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Wood Handbook

Wood as an Engineering Material



Centennial Edition

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Abstract

Summarizes information on wood as an engineering material. Presents properties of wood and wood-based products of particular concern to the architect and engineer. Includes discussion of designing with wood and wood-based products along with some pertinent uses.

Keywords: wood structure, physical properties (wood), mechanical properties (wood), lumber, wood-based composites, plywood, panel products, design, fastenings, wood moisture, drying, gluing, fire resistance, finishing, decay, preservation, wood-based products, heat sterilization, sustainable use

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This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

Caution: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife, if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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We are proud to present this edition of the *Wood Handbook—Wood as an Engineering Material*, prepared and updated to include fascinating new developments in the field of wood utilization and released as part of the celebration of the Forest Products Laboratory's first 100 years of service to the public.

Efficient use of our nation's timber is of critical importance. This handbook is intended to serve as a primary reference on the use of wood in a variety of applications—from general construction to use of wood for decorative purposes. It provides engineers, architects, and others who use wood with a source of information on the various properties of wood, its relationship with moisture, and characteristics of various wood-based materials. Continuing research holds promise for wider and more efficient utilization of wood in an increasing number of applications.

This handbook was prepared by the Forest Products Laboratory (FPL), a research unit within the USDA Forest Service. The FPL, first established in 1910 in Madison, Wisconsin, was the first institution in the world to conduct general research on wood and its utilization. The information that resulted from many of its scientific investigations of wood and wood products over the past century is the primary basis for this handbook.

The *Wood Handbook* was first issued in 1935, and slightly revised in 1939, as an unnumbered publication. Further revisions in 1955, 1974, and 1987 were published by the U.S. Department of Agriculture as Agriculture Handbook No. 72. The 1999 revision was published by the FPL as General Technical Report FPL–GTR–113 and reprinted for broader distribution by the Forest Products Society.

The audience for the *Wood Handbook* is broad. Consequently, the coverage of each chapter is aimed at providing a general discussion of the topic, with references included for additional information. Thousands more publications are available on the FPL website (www.fpl.fs.fed.us).

Wood resources continue to play an important role in the world, from packaging materials to buildings to transportation structures. Wood has been useful to human societies for thousands of years; archeological discoveries have shown wood was used by ancient civilizations as a construction material, as a substrate for ornate decorative objects, and for providing the final resting place for royalty. These discoveries highlight the unique, long-lasting performance characteristics of wood, as many of these artifacts have survived for thousands of years. FPL continues on its journey of discovery and public service; working with cooperators from around the world, we are discovering information that covers the entire spectrum of wood science—from the use of wood in ancient societies to developing new theories that describe the fundamental structure of wood based on the emerging field of nanoscience. If our forests are managed wisely, and if we continue to build our intellectual capacity to meet the challenges of evolving human needs and changing wood characteristics, this amazing material that is wood will serve the public well for years to come.

Christopher D. Risbrudt, Director

Michael A. Ritter, Assistant Director

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This edition of the *Wood Handbook—Wood as an Engineering Material* builds upon past editions, in particular the 1999 version, with some important additions and modifications:

- A chapter has been added that highlights the importance of wood as an environmentally responsible, sustainable material (Chapter 1).
- Low-magnification micrographs of cross sections of commercial wood species have been added (Chapter 2).
- An extensive discussion on the microscopic structure of wood and its foundational elements are presented (Chapter 3).
- Reference to the most recent research on properties of the wood cell wall, at the nanoscale, has been included (Chapter 5).
- To address the need to find uses for wood obtained from trees killed by invasive insect species as they propagate through various regions of the United States, a chapter has been added on heat-treating and sterilization procedures for wood products (Chapter 20).
- Important updates are included on wood–moisture interactions and wood preservation practices (Chapters 4 and 15).

The *Wood Handbook* originally focused on construction practices that utilized solid-sawn wood. Since its first printing, the state-of-the-art in wood construction practices and the range of wood-based products available to the consumer have changed considerably. Excellent printed reference and websites have been developed by various trade associations and wood products manufacturers that document, in detail, current design information for the ever-changing range of products available. We have made a concerted effort

to include the most current references, in addition to many historic ones, to help guide the reader to appropriate sources of information.

This 2010 edition was reviewed by numerous individuals from industry, academia, and government. Several dozen industry, university, and government colleagues reviewed various sections and chapters of this edition during various stages of revision. We gratefully acknowledge their contributions.

The following individuals provided in-depth technical reviews of this edition in its entirety: Donald Bender (Washington State University), David Green (USDA Forest Products Laboratory, retired), John Erickson (USDA Forest Products Laboratory, retired), Howard Rosen (USDA Forest Service, retired), World Nieh (USDA Forest Service), Robert White (USDA Forest Products Laboratory), and staff of the American Wood Council, American Forest & Paper Association. We gratefully acknowledge their contributions.

Although listing every technical author and contributor to the *Wood Handbook* would be nearly impossible—early editions did not even list individual contributors by name—we do acknowledge the authors of previous editions; they all made significant, noteworthy contributions.

Finally, we thank our many research cooperators from industry, academia, and other government agencies. By working with you we are able to continue developing the technical base for using wood, wood-based materials, and wood structural systems in a technically sound manner.

Robert J. Ross, Editor

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