

Wood Fiber-Reinforced Plastics in Construction

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Abstract

Use of conventional wood composites (wood glued together with thermosetting adhesives) in construction has been growing for many years. This growth is fueled by the changing wood supply and competition from nonwood building materials. A new class of materials, wood fiber-filled thermoplastic profiles, are starting to be used for deck surfaces and window and door components. As these materials become more common, construction methods will be developed to use them to their fullest potential.

Introduction

Use of wood composites in construction has been growing for many years. Plywood and oriented strand-board has all but replaced solid sawn sheathing. Engineered wood I-beams are replacing solid sawn rafters and joists. This growth is fueled by the changing wood supply and competition from nonwood building materials.

Building techniques for these materials are an extension of existing building practices and codes. These composite materials perform much like solid wood because the adhesives that bind the wood component together are thermosetting, or cross-linking. A new class of composite materials is now entering construction that does not behave the same as either solid wood, or like composites glued together with thermoset adhesives.

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Definition

For the purpose of this article, the term “wood fiber-plastic composite” means a product made using substantially conventional plastic processing equipment, where wood fiber serves as a reinforcing filler in a continuous plastic matrix. This differs from traditional wood composites where thermoset glues are used to assemble wood components into a product.

For construction applications, most wood fiber-plastic composites will be made using extrusion equipment, whereby a piece of uniform cross section and any practical length can be produced. This product might be a sheet, or more commonly, a lumber or mill work profile. Other viable technologies include injection and compression molding.

Why use wood fiber-plastic composites?

Manufacturers constantly look for more efficient and cost-effective ways to make durable products. Plastic processes offer a way to make articles to net shape with very little wasted material. Most plastics, though, are not stiff and creep-resistant enough for construction applications, and need further reinforcement to become viable products.

Typical reinforcements for plastic include fiberglass and various minerals. These materials are heavy and expensive. Wood fibers can be used to provide the reinforcement, with little of the weight gain associated with mineral and glass fillers. The issue of wood waste disposal also affects many wood products manufacturers. These materials include sawdust and planer shavings, short solid pieces, and conventional wood

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composite scrap. These materials, and others from recycled sources, are well suited for use as the reinforcing element in wood fiber-plastic composites. In addition, for many wood fiber-plastic composites, the plastic component may also be recycled.

Performance attributes

Durability

Properly manufactured wood fiber-plastic composites encapsulate the individual wood elements in a continuous plastic matrix. The plastic matrix serves to protect the wood from the environment. Therefore, care must be taken to insure the plastic is properly stabilized to withstand ultraviolet light (UV) and other environmental factors. If the individual wood elements are not adequately encapsulated, moisture can migrate through the piece causing swelling, delamination, and fungal decay.

Linear expansion

Plastics expand and contract from temperature variations; wood expands and contracts from humidity variations. Adding wood to plastics significantly decreases thermal linear expansion, often by 50 percent or more. Decreasing the rate of thermal expansion is important, especially when wood fiber-plastic composites are used with other materials with much lower thermal expansion rates, such as solid wood.

Properly manufactured, wood fiber plastics change very little with humidity variations. The plastic serves to moderate and somewhat mitigate moisture movement through the article.

Stiffness

Adding wood to plastics can make them stiff enough for certain building applications. Adding wood fiber can double, and sometimes triple, the stiffness of the plastic matrix. Even with these improvements, most wood fiber plastics have a modulus of elasticity (MOE) less than half that of solid wood.

The differences in MOE between wood fiber plastics and solid wood become more apparent at higher temperatures. Plastic MOE decreases significantly with increasing temperature. Increasing the fiber content decreases the rate of loss of stiffness, but the loss of stiffness must be considered when wood fiber-plastic composites are used for applications that undergo temperature variation.

Other attributes

Depending on the application, other attributes for the user to consider include fire performance, coefficient of friction, machinability, and sound absorption.

Examples of applications

Exterior construction

Wood fiber-plastic composites for exterior construction applications are typically made to standard lumber profile cross-section dimensions. Two of the products sold in this category, one by Advance Environmental Recycling Technologies (AERT) and the other by Mobile Chemical Company, consist of approximately 50 to 55 weight percent wood fiber and the remainder high- and/or low-density polyethylene. Both claim their product is practically maintenance free and very durable in exposed environments.

