Building Products From Recycled Wood Waste

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Abstract

This paper describes the ongoing techology efforts at the USDA Forest Service, Forest Products Laboratory, that focus on the development of building products from recycled wood waste. Promising technologies, including dry-formed processing, wet-formed processing, and wood/plastic and wood/cement composite manufacture, are discussed. Performance evaluation and standards development, which are necessary to move recycled building products into widespread use, are also covered.

Introduction

Every year in the United States, approximately 1 million new single-family homes are built, representing an estimated $100 billion investment. If multifamily and manufactured housing is also considered, as well as the repair and remodeling of existing homes, this dollar investment more than doubles. A major portion of this investment goes toward the variety of wood building products used in house construction, including framing lumber, sheathing, millwork doors, and windows. Currently, nearly all wood used to produce these building products comes from virgin timber.

We are facing a serious challenge in the United States in dealing with municipal waste landfills that are near or at capacity. Wood waste, including wastepaper, construction waste, demolition waste, and tree trimmings make up a significant portion of this municipal waste. Wastepaper is the single largest component of our Nation's waste stream. At more than 70 million t/year, wastepaper accounts for nearly 40% of all landfilled material. Another 6% of landfilled material is wood waste (excluding paper). Currently, few building products (< 5%) utilize recovered materials from this municipal solid waste (MSW).

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Great potential exists for developing products for housing made from recycled wood waste and wastepaper, which will have the positive effect of reducing our landfill problem. Existing technologies can likely be modified and new technologies developed to produce building products from recycled waste wood, wastepaper, and other materials from the MSW. The Forest Products Laboratory (FPL) has established a goal, over the next decade, to help provide the technologies that will allow greater use of recycled wood waste recovered from the MSW for use in housing. Our goal would provide technologies capable of using up to 15 million t/year of wastepaper and wood waste now going to landfills.

The full spectrum of wood waste that might be converted into housing products includes full-sized used lumber salvaged from razed buildings, wood broken-up during building demolition, old wooden pallets, scrap wood from new construction sites, old wood utility poles and railroad ties, wastepaper in landfills, yard trimmings, and wood fiber found in the landfilled sludge produced by paper mills. Most of these raw materials will require chipping, grinding, or fiberizing to reduce the nonhomogeneous waste into a uniform material for processing.

A significant advantage of utilizing recycled wood waste is the opportunity to depart from conventional frame and panel building systems. Because fiber, flakes, and particles will be utilized for many of the products envisioned, opportunities exist to produce a variety of molded products. These molded products can be designed for structural efficiency as well as architectural flexibility.

Although there is great opportunity to utilize recycled wood waste materials using these technologies, the building products produced from them must perform satisfactorily. This requires evaluation of the characteristics that affect the in-place performance of the developed products and building systems.

Finally, building components and building systems made from MSW materials must be accepted by consumers if they are to become viable alternatives to traditional virgin timber-based and nonwood construction materials. This acceptance must come from not only home buyers and owners, but builders, remodelers, producers of manufactured housing, financial institutions, and regulatory agencies.

Technology Development

Several existing processes have the potential to produce building products from recycled wood waste.

Reconstituted Wood Composites

Reconstituted wood composites can be formed from recycled wood waste in much the same way as conventionally produced particle-based composites e.g., Oriented Strand Board (OSB), particleboard). By utilizing various-sized wood particles generated from the waste stream and hot pressing the particles with a conventional adhesive, a variety of panel products can be produced.

The term "reconstituted" describes a process in which wood waste is broken down into strands, flakes, particles, or fibers (heretofore referred to as particles) and reassembled into new forms with the aid of an adhesive.

An important part of particle-based composite panel manufacture from virgin wood is a consistent and homogeneous raw material source to assure uniform panel properties. Because the raw materials being considered here are derived from waste, the many forms and sources of wood waste may pose special processing considerations. For example, dimensional lumber scrap may be mixed with particleboard trimmings, old pallets, and tree limbs. Therefore, sizes and specie will likely vary, as will the cleanliness of the raw material. Waste wood from demolition sites may be contaminated with lead-based paint, nails, stones, plastic, gypsum, and concrete. In addition to this surface contamination, the wood waste may contain preservative or fire-retardant chemicals.

Wet-Formed Structural Fiber Products

Wet-formed fiber products can be produced from basic papermaking technologies employing the use of a wood fiber/water mixture (pulp slurry). Three basic techniques—molding, extruding, and laminating—can be used to produce products thick enough for wall, roof, or other building applications.

Research is currently underway at the FPL to produce both structural and nonstructural housing components from recycled wastepaper fiber. Using a three-dimensional pulp molding process, a structural component, called Spaceboard, is formed by draining a pulp slurry through a resilient mold. The mold is then hot-pressed to densify and dry the product. A preliminary study illustrated the potential of Spaceboard as a structural product. It is anticipated that the Spaceboard technology can also be used to produce a variety of housing components. This process can readily accept recycled wood fibers, and although now limited to rectangular panels, has the potential for both curvilinear and three-dimensional solid

formed products. This molding potential could greatly enhance design flexibility for architects and engineers.

