Pacific Timber Engineering Conference
Gold Coast Australia
July 11 - July 15,1994.

HOUSING PRODUCTS FROM RECYCLED WOOD WASTE

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SUMMARY

This paper describes the 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- and wet-formed processing and wood/plastic and wood/cement composite manufacture, are discussed. Also covered are waste resource assessment and product performance evaluation and standards development, which are necessary to move recycled building products into widespread use.

INTRODUCTION

Every year in the United States, approximately 1 million single family homes are built, representing an estimated $100 billion investment. If multifamily and manufactured housing are also considered, as well as the repair and remodeling of existing homes, this figure 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 wood used to produce these building products comes from virgin timber.

Currently, increasingly competitive and diversified demands in the United States are being placed on forest ecosystems, which are making alternatives to virgin timber more attractive. Using recycled wood-based waste for building products offers an important opportunity to conserve existing forests and encourage the greatest use of harvested materials.

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At the same time, the United States is facing a serious challenge in disposing of this waste in landfills that are near or at capacity. The U.S. landfill situation is resulting in high disposal costs as well as 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 landfills.

The U.S. Environmental Protection Agency estimated that more than 195 million tons of municipal solid waste (MSW) were generated in 1990 in the United States. Municipal solid waste includes durable and nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. Municipal solid waste does not include construction and demolition wastes, municipal sludges, combustion ash, and industrial process waste that might also be disposed 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 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.

PROGRAM GOALS

The Forest Products Laboratory (FPL) has established the following goals to provide the technologies that will permit the use of wood-based waste materials in housing products by the year 2000:

- Characterize components of the waste stream that can be utilized in building products for housing
- Develop technologies so that 20 percent of the virgin wood currently used in house construction can be of recycled origin
- Develop innovative building components and systems maximizing the use of wood-based waste
- Develop performance standards for the evaluation and use of wood-based waste building components and systems

RESEARCH NEEDS

To meet these goals, research is needed in several areas, including waste resource assessment, technology support for industrial systems and processes, product performance evaluation, standards development, economic studies, and cooperative technology demonstrations.

The full spectrum of wood-based waste that might be converted into housing products includes full-sized used lumber salvaged from razed buildings, wood resulting from building demolition, old 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. Currently, with the exception of paper mill sludge, there is little source separation of discarded wood-based waste. To fully utilize these materials, much more needs to be known about volumes generated, geographical distributions, and material characteristics (e.g., sizes, level of contamination).

Also, a relatively homogeneous raw material is needed because of the varied nature of the waste materials and 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 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 be utilized for many of the products envisioned, a variety of molded products can be developed and designed to provide structural efficiency as well as new opportunities in architectural design.

Although there is great opportunity to utilize recycled wood waste materials, the building products produced from them must perform satisfactorily. This requires evaluation of characteristics that affect the in-place performance of the products and building systems developed as well as 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, and grading procedures for recycled lumber and timber; insulative and acoustical properties; and toxicity hazards. Additionally, each product must be evaluated for its recyclability.

Finally, these products must be economically feasible, 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 will be dependent 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 a 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 costs 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 the costs of acquisition, concentration and transportation. Likely changes in these factors must be evaluated to determine possible effects on the raw material supply.

NEW TECHNOLOGIES

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

To expedite the transfer of wood waste into the housing market and show that building products from recycled wood waste are a viable alternative to virgin wood building products, existing industrial wood product manufacturing processes will be used where possible. This will require modification of the raw material into forms and levels of cleanliness acceptable to existing industries.

The use of recycled wood-based waste in structural panel products has great potential. Because many existing building panels in use today (e.g., fiberboard, particleboard, Oriented Strand Board) are manufactured from wood fibers or wood particles, a transition to substitute recycled wood-based materials for virgin materials should be relatively straightforward.

Research is needed to increase the use of post-consumer wood and paper wastes in composite products suited for existing manufacturing processes. Several essential issues need to be addressed to fully utilize these materials. First, characterization of the recyclable material and their levels of contamination are needed. Secondly, the raw material needs to be converted into a form suitable for the manufacturing process. Also, 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. Finally, evaluation, testing, and design standards must be developed to use these products.

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 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.

Potential products are targeted that could be made with a high content of recycled materials and can be used in place of existing products that contain little or no recycled materials. Although this may require an entirely new manufacturing process, the product produced 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, require changes in established building practice, or 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 a lower product price, savings in labor, or improved quality.

An examination of existing building systems is needed to determine which

products could be most readily introduced, and strategies should be developed to make these products with high recycled content. Overall, it must be remembered that any component that is sought to be replaced by a recycled alternative is part of a building system. Such systems need to be examined to determine which components may be manufactured from recycled materials. Once a component is chosen, the baseline performance of the component needs to be established using existing standards. The new product will be developed using an iterative design process where constant comparison is made between baseline performance requirements and manufacturing capabilities.

TECHNOLOGY DEVELOPMENT

Several existing processes have the potential to produce housing 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 (i.e., Oriented Strand Board, 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 into strands, flakes, particles, or fibers (hereafter 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 ensure uniform panel properties. Because the raw materials 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 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 structural 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. 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 a pulp 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 dimensions 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. Several potential housing components can be produced with this laminating process, because circular, rectangular, and other efficient cross-sectional shapes 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 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 a high level of strength.

Creep as a result of thermal or long-term loading deformation could restrict the use of thermoplastics in composites for 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 levels of moisture and fire resistance, and improved impact resistance. Other reported advantages include improved antisag properties (for ceiling boards), better sound insulation, and easy installation. 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 great opportunity exists 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 evaluation results in a measure and an ensurance 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 housing products, research is required to evaluate applicable technologies, ensure 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.

In: PTEC 94 Timber shaping the future: Proceedings of Pacific timber engineering conference; 1994 July 11-15, Gold Coast, Australia. Fortitude Valley MAC, Queensland, Australia: Timber Research Development and Advisory Council: 745-750. Vol. 2.