



Wood-Based Composites and Panel Products

An Online Continuing Education Course for Engineers

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Wood-Based Composites and Panel Products

The term composite is being used in this course to describe any wood material adhesively bonded together. Wood-based composites encompass a range of products, from fiberboard to laminated beams. Wood-based composites are used for a number of nonstructural and structural applications in product lines ranging from panels for interior covering purposes to panels for exterior uses and in furniture and support structures in buildings (Fig. 1). Maloney (1986) proposed a classification system to logically categorize the array of wood-based composites. The classification in Table 1 reflects the latest product developments.

The basic element for wood-based composites is the fiber, with larger particles composed of many fibers. Elements used in the production of wood-based composites can be made in a variety of sizes and shapes. Typical elements include fibers, particles, flakes, veneers, laminates, or lumber. Figure 2 shows the variation and relative size of wood elements. Element size and geometry largely dictate the product manufactured and product performance. Performance standards are in place for many conventional wood-based composite products (Table 2).

A variety of wood sources are appropriate for use in wood-based composites. Wood with localized defects (such as knots) can often be used effectively in wood-based composites. Reducing wood with defects to wood elements mitigates the influence of these characteristics in the manufactured products. Recovered wood from construction waste or industrial manufacturing processes, and wood derived from small-diameter timber, forest residues, or exotic and invasive species, may also be effectively used in wood-based composites. Because natural wood properties vary among species, between trees of the same species, and between pieces from the same tree, solid wood

Veneer-based material

- Plywood
- Laminated veneer lumber (LVL)
- Parallel-strand lumber (PSL)

Laminates

- Glue-laminated timbers
- Overlaid materials
- Laminated wood–nonwood composites^b
- Multiwood composites (COM-PLY^c)

Composite material

- Fiberboard (low-, medium-, or high-density)
- Cellulosic fiberboard
- Hardboard
- Particleboard
- Waferboard
- Flakeboard
- Oriented strandboard (OSB)
- Laminated strand lumber (LSL)
- Oriented strand lumber (OSL)

Wood–nonwood composites

- Wood fiber–polymer composites
- Inorganic-bonded composites

^aAdapted from Maloney (1986).

^bPanels or shaped materials combined with nonwood materials such as metal, plastic, and fiberglass.

^cRegistered trademark of APA–The Engineered Wood Association.

Table 1. Classification of wood-based composites^a

cannot match composite products in the uniformity and range of properties that can be controlled.

Scope

This course gives an overview of the general types and composition of wood-based composite products and the materials and processes used to manufacture them. It describes conventional wood-based composite panels and structural composite materials intended for general construction, interior use, or both. This course also describes wood– nonwood composites. Because wood-based composites come in a variety of forms, we briefly describe several of the most common commercial products.

This course is organized into three sections. The first section covers conventional wood-based composite panels. Materials, adhesives, and additives common to conventional wood-based composites are summarized. Specific products addressed include panel products such as plywood, oriented strandboard, particleboard, and fiberboard. Specialty composites are also discussed. The second section covers structural composite lumber, including glued-laminated timber, laminated veneer lumber, parallel strand lumber, laminated strand lumber, and oriented strand lumber. Wood–nonwood composites are discussed in the third section, including inorganic-bonded composites and wood–thermoplastic composites. Books have been written about each of these categories, and the constraints of this course necessitate that the discussion be general and brief. References are provided for more detailed information.



Figure 1. Wood-based composites used in the new Centennial Research Facility at the Forest Products Laboratory. Glulam timbers support composite I-joists and plywood sheathing. (Photo by Steve Schmieding, Forest Products Laboratory.)

Conventional Wood-Based Composite Panels

Conventional wood-based composites are manufactured products made primarily from wood with only a few percent resin and other additives. A useful way to classify conventional wood-based composites based on specific gravity, density, raw material, and processing methods is

shown in Figure 3, which presents an overview of the most common types of commercial panel products discussed in this course and a quick reference to how these composite materials compare with solid wood from the standpoint of density and general processing considerations. The raw material classifications of fibers, particles, and veneers are shown on the left y-axis. Specific gravity and density are shown on the top and bottom horizontal axes (*x*-axes), respectively. The right y-axis, wet and dry processes, describes in general terms the processing method used to produce a particular product. Selection of wood elements, adhesives, and processing techniques all contribute to product performance. Figure 4 shows examples of some commercial wood-based composites.

