



Glued laminated Timber Member Capacity at Connection

An Online Continuing Education Course for Engineers

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Credit: 3 Hours / 3 PDH / 3 CPD

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An AITC Continuing Education Course

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Introduction

Structural glued laminated timber (glulam) is a material that combines the warmth and beauty of wood with modern engineering to create structures for the most demanding applications. From short-span headers and beams in residential construction, to graceful exposed arches and curved beams in churches, to long span beams and trusses for commercial spaces, glulam has the answer.

This three-hour course will provide the timber engineer with the knowledge necessary to properly detail connections to minimize the occurrence of member failure modes at connections. Procedures for the evaluations of connections loaded in the parallel-to-grain and perpendicular-to-grain directions will be presented. While the focus of this course is structural glued laminated timber, the principles taught are applicable to solid sawn lumber and other engineered wood products, as well.

This course builds on the knowledge obtained from previous courses *Glued Laminated Timber Fundamentals*; *Glued Laminated Timber Design Values, Adjustment Factors, and Beam Design*; and *Glued Laminated Timber Connection Design Overview*. It is recommended that the student prepare for this course by reviewing the material presented in the earlier courses.

To receive PDH credit for this course, the student must pass a multiple-choice quiz consisting of 15 questions.

Learning Objectives

Upon successful completion of this course the student should be able to:

1. Calculate the required bearing length for a bearing connection.
2. Calculate the shear design capacity of a glulam member at a bearing connection.
3. Evaluate a glulam member with a notch on the tension face at the end support.
4. Evaluate a glulam member with a notch or taper cut on the compression face at the end support.
5. Determine the design capacity of a member at a connection using mechanical fasteners to support a member loaded perpendicular-to-grain.
6. Calculate member design capacities for net section failure, row tear-out, and group tear-out at connections loaded parallel-to-grain.
7. Design bolt spacing to prevent row and group tear-out.

Glued Laminated Timber Member Load Capacity at Connections

1. Introduction

Several different failure types are possible at timber connections, and each must be considered. Failures can occur in the fasteners themselves, at the interface between the fasteners and wood, or in the timber member at the location of the connection due to local stress concentrations. The capacity of the connection to resist each failure mode is determined independently, and the lowest capacity is assigned to the connection. This course focuses on determining the capacity of members to resist failure in various modes at connections, including bearing connections where fasteners aren't used to transfer the loads.

2. Member Capacity at Connections Loaded Perpendicular-to-Grain

For connections where forces are transferred perpendicular to the grain of a member, the shear capacity of the member must be sufficient to support the shear load at the connection. The shear capacity at a connection is dependent on the type of connection and must be determined by the appropriate equation. In addition, members supported by bearing must have sufficient bearing area to prevent excessive deformation and wood crushing at the contacting surfaces.

2.1 Bearing Connection with Unaltered Cross-Section

For the case of a simple bearing connection with an unaltered cross section (no notches or tapers), the requirements for shear and compression perpendicular to grain are given by Equations 2.1-1 and 2.1-2.

$$V \leq \frac{2}{3}bdF'_v \quad (2.1-1)$$

$$V_r \leq b l_b F'_{c\perp} \quad (2.1-2)$$

where: V = design shear force in member
 V_r = reaction shear force at connection
 b = width of member
 d = depth of member
 l_b = bearing length
 F'_v = adjusted shear design value
 $F'_{c\perp}$ = adjusted compression perpendicular-to-grain design value

Example 2.1-1 Bearing Length

Given: A simply-supported 5-1/8 in. x 12 in. 24F-V4 DF glulam beam has a reaction force of 5000 lb. The full width of the beam will be supported. The beam will be in dry use with normal temperatures. The reference design value for compression perpendicular-to-grain is 650 psi.

Wanted: Determine the required bearing distance.

Solution:

Design value:

$$F'_{c\perp} = F_{c\perp} C_M C_t C_b = (650 \text{ psi})(1.0)(1.0)(1.0) = 650 \text{ psi}$$

Required bearing length (from Equation 2.1-2):

$$V_r \leq b l_b F'_{c\perp} \Rightarrow l_b = \frac{V_r}{b F'_{c\perp}} \Rightarrow l_b = \frac{V_r}{b f_{c\perp}}$$

$$l_b = \frac{V_r}{b f_{c\perp}} = \frac{5000 \text{ lb}}{(650 \text{ psi})(5.125 \text{ in})} = 1.50 \text{ in}$$

Answer: The minimum bearing length is 1.50 in.

2.2 Bearing Connection

The notching of a bending member induces stress concentrations around the notch which can lead to splitting tendency. For these notches, the depth should be limited in smaller members.

For glulam members, tension perpendicular to grain stresses are limited to an absolute maximum of 3 inches. For notches in a slightly shorter column or low height beam, Equation 2.2-1.

$$V_r \leq \left[\frac{2}{3} F'_v b d_e \right] \left[\frac{d_e}{d} \right]^2 \quad (2.2-1)$$

where: d_e = the depth of the member, minus the depth of the notch

The designer should also consider reducing the stress concentration that occurs when a member is notched by using a gradual tapered notch configuration in lieu of a square-cornered notch (Figure 2.2-1). The designer may also need to consider the use of reinforcement such as fully threaded lag screws to resist the tendency of the member to split at the notch. Notching on the tension side of beams away from the ends is not permitted. Although the length of the notch is not explicitly included in the analysis, the notch should be confined to the immediate vicinity of the end of the beam.

In addition to the evaluation of shear capacity, bearing must be evaluated using Equation 2.1-2. In some cases, the tension-face notch may result in bearing on lower grade laminations used in the core of the beam. Where this occurs, it is appropriate to use the compression perpendicular-to-grain reference design value for the lower grade core laminations. The reference design value for bearing on the side face, $F'_{c\perp y}$, corresponds to the lower grade core laminations and should be used for this case.

