



# Glued Laminated Timber Fundamentals

An Online Continuing Education Course for Engineers

**Course Number: S-2006**

**Credit: 2 Hours / 2 PDH / 2 CPD**

# Glued Laminated Timber Fundamentals

An AITC Continuing Education Course

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# Glued Laminated Timber Fundamentals

## 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 two-hour course will provide the student with a basic understanding of structural glued laminated timber and its use as a structural material. Course topics include fundamental properties of wood, characteristics of structural lumber, and basic manufacturing concepts for structural glued laminated timber (glulam). The information presented will provide the practicing structural engineer or architect with a solid foundation upon which to build for engineered timber design.

To receive PDH credit for this course, the student must pass a multiple-choice quiz consisting of 20 questions.

## Learning Objectives

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

1. Identify the three principle axes of wood
2. Calculate the moisture content of a piece of wood
3. **Explain what is meant by “fiber saturation point”**
4. Estimate shrinkage of wood due to drying
5. Discuss engineering strengths and weaknesses of wood
6. Identify common lumber characteristics and discuss their effects on lumber quality
7. Recognize several benefits of structural glued laminated timber
8. Name the primary standard that governs the manufacture of glulam in the U.S.
9. Explain why optimized lay-ups are typically more efficient than uniform-grade lay-ups
10. Identify the differences between balanced and unbalanced lay-ups
11. Recall several quality control measures taken to ensure good performance of glulam timbers

## Required Texts

The following documents are included as Appendices to this course document. The student is not required to study the Appendices in their entirety. Rather, refer to specific sections of the Appendices where indicated herein.

1. APPENDIX 1: Wood Handbook: Wood as an Engineering Material. 2010 edition. Chapters 3-5. ([http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter\\_03.pdf](http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter_03.pdf), [http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter\\_04.pdf](http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter_04.pdf), [http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter\\_05.pdf](http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter_05.pdf))
2. APPENDIX 2: AITC 117-2004. Standard Specifications for Structural Glued Laminated Timber of Softwood Species. American Institute of Timber Construction. ([http://www.aitc-glulam.org/shopcart/Pdf/aitc\\_117-04-with%20\\_errata\\_incorporated.pdf](http://www.aitc-glulam.org/shopcart/Pdf/aitc_117-04-with%20_errata_incorporated.pdf))

## GLUED LAMINATED TIMBER FUNDAMENTALS

In the simplest of terms, structural glued laminated timber (glulam) may be described as simply a stack of lumber glued together. While useful for the purpose of visualizing glulam, this description is entirely inadequate from a technical perspective. Glulam is a highly engineered, wood product capable of large sizes, curved shapes, and long spans. It is manufactured from carefully graded and prepared lumber pieces, which are joined end-to-end to form long lengths, arranged based on grade, and bonded together with durable adhesives. Every step of the process is subject to rigorous quality control to ensure a reliable, consistent product.

To understand structural glued laminated timber, a working knowledge of wood properties and lumber characteristics is necessary. Beginning with fundamental properties of wood, this course will progress to cover important characteristics of lumber, and finally to key glulam concepts. Subsequent courses will cover design of glulam members and connections.

### Fundamental Wood Properties

Certain fundamental knowledge of wood is necessary to effectively design with structural glued laminated timber (glulam) and communicate with others in the wood industry. This section will provide a basic foundation of wood knowledge upon which the designer can build. The student should also have available Chapters 3-5 of the Wood Handbook for reference.

### Cellular Structure

The AITC **Timber Construction Manual** states, “Wood is a cellular, organic material made up primarily of *cellulose*, which comprises the structural units (cells), and *lignin*, which bonds the structural units together. Wood cells are hollow and vary from about 0.04 to 0.33 in. in length and from 0.0004 to 0.0033 in. in diameter. Most cells are elongated and are oriented parallel to the trunk and branches in the growing tree.” (TCM, 5<sup>th</sup> ed., pps. 19–20). **Wood’s hollow cells provide the structural support and also serve** as a piping system to conduct moisture and nutrients between the roots and branches of a living tree.

### Orthotropic Nature

**According to the Wood Handbook, “Wood may be described as an orthotropic material; that is, it has unique and independent mechanical properties in the directions of three mutually perpendicular axes: longitudinal, radial and tangential.” (Wood Handbook, p. 5–1).** The longitudinal axis is parallel to the longitudinal axis of the cells. The radial and tangential directions relate to the growth rings observed on a cross section of a log. The radial direction is perpendicular to the growth rings, and the tangential direction is parallel to the growth rings. (Figure 1; see also Figure 5-1 in Wood Handbook.)

Even though wood is orthotropic, for simplicity in design, the structural properties of wood in the radial and tangential directions are typically treated as identical. Because lumber is generally sawn indiscriminately with respect to the growth rings, it would be virtually impossible for the designer to determine in advance the radial and tangential directions. The differences in the properties in the radial and tangential directions are also small compared to the differences between either direction and the longitudinal direction.

The direction of the longitudinal axis of the wood cells is often referred to as the *grain* of the wood. Loads and resistances for wood members are typically characterized in relationship to the grain. Terms such as *parallel-to-grain* and *perpendicular-to-grain* are common. Wood is much stronger and stiffer in resistance to loads applied parallel to the longitudinal axis of the cells than in directions perpendicular to this axis. Of particular note, wood is very weak in tension perpendicular to grain (Figure 2).

