HOUSING PRODUCTS FROM RECYCLED WOOD

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Abstract

This paper describes potential technologies for the development of building products from recycled wood waste, including dry-formed and wet-formed processing, wood/plastic and wood/cement composite manufacture, and solid lumber and timber recycling. Waste resource assessment, product performance evaluation, and standards development, which are necessary to move recycled building products into widespread use, are also discussed.

Introduction

Every year in the United States, more than 1 million single-family homes are built, representing an estimated 100 billion dollar investment. If multifamily and manufactured housing are also considered, as well as repair and remodeling of existing homes, this estimate more than doubles. A large portion of this investment goes toward a variety of wood building products, including framing lumber, sheathing, millwork, doors, and windows. Nearly all the wood used to produce these building products comes from virgin timber. However, alternatives to virgin timber are becoming more viable as increasingly competitive and diversified demands are being placed on forest ecosystems.

At the same time, the United States is facing a serious challenge in disposing of waste in the many landfills throughout the country that are near or at capacity. The landfill situation is resulting in high disposal costs and potential environmental problems. If current trends continue, by the year 2000 nearly half a million tons of potentially useful wood-based waste will be discarded daily in our waste stream.

The U.S. Environmental Protection Agency estimates that more than 195 million tons of municipal solid waste (MSW) were generated in 1990 in the United States. This MSW includes durable goods, nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. It does not include wastes such as construction and demolition wastes, municipal sludges, combustion ash, and industrial process waste that might also be disposed of in municipal landfills or incinerators. Nearly 38 percent of the MSW generated in 1990 was paper and paperboard. 6 percent solid wood, and 18 percent yard trimmings. Solid wood waste includes wooden pallets and containers, furniture and other household items, and other miscellaneous products made from wood. If current trends continue, an estimated 222 millions tons of MSW will be generated by the year 2000. This figure increases dramatically if construction and demolition wastes are included.

The spectrum of wood-based waste that might be converted to housing products includes full-sized used lumber salvaged from razed buildings, wood resulting from building demolition, old

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Large volumes of demolition and construction debris are sent to municipal landfills yearly.

wooden pallets, scrap wood from new construction sites, preservative-treated wood waste from treating facilities and building construction, old wooden utility poles and railroad ties, wastepaper, yard trimmings, and wood fiber found in the sludge produced by paper mills.

Also, a relatively homogeneous raw material is needed because of the need to accommodate existing manufacturing processes. This suggests that much of the wood-based waste will require chipping, grinding, or fiberizing to reduce the nonhomogeneous wood material into **a** uniform material for processing.

The use of recycled wood-based waste in building products provides an opportunity to depart from conventional frame and panel building systems. Because fiber, flakes, and particles will likely be utilized for many of the products envisioned, a variety of molded products can be designed to maximize structural performance and provide architectural design flexibility.

Although there is great opportunity to utilize recycled wood waste materials, the resulting building products must perform satisfactorily. This requires evaluation of characteristics that affect the in-place performance of the products and building systems developed as well as the establishment of testing, design, and evaluation standards to measure and maintain this performance. These characteristics include engineering properties and structural performance, building systems behavior, fire performance, moisture and thermal stability and resistance, durability, grading procedures for recycled lumber and timber, insulative and acoustical properties, and toxicity hazards. Additionally, each product must be evaluated for its future recyclability.

Finally, these products must be economically feasible and competitively priced, and acceptable to builders, consumers, and financial institutions if they are to make significant inroads into housing construction.

Waste Resource Assessment

The success of developing technologies to produce housing products from recycled wood waste depends on the availability of a consistent and relatively uniform raw material source. Acquisition of detailed raw material resource information is a necessary first step in developing any

new technology or system to convert a raw material into a usable product. Adequate near- and long-term raw material supplies must be available at reasonable cost for a technology to be commercially adopted and implemented. Factors affecting the economic supply of recyclable raw materials include the amounts and types of material generated, the condition and quality of the material, the extent of commingling of materials, the separability of materials, types of contaminants present, the physical location of the material, and costs of acquisition, concentration, and transportation. Likely changes in these factors must be evaluated to determine possible effects on raw material supply.

New Technologies

To develop technologies and products that rapidly expand the use of recycled wood waste, near-term research must emphasize technologies that are most easily and rapidly implemented and that can be integrated in existing or easily modified industrial manufacturing processes. This must include a focus on products that are readily adaptable into existing building practices and that can utilize conventional construction techniques.

To increase the use of postconsumer wood and paper wastes in composite products suited for existing manufacturing processes, several essential issues need to be addressed: Characterizations of the recyclable material and its level of contamination are needed. The raw material needs to be converted to a form suitable for the manufacturing process, and any effect of existing residual contamination on the manufacturing process needs to be quantified. Most importantly, the link between raw material characteristics and final product performance must be established.