These products are not intended for primary structures. Instead, they are used as deck and dock surface boards, landscape timbers, picnic tables, industrial flooring, and the like. Because their stiffness is less than solid wood, many manufacturers recommend that joist spacing for decks and docks be changed. Typically, the recommended spacing is 12 to 16 inches. Mobile says that 5/4inch Trex boards are sufficient for residential applications, but nominal 2-inch profiles are recommended for commercial applications. Most manufacture also recommend that the composite be gapped on both the edges and ends to allow for thermal expansion, unlike wood, which is gapped on the edge only to allow for moisture related expansion.

Weyerhaeuser has recently begun distributing the AERT material. The AERT material has also been used by General Motors as flooring blocks around heavy equipment. These flooring blocks replace creosote-treated oak and are quite good at shock absorption. Other than joist spacing and gapping for expansion, construction practices for this class of materials is much the same as solid wood. The composite can be nailed, attached with screws, and sawn with conventional tools. The composites also readily accept paint and stain.

The first generation of these matexials did not always fare well in exterior applications. For instance, after several structures made with early iterations of this class of materials failed, the importance of proper *W* stabilization of the plastic component was shown to be critical. Manufacturing practices were also improved, and variation in raw materials, some times difficult with recycled materials, was brought under control.

People buy these materials for several reasons. Some like the low maintenance required. Others like the recycled content, or the actual and perceived environmental aspects. Still others appreciate that no preservatives are used. Certain states are already outlawing

some lumber preservative treatments for some structures, such as docks and bulkheads. Currently, these composites can be used for some of these applications.

Window and door applications

Many window and door manufacturers are looking seriously at wood fiber-plastic composites as an alternative for solid wood in clad components. Clear ponderosa pine, a traditional material for these applications, is becoming increasingly scarce and expensive. The available ponderosa pine needs extensive cutting, edge gluing, and finger-jointing to get sufficiently clear sections for window and door fabrication. The glued-up material is then milled to the correct cross section use in the assembly. This increases cost and waste wood generated.

The first entries into this application were lumber type profiles as described above that were made into the correct profile by standard millwork operations, like solid wood. This process is less wasteful than solid wood millwork applications because the shavings can be recycled directly back into product. While still viable, this technology does not exploit the composites' ability to be made to the correct net shape.

An example of true net shape forming was developed by Strandex Corporation and licensed by Crane Plastics. This proprietary system uses modified plastics technology to make a high wood content composite (typically 70%) to tolerances of ± 0.001 inch. Profiles made to this tolerance can go directly to vinyl cladding operations, and can be used with other precision components such as extruded aluminum profiles. The Strandex product can also be stained or painted.

Andersen Windows integrates wood fiber-plastic composites into their products and manufacturing by utilizing their own in-plant waste and other wood waste sources. Unlike other manufacturers that use polyethylene, Andersen uses the waste polyvinyl chloride (PVC) generated in their cladding operations as a polymer base for their composites. Typically formulated from 60 percent PVC and 40 percent wood waste the profiles are currently being used as sills with

aluminum cladding. Interestingly, and to Andersen's advantage, the composite materials' thermal coefficient of expansion is almost the same as aluminum.

Future issues

For these materials to continue market growth in construction, performance will have to improve and better ways to use them will have to be devised. Material science issues related to efficient transfer of stress between the fiber and the matrix will need to be improved upon.

Impact performance is also relatively low. Although not significant in many applications, objects propelled by high winds into a structure could cause serious damage if the wood fiber-plastic composite building element failed. Use in transportation structures may also be limited by low impact values.

Fire performance also has yet to be fully characterized, and fire retardant research could be conducted from both the wood side and the plastic side. The use of additive technology (compatibilizers, fire retardants, impact modifiers, UV stabilizers) can be used to overcome some of the possible shortcomings of the composites.

The use of wood fiber-plastic composites in building products also provides an opportunity to depart from conventional frame and panel building systems. Because thermoplastics are used, a variety of molded products can be developed to provide material efficiency as well as new opportunities in architectural design. As performance is increased, true structural applications may be developed.

For construction purposes, uniform standards must be adopted to handle the wide compositional ranges possible with wood-plastic composites. Key properties such as creep, fire performance, dimensional stability, and durability need to be fully investigated and compared with construction standards. In response to this need, the American Society for Testing and Materials already has a committee on wood fiber-plastic composite lumber type profiles, and another committee on plastic lumber profiles.

The Use of Recycled Wood and Paper in Building Applications

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