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Recycled Lumber and Timber

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Abstract

This paper briefly describes opportunities for and barriers to the use of recycled lumber and timber in construction. While significant amounts of "old" timber are available from demolished buildings and other structures, the efficient use of this material is currently limited by lack of appropriate grading rules and engineering design values. Research and technology transfer efforts necessary to develop this information are discussed.

Introduction

The increasingly competitive and diversified demands being placed on forest ecosystems make alternatives to virgin timber more attractive. The use of recycled lumber and timber offers an important opportunity to help conserve existing forests and encourage the most efficient use of harvested materials. Identifying outlets for such material can create economic opportunities and can also help mitigate an expensive and environmentally sensitive landfill problem.

One source of building material ideal for reutilization is the "old" lumber and timbers generated from the demolition of wood buildings. Thousands of large timber structures are in use in the United States, and millions of single-family homes are constructed of dimension lumber. This material is attractive for recycling because it takes little energy to put it in reusable form. The potential for utilizing old lumber or timbers depends on not only the economic practicality of recovery as opposed to disposal, but also the acceptance of these materials in new construction. At the building site, building officials require some measure of assured performance of construction lumber (typically given by the grade stamp on virgin lumber). Development of a practical property assignment system for recycled timber would likely result in improved acceptance and wider use of this material.

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Current Methods for Assessing Timber Properties

Currently, the only standardized method available for assigning allowable engineering properties to timbers (lumber greater than 102 mm (4 in.) in thickness) is to use visual grading procedures. Visual grading is based on the premise that the growth characteristics of timber can be seen and judged by the eye. Characteristics such as knot size, knot location, slope-of-grain, and degree of checking are used to sort the lumber into visual stress grades. A relationship between the mechanical properties of the graded timbers and the mechanical properties of clear wood is used to establish stress values for engineering design.

The visual grading rules for dimension lumber $\leq$ 102-mm ($\leq$ 4-in.-) thick are standardized across species and the description for a given grade is therefore the same regardless of species. So, Southern Pine, Douglas Fir–Larch, and Red Oak are all dealt with in the same way. Grade descriptions for timbers, however, are not standardized. Therefore, a No. 2 grade Southern Pine timber may have a different allowable knot size than No. 2 White Pine. Table 1 shows an example of this lack of standardization.

Further, all grading agencies, except the Southern Pine Inspection Bureau, separate timbers into "use" categories of Beams and Stringers, and Post and Timbers. Beams and Stringers are intended for use as bending members, and Posts and Timbers are intended for use as columns. This lack of standardization of grading rules and the necessity of deciding in advance how a timber is to be used are confusing to the consumer. This confusion can lead to errors in design.

The allowable mechanical properties of visually graded timbers are established by applying appropriate modification factors for the growth characteristics specified in the grade description to results from tests of small, clear specimens for a given species. For lumber $\leq$ 102-mm- ($\leq$ 4-in.-) thick, this "clear wood" procedure has been replaced by a system based on results obtained from full-sized tests of commercially graded lumber. However, comparable data do not exist for most timber species.

Limitations on Stress Grading of Recycled Timbers

To reuse an old timber as a structural member, the wood should be graded by a grading agency. In the unlikely case that the member has an old grade stamp, the stamp is of limited use since grade descriptions and property assignment procedures have changed significantly over the years. Visual grading is currently the only method available for assigning allowable properties to timbers. This is not a very efficient grading process for old timbers for the following reasons.

First, many old timbers have been painted, making visual assessment difficult. Also, old timbers might contain internal decay or insect damage that cannot be seen on the surface. For these reasons, some grading agencies may not be willing to visually grade recycled timbers.

Second, when an old timber is visually graded, property assignments may be overly conservative. Since it is likely that many older timbers were cut from large trees from old growth forests, they may be of higher density and have fewer knots (thereby having better engineering properties) than lumber currently produced.

Finally, the grouping of species for marketing purposes affects property assignment. Once mixed, the lumber of some species cannot be easily identified and separated, and the properties of the weakest species dictates the design properties of the species group. For example, of the four species that make up the commercial grouping called Northern Red Oak, black oak has the lowest properties and controls the properties assigned to the group. This means that old lumber of a particular species may be assigned engineering properties lower than it deserves because it is grouped into a species group (Table 2).