Different composite products require different raw material forms, and the manufacture of these products will tolerate different levels of contamination. Material sources must be matched to manufacturing techniques and product types. For consumer acceptance, developed products must perform at least as well as products made from virgin materials and ideally have some distinct performance advantage.

For rapid acceptance into the building market, focus must be directed towards the development of products that are acceptable for, or adaptable to, existing building practices. Although this may require an entirely new manufacturing process, the product should fit into an existing building system as a recognizable component. As a whole, housing contractors are generally slow to make changes in construction practice and material usage. Building products that are perceived as inferior, that require changes in established building practice, or that potentially risk investment are often approached with apprehension. Clearly, a new building product must show a distinct advantage over existing products to be widely accepted. This advantage can be lower product price, savings in labor, or improved quality.

Technology Development

Several existing and developing technologies have the potential to produce housing products from recycled wood waste.

Dry-Formed Wood Composites

Dry-formed wood composites can be formed from recycled wood waste in much the same way as conventionally produced particle-based composites (i.e., oriented strandboard (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 made.

Dry-formed processing would involve breaking down wood waste into strands, flakes, particles, or fibers and reassembling them into new forms with the aid of an adhesive. An important

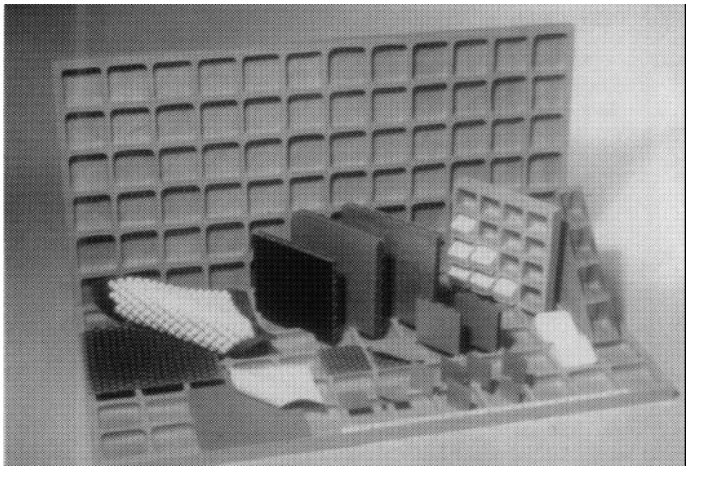
part of particle-based composite panel manufactured from virgin wood is a consistent and homogeneous raw material source to assure uniform panel properties. Because the raw materials being considered here are derived from waste, the many forms and sources of wood waste will likely pose special processing considerations. For example, dimensional lumber scrap may be mixed with particleboard trimmings, old pallets, and tree limbs. Therefore, sizes and species 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

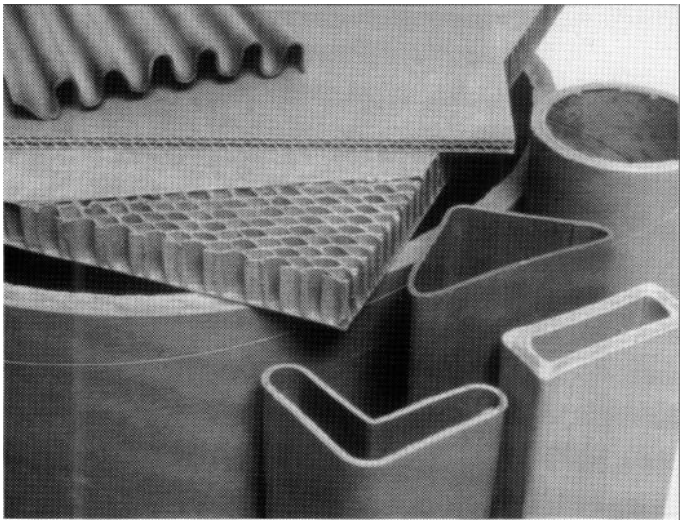
Wet-formed fiber products can be produced from basic papermaking technologies employing the use of wood fiber/water mixtures (pulp slurries). Three basic techniques-molding, extruding, and laminating-can be used to produce products thick enough for wall, roof, or other housing applications.

Research is underway on 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. Preliminary studies have 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. The 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 is a pulp extrusion process, where pulp slurry is dewatered.



Spaceboard, a technology developed at the Forest Products Laboratory, creates lightweight, honeycombed panels from recycled paper and other wood-based waste. This technology is now being commercially produced by Gridcore Systems International, and was named by Popular Science Magazine as one of the top 100 innovative products of 1993.



Paper sheet-forming technologies can be modified to produce structural products for housing. These products can potentially utilize the low-grade recycled paper stock unsuitable for higher-grade writing paper.

densified, and dried as it is forced through special dies. This process has the potential to produce products with various dimensions and cross sections and essentially unlimited length. Potential products developed with this process might include decorative molding and trim products and lumber substitute products.

