Understanding the Effect on Adhesive Joints of Wood Swelling Under Wet Conditions

Many adhesives, including epoxy resins, perform well when bonding dry wood. These adhesives often fail, however, when the wood substrate absorbs water. This research program will lead to a better understanding of the mechanisms of bond failure by determining the stresses and strains placed on the adhesive–wood bond during water absorption. This information will ultimately be used to develop improved epoxies for repair of wooden structures and marine applications and to improve the performance of other adhesives.

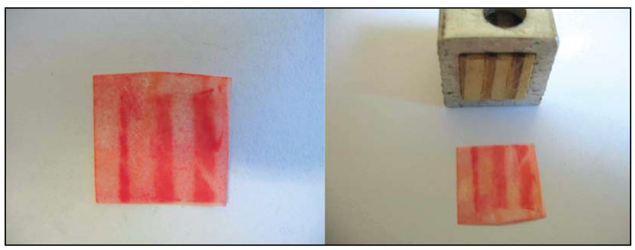

Figure 1. Pressure-sensitive film showing stresses developed in wood as it absorbs water.

Background

Most durability tests of wood bonds require the bond to pass water-soaking tests. FPL researchers have developed models of wood bond durability that emphasize the importance of the concentration and dissipation of strain and stress at the interface between wood and adhesives.

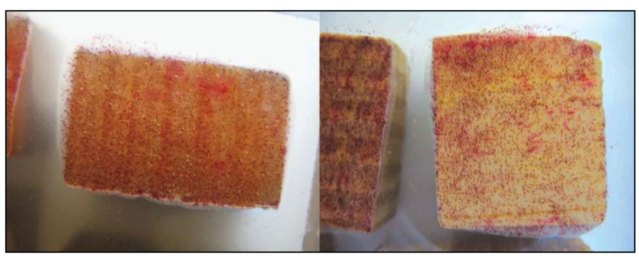

Figure 2. Loblolly pine bonded to clear glass using epoxy resin loaded with microencapsulated ink spheres.

Objective

The main objective of this work is to develop a method to measure stresses and strains on a wood–adhesive bond line as the wood absorbs and desorbs water.

Approach

Pressures exerted by loblolly pine wood as it absorbed water were measured using a pressure-sensitive film that changes color with greater pressures (Figure 1). The shear stresses developed within a bond line were evaluated by bonding wood samples to a clear glass plate. The adhesive was modified by the addition of microencapsulated ink spheres (microcapsules). When these spheres are subjected to stress, they rupture, releasing a red dye. The more microcapsules that break, the greater the stress.

FPL 1A epoxy resin—with microcapsules added at 2% by weight—was used to bond loblolly pine to a clear, silane-treated glass plate. After curing, the sample was placed in water for 75 hours, observed under an optical microscope at 30× magnification, and evaluated for microcapsule breakage. Significant differences were observed in shear stress in the adhesive above the latewood and earlywood sections of the samples. The epoxy resin above the earlywood exhibited higher levels of shear stress with, approximately 90% of the microcapsules breaking. Above the latewood, however, only 10% of the microcapsules were broken (Figure 2).

Expected Outcomes

Calibrating the microcapsules to quantify shear stresses within the adhesive will allow us to determine shear stress distribution within the bondline. This may also allow us to determine why adhesive above the early-wood exhibits higher shear stresses than does adhesive above the latewood.

Timeline

This work will be completed by August 2007.

Cooperators

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