Elements

The primary component of wood-based composites is the wood element, often 94% or more by mass. Common elements for conventional wood-based composites include veneers, strands, particles, and fibers. The physical characteristics of common elements can be seen in Figure 5. Properties of composite materials can be changed by changing the size and geometry of the elements and by combining, reorganizing, or stratifying elements.

Table 2. Commercial product or performance standards for wood-based composites

Product category	Applicable standard	Name of standard	Source
Plywood	PS 1–07	Voluntary product standard PS 1–07 construction and industrial plywood	NIST 2007
	PS 2–04	Voluntary product standard PS 2–04 performance standard for wood-based structural-use panels	NIST 2004
	HP–1–2004	Voluntary product standard HP–1–2004 hardwood and decorative plywood	HPVA 2004
Oriented strandboard (OSB)	PS 2–04	Voluntary product standard PS 2–04 performance standard for wood-based structural-use panels	NIST 2004
Particleboard	ANSI A 208.1–2009	Particleboard standard	CPA 2009a
Fiberboard	ANSI A 208.2–2009	MDF standard	CPA 2009b
	ANSI A 135.4–2004	Basic hardboard	CPA 2004a
	ANSI A 135.5–2004	Pre-finished hardboard paneling	CPA 2004b
	ANSI A 135.6–2006	Hardboard siding	CPA 2006
	ASTM C 208–08a	Cellulosic fiberboard	ASTM 2008c
Glued-laminated timber (glulam)	ANSI/AITC 190.1	American National Standard for Wood Products—structural glued-laminated timber	AITC 2007a
Structural composite lumber (including laminated veneer lumber (LVL), laminated strand lumber (LSL), and parallel strand lumber (PSL))	ASTM D 5456–07	Standard specification for evaluation of structural composite lumber products	ASTM 2008b

Adhesives

Bonding in most conventional wood-based composites is provided by thermosetting (heat-curing) adhesive resins. Commonly used resin–binder systems include phenol-formaldehyde, urea-formaldehyde, melamine-formaldehyde, and isocyanate.

Phenol-Formaldehyde

Phenol-formaldehyde (PF) resins are typically used in the manufacture of construction plywood and oriented strandboard where exposure to weather during construction is a concern. Other moisture exposure situations, such as temporary weather exposure, occasional plumbing leaks, or wet foot traffic, may also necessitate the use of PF resins. PF resins are commonly referred to as phenolic resins. Phenolic resins are relatively slow-curing compared with other thermosetting resins. In hot-pressed wood-based composites, use of phenolic resin necessitates longer press times and higher press temperatures. Hot-stacking of pressed material shortly after emergence from the press is a fairly common industrial practice, used to attain adequate resin cure without greatly extending press time. Significant heat exposure associated with pressing of phenolic-bonded composites commonly results in a noticeable reduction in their hygroscopicity. Cured phenolic resins remain chemically stable at elevated temperatures. Their bonds also are sometimes referred to as being “boil-proof” because of their ability to maintain composite dimensional and mechanical properties under wet conditions. The inherently darker color of PF resin compared with other resins may make them aesthetically unsuitable for product applications such as interior paneling and furniture.

Urea-Formaldehyde

Urea-formaldehyde (UF) resins are typically used in the manufacture of products used in interior applications, primarily particleboard and medium-density fiberboard (MDF), because moisture exposure leads to a breakdown of the bond-forming reactions. Excessive heat exposure will also result in chemical breakdown of cured UF resins, therefore UF-bonded panels are typically cooled after emergence from the press. Advantages of UF resins include lower curing temperatures than PF resins and ease of use under a variety of curing conditions. UF resins are the lowest cost thermosetting adhesive resins. They offer light color, which often is a requirement in the manufacture of decorative products. However, the release of formaldehyde from products bonded with UF is a growing health concern.



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Figure 2. Basic wood processing chain

(Knauff and others 2007).

Melamine-formaldehyde (MF) resins are used in combination with wood adhesives. MF resin is needed and required.

minates, paper treating, resins may, despite MF resins are often conspicuous (light color) can be attained with UF resin is

Isocyanates

The isocyanate wood adhesive is a polymeric methylene diisocyanate (pMDI). It is used as an alternative to PF resin, primarily in composite products fabricated from strands. pMDI resins are typically more costly than PF resins but have more rapid cure rates and will tolerate higher moisture contents in the wood source. pMDI resin is sometimes used in core layers of strand-based composites, with slowercuring PF resin used in surface layers. Facilities that use pMDI are required to take special precautionary protective measures because the uncured resin can result in chemical sensitization of persons exposed to it. Cured pMDI resin poses no recognized health concerns.