \text{ lbs} \div (805 \text{ lbs/in}^2 \times 1.0 \times 1.0 \times 1.0 \times 1.0) = 14.91 \text{ in}^2$$

Species ($F_{c\perp}$)	Plate Size	Bearing Area Factor, C_b	No. of Truss Plys (assumes each ply is 1-1/2" thick)			
			1	2	3	4
Southern Pine[3] (565 psi)	2x4	Yes[4]	3,708	6,674	9,640	11,865
		No	2,966	5,933	8,899	11,865
	2x6	Yes[4]	5,827	10,488	15,149	18,645
		No	4,661	9,323	13,984	18,645
Douglas Fir-Larch (625 psi)	2x4	Yes[4]	4,102	7,383	10,664	13,125
		No	3,281	6,563	9,844	13,125
	2x6	Yes[4]	6,445	11,602	16,758	20,625
		No	5,156	10,313	15,469	20,625
Spruce-Pine-Fir (425 psi)	2x4	Yes[4]	2,789	5,020	7,252	8,925
		No	2,231	4,463	6,694	8,925
	2x6	Yes[4]	4,383	7,889	11,395	14,025
		No	3,506	7,013	10,519	14,025
Hem-Fir (405 psi)	2x4	Yes[4]	2,658	4,784	6,910	8,505
		No	2,126	4,253	6,379	8,505
	2x6	Yes[4]	4,177	7,518	10,859	13,365
		No	3,341	6,683	10,024	13,365
Spruce-Pine-Fir South (335 psi)	2x4	Yes[4]	2,198	3,957	5,716	7,035
		No	1,759	3,518	5,276	7,035
	2x6	Yes[4]	3,455	6,218	8,982	11,055
		No	2,764	5,528	8,291	11,055

Table 1. Maximum Truss Reaction (lbs) Based on Allowable Compression Stress Perpendicular to Grain ($F_{c\perp}$) of the Lumber Plate[1,2].

[1]Reaction values are based on C_M, C_t and C_i = 1.0.

[2]Reaction values assume that the truss bears on the full width of the lumber plate.

[3]Reaction values may be increased by 1.168 if the lumber plate is Dense Select Structural, Dense No. 1 or Dense No. 2.

[4]Use the reaction value in this row if the truss is located at least 3" from the end of the lumber plate.

Since A_{req} = the width of the truss x l_b, and the width of this girder truss is 4.5" (i.e., 3 x 1.5"), the minimum required l_b is,

$$l_b = 14.91 \text{ in}^2 \div 4.5"$$

$$l_b = 3.31" < 3.5" \text{ (i.e., width of 2x4 wall) } \therefore \text{ OK}$$

For the Top Wall Plate:

$$R = 12{,}000 \text{ lbs}$$

$$F_{c\perp adj} = F_{c\perp} \times C_M \times C_t \times C_i \times C_b,$$

where:

$F_{c\perp} = 425 \text{ lbs/in}^2$ (from Table 4A of NDS Supplement for Spruce-Pine-Fir),

C_M, C_t and C_i = 1.0 and C_b = 1.0833 (i.e., (4.5 + 0.375)/4.5, assuming that the girder truss is located at least 3 inches from the end of the plate)

Therefore,

$$A_{req} = 12{,}000 \text{ lbs} \div (425 \text{ lbs/in}^2 \times 1.0 \times 1.0 \times 1.0 \times 1.0833) = 26.06 \text{ in}^2$$

$$l_b = 26.06 \text{ in}^2 \div 3.5" \text{ (i.e., the width of the plate)}$$

$$l_b = 7.45" > 4.5" \text{ (i.e., the width of the girder truss) } \therefore \text{ NG}$$

The above example indicates that the 2x4 wall provides adequate bearing length for the truss, but is insufficient in terms of the bearing capacity of the top plate. Since the truss design only evaluates the materials in the truss, the Truss Design Drawing for this girder would indicate that 3.5" of bearing is sufficient, yet crushing in the top plate of the wall will most likely occur unless the wall is increased to 2x6 and a lumber species with a higher $F_{c\perp}$ is used.

Table 1 provides the maximum truss reaction load based on the allowable perpendicular to grain bearing capacities of selected species of lumber commonly used as wall plate material. The reaction forces are derived for both 2x4 and 2x6 wall widths, as well as with and without the C_b factor.

Note: there are other, often more critical, design parameters besides compression perpendicular to grain strength that must be considered when determining the capability of a structural framing member to support the loads from trusses. Beams and headers must have sufficient bending strength, shear strength and stiffness, while walls and columns must have sufficient axial and bending strength and stiffness, to name a few. These parameters will be discussed in future editions of this column. SBC

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