Research for Resilience at the USDA Forest Products Laboratory

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As the only national laboratory of the USDA Forest Service, research at the Forest Products Laboratory (FPL) promotes healthy forests and forest-based economies through the efficient, sustainable use of wood. The long-term health of our nation's forests depends on sound conservation practices, including wise use. Efficient use of forest resources is a forest management tool that can improve resilience to natural disturbances such as wildfires, invasive species, and a changing climate.

For more than 100 years, FPL has been developing innovative ways to use one of the world's oldest building products. Today, one of those innovations is in mass timber, as researchers study the performance of materials like cross-laminated timber (CLT), which make building taller structures out of wood possible.

CLT is made from layers of dried lumber boards stacked in alternating direction at 90-degree angles, glued, and pressed to form solid panels. These panels have exceptional strength and stability and can be used as walls, roofs, and floors. Researchers at the lab have been studying CLT from many angles, including strength properties; fire, seismic, and moisture performance; and even their ability to withstand explosions.

FPL researchers recently recreated five fire scenarios in a two-story, full-scale test building constructed using CLT. The tests demonstrated that it is possible to build a CLT structure that's fire resistant, even with exposed CLT. Results from these tests will not only help inform building codes, but also provide useful information for property insurance groups, contribute to more accurate fire behavior modeling, and lead to safer firefighting in CLT buildings.

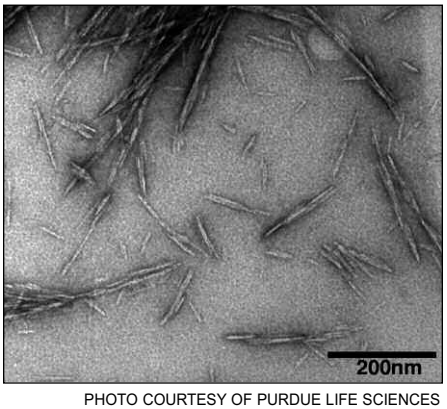
Researchers also conducted a series of blast tests on two-story structures made of CLT. The objective of these studies was to demonstrate the capability of CLT structures to resist airblast loads, thereby allowing the military to incorporate mass timber materials into their construction projects. The structures survived blasts with charges large enough to potentially cause lethal injuries.

Another critical part of the mission of FPL is to develop wood products that help pay for forest management. "On many forests where small diameter trees need to be removed to improve forest health, there must be product opportunities for that material that pay all costs, including logging and transportation," says Alan Rudie, FPL assistant director.

Thinning overgrown forests can reduce fire intensity and reduce the risk of beetle infestations, but the process is costly. Rudie explains how FPL researchers are looking to offset those costs by focusing on deriving chemicals with higher value than fuels from wood, and cellulose nanomaterials with high value as reinforcement materials in composites and as rheology modifiers.

Cellulose nanomaterials—wood broken down to the miniscule nanoscale—have incredible properties with strength greater than steel at one-fifth the weight, and are produced from a renewable resource, no less. Examples of potential uses for these materials include automotive and aircraft parts, food packaging, biomedical applications, and even "green" computer and cell phone components.

Cellulose nanomaterials are already solving problems in a variety of industries, as they are being used to keep things flowing for oil drilling in Canada and ink pens in Japan, keep diaper odors in check, and keep swim-



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Cellulose nanocrystals as seen through a transmission electron microscope. Adding cellulose nanomaterials to concrete can improve its tensile strength by 30 