Two other potential technologies are proposed for study to utilize recycled wood fiber using wet-formed processes. One technology is an extrusion process where pulp slurry is dewatered, densified, and dried as it is forced through special dies. This process has the potential to produce products with various dimension and cross sections, with essentially unlimited length. Potential products developed with this process might include decorative molding and trim products and lumber substitute products.

A second technology is a wet-formed fiber-based process that involves shaping structural components through the winding of paper sheet stock. This laminating process incorporates existing paper sheet-forming technology and is familiar to most builders that have used paper tubes for concrete formwork. This type of process has the potential to utilize low-grade recycled paper stock. A number of potential housing components can be produced with this laminating process, because circular, rectangular, and other efficient cross-sectional shapes can be formed.

Wood/Plastic Composites

Wood/plastic composites include those made by binding various recycled wood waste with recycled plastics, synthetic fibers, and resins. These combinations can produce a variety of composite building products.

Recycled wood-based fiber and plastics could be used in the future to produce a wide spectrum of products, ranging from inexpensive, low-performance composites to expensive, high-performance materials. Fiber technology, bonding performance, and fiber modification can be used to manufacture wood/plastic composites with uniform densities, durability in adverse environments, and high strength.

Creep, as a result of thermal or long-term loading deformation, could restrict the use of thermoplastics in composites to nonstructural uses. However, thermoplastics can be converted to thermosetting materials by oxidation and crosslinking reactions, so that it would be possible to make creep-resistive structural products using recycled thermoplastics.

Wood/Inorganic Composites

Recycled particles or fibers of wood held together with an inorganic matrix, such as Portland cement and gypsum, form a composite that can be used in a variety of structural and architectural applications. Wood/inorganic composites offer unique advantages over some conventional building materials, in that these composites combine the advantageous

characteristics of both the wood fiber and mineral matrix. These composites offer the potential to be fire resistant and are likely to be highly resistant to attack by decay fungi and insects.

The use of inorganic materials to bind waste wood fiber, chips, and particles has proven to be technically feasible in commercial products such as sound insulation board, gypsum fiberboard, and low-density cement-bonded wood building blocks. This range of products can be greatly extended if means are developed to convert waste wood into desirable particle sizes.

Cement-bonded particle and fiber boards machine well. They can be used to construct a wall product for residential construction that combines studs, sheathing, and siding into a single panel. Other uses include cladding, balcony parapets, flooring, sound barriers, garden and fence walls, interior partitions, and wall linings in areas requiring higher durability.

Gypsum-bonded wood fiber panels are used as replacements for gypsum wall board and are reported to have strong nail- and screw-holding properties, high moisture and fire resistance, and improved impact resistance. Other reported advantages include improved antisag properties (for ceiling boards), better sound insulation, and easy installation (joints do not require taping). The combination of wood fibers with inorganic binders provides a unique opportunity to utilize recycled waste and low-grade wood fiber.

Performance Evaluation and Standards Development

Although there is great opportunity to utilize recycled wood waste materials using the described processing technologies, the building products produced from them must perform satisfactorily. This requires evaluation of characteristics that affect the product's performance when used in a building. This evacuation results in a measure and an assurance of public safety as well as the facilitation of regulatory acceptance of the developed products and building systems. Therefore, evaluations of structural performance, fire performance, environmental performance (including moisture effects and durability). insulative and acoustical properties, and toxicity hazards are needed. The establishment of testing, design, and evaluation standards to measure and maintain this performance is also required.

An evaluation of product performance is required during process and manufacturing development as well as when the potentially viable product is developed. Depending upon the manufacturing process, the property measured, and the product application, it may be possible to use the same test protocol for several purposes. The order of test development and application will depend upon the type of recycled product and stage of product development.

Areas of evaluation to be investigated include the following:

- Process and manufacturing
- Engineering properties and structural performance
- Grading procedures for recycled lumber and timber
- Building systems behavior
- Fire performance
- Insulative and acoustical performance
- Health hazards and toxicity

Standards organizations, such as the American Society for Testing and Material (ASTM) and the American National Standards Institute (ANSI), develop test standards and performance criteria for comparing properties across a range of products intended for a specific application. The development of such "consensus" standards is the keystone to equitable treatment of properties across product lines and provides the consumer confidence in product performance and safety. Such standards are essential for the acceptance of product performance criteria by building code authorities.

Concluding Remarks

Although potential exists to utilize a significant volume of recycled wood waste in building products, research is required to evaluate applicable technologies, assure customer safety through performance evaluation, and maintain quality control through the development of manufacturing, testing, and design standards. The research program at the Forest Products Laboratory is designed to address these factors and will involve the cooperative efforts of government, industry, building associations and practitioners, as well as university researchers.

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