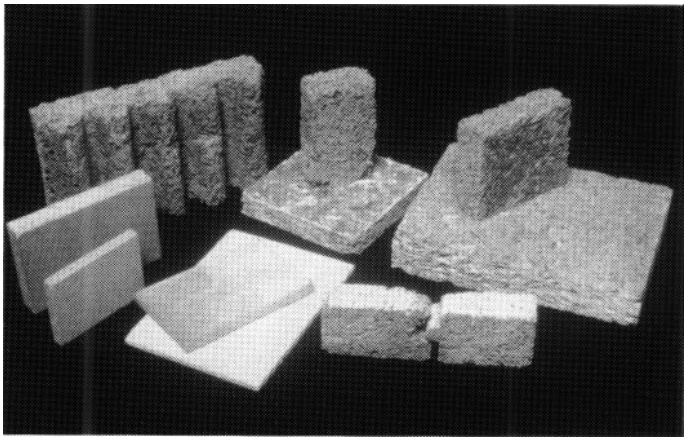
A second technology is a wet-formed fiber-based process that involves shaping structural components through the winding of paper sheet stock. This laminating process incorporates existing paper sheet-forming technology and is familiar to most builders that have used paper tubes for concrete form work (Sonatubes). 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 ma& 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 to produce a wide spectrum of products, ranging from very 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 cross-linking reactions, so it may be possible to make creep-resistive structural products using recycled thermoplastics.



Waste wood and cement composites can be used for building products requiring increased fire, insect, and decay resistance.

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 conventional wood 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 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 extended if means are developed to convert waste wood into desirable particle shapes and sizes.

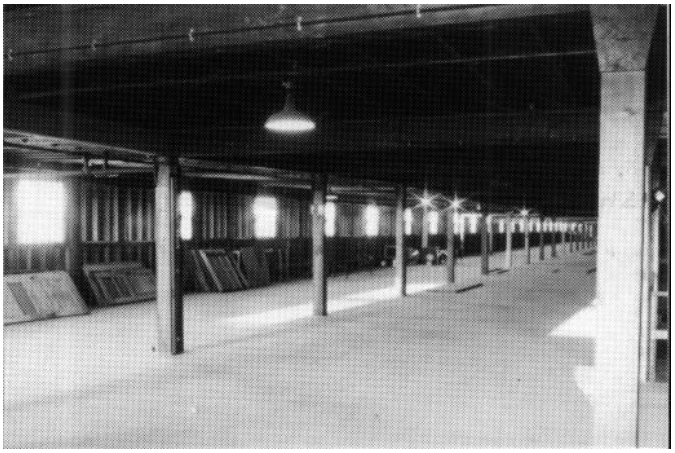
Cement-bonded particle and fiber boards machine well. They could be used, for example, to construct walls for residential construction that combines studs, sheathing, and siding in a single panel. Other uses might include cladding, balcony parapets, flooring, sound barriers, garden and fence walls, interior 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 tire resistance, and improved impact resistance. Other reported advantages include improved anti-sag properties (for ceiling boards), better sound insulation, and easy installation (joints do not require retaping).

Regrading and Reprocessing of Recycled Lumber and Timber

One source of lumber that has great potential for reutilization is “old” lumber and timbers from dismantled structures. This material is an attractive recyclable because it takes little energy to put it in reusable form.

The lumber and timbers salvaged from the demolition of existing wood structures are increasing in value as building materials. This is due to the fact that large-size virgin timbers are not readily available from contemporary forests. Also, salvaged timbers, while sometimes containing bolt holes and other defects. are often well seasoned.



Millions of board feet of recyclable lumber and timber exist in military structures dated for disposal.

In addition to the millions of single-family residential buildings in this country, there are thousands of WWII military buildings slated for demolition that contain millions of board feet of usable lumber and timbers. Wider widths of dimension lumber (2 by 8's, 2 by 10's, 2 by 12's, etc.) and heavy timbers (up to 12 by 24) are common.

The potential for utilizing old lumber or timbers depends not only on the economic practicality of recovery versus disposal but also on the acceptance of used products in new construction. Because. the grade of lumber is correlated to its structural performance, and building officials require some measure of assured performance (typically given by the grade stamp on virgin lumber), the development of a system to grade and assign design properties for old lumber is needed.

Performance Evaluation and Standards Development

Although there is great opportunity to utilize recycled wood waste materials using the processing technologies described, the resulting building products must perform satisfactorily. This requires evaluation of characteristics that affect the product's performance when used in a building. This evaluation 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.

Standards organizations, such as the American Society for Testing and Materials (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 the potential exists to utilize a significant volume of recycled wood waste in housing 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. To be successful, this research and development will require the cooperative efforts of government, industry, building associations, and building practitioners.

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