Research Needs

One of the greatest impediments to the use of recycled timber is the lack of effective grading rides and engineering design properties, especially for bending and shear. This causes problems when building officials ask for proof that recycled timbers are of adequate strength for the intended end-use. Because of the lack of technical information, very low strength values are often assigned. Overly conservative property assignments require that a larger timber is used than necessary and therefore increases the cost of the construction project.

The effect of checks and splits on timber shear properties is an area of concern, especially for recycled timbers. The Forest Products Laboratory (FPL) is currently conducting a large, long-term research program on shear to improve timber beam design for buildings and bridges. This research is conducted in cooperation with the Federal Highway Administration, the Association of American Railroads, and the American Forest and Paper Association. Results derived from this program will lead to improvements in the National Design Specifications for Wood Construction (NDS) and the standard specifications for highway bridges given by the American Association of State Highway and Transportation Officials (AASHTO). This program consists of testing split and unsplit glued-laminated and solid-sawn timbers.

A grading system that may have potential to stress grade 25-mm- (2-in.-) thick recycled lumber is mechanical grading. Mechanical grading combines a direct measurement of the lumber modulus of elasticity (MOE) with a visual assessment to sort individual pieces of lumber into mechanical grades (Table 3). This system can grade lumber more precisely than visual grading because MOE can be measured directly and many more grades can be distinguished. Unfortunately, a mechanical grading system does not exist for either new or recycled timbers.

The FPL is currently sponsoring an initial series of tests to establish a mechanical grading system for new timbers. The species being evaluated are Red Oak, Red Maple, Southern Pine, and Eastern Hemlock. These studies are using stress wave techniques to measure MOE. This technique may also be able to detect internal defects and decay. These studies will provide basic information on the engineering properties of visually graded timber. A study on recycled timbers would be the next logical step.

As part of the initial effort, the FPL is cooperating with the U. S. Army at the Twin Cities Army Ammunition Plant (TCAAP) in Minnesota, where several large timber buildings are slated for disposal. The TCAAP is developing and implementing strategies to dismantle and recycle these timber structures in contrast to conventional demolition and landfill disposal. The FPL has developed a material testing program that will address the issues covered in this paper.

Conclusion

Great potential exists for the reuse of old lumber and timber in existing buildings, bridges, and other wood structures slated for disposal in the United States. However, grading methods and engineering design information need to be developed to utilize these materials efficiently. The development of this information will require cooperative efforts among lumber grading agencies, engineering designers, and material users and suppliers.

TABLE 1. Lack of Standardization of Edge-Knot Size Limitations in Grading Rules for No. 2 Grade Structural Timbers[a]

	Knot limitations		
		White Pine	
Nominal thickness[b]	Southern Pine	Beam & Stringer	Post & Timber
152 (6)	76 (3)	89 (3-1/2)	70 (2-3/4)
203 (8)	114 (4-1/2)	114 (4-1/2)	92 (3-3/4)
254 (10)	140 (5-1/2)	143 (5-5/8)	121 (4-3/4)
305 (12)	165 (6-1/2)	175 (6-7/8)	146 (5-3/4)
356 (14)	191 (7-1/2)	206 (8-1/8)	171 (6-3/4)
406 (16)	203 (8)	232 (9-1/8)	197 (7-3/4)
457 (18)	216 (8-1/2)	244 (9-5/8)	222 (8-3/4)

[a]Values are in millimeters (inches in parentheses).
[b]For Southern Pine and White Pine.

TABLE 2. Average Flexural Properties of Species in Northern Red Oak Grouping

	Modulus of rupture		Modulus of elasticity	
Species	(MPa)	(lb/in^2)	(MPa)	($\times 10^6$ lb/in^2)
Black Oak	95.9	13,900	11,300	1.64
Northern Red Oak	98.7	14,300	12,560	1.82
Pin Oak	96.6	14,000	11,940	1.73
Scarlet Oak	120.1	17,400	13,180	1.91

TABLE 3. Property Designations for Mechanically Graded Lumber With Properties Assigned by Visual Grading[a]

Grade	Red Oak	Red Maple
Mechanical	1650f-1.4E	2100f-1.8E
Select Structural	1380f-1.4E	1300F-1.3E
No. 2	960f-1.2E	910f-1.1E
No. 3	570f-1.1E	500f-1.0E

[a]For 51-mm- (2-in.-) thick lumber. Number preceding "f" refers to bending strength in pounds/square inch and number preceding "E" refers to MOE in millions of pounds/square inch. 1 lb/in^2 = 0.0069 MPa.