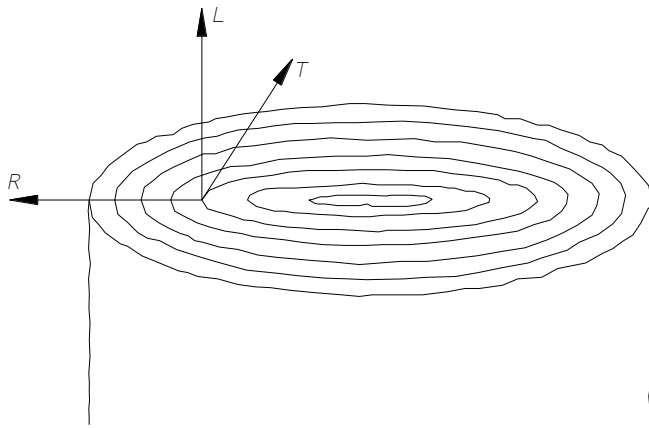


Figure 1. Three principle axes of wood: *L*, longitudinal (parallel to the grain), *R*, radial (perpendicular to the grain, radial to the annual rings). *T*, tangential (perpendicular to the grain, tangential to the annual rings).

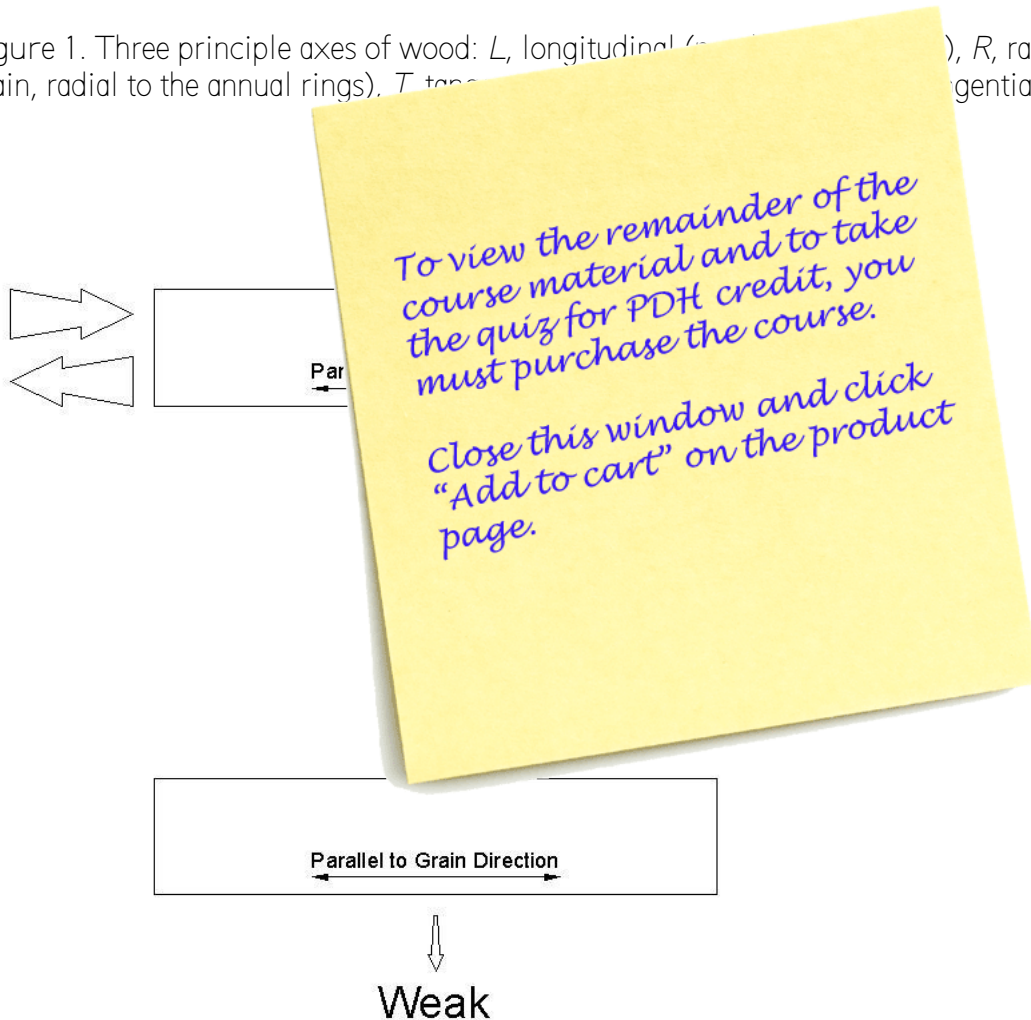


Figure 2. Wood is strong to resist stresses applied parallel-to-grain and to resist compression perpendicular-to-grain. Wood is weak in tension perpendicular-to-grain.

It is important to understand the strengths and weaknesses of a structural material, so that the strengths can be exploited and the weaknesses can be minimized or avoided. Wood is very strong in compression and tension parallel-to-grain and is reasonably strong in compression perpendicular-to-grain. However, wood is very weak in tension perpendicular to grain. Understanding this characteristic weakness will enable the designer to avoid common pitfalls in the detailing of timber connections and minimize structural problems and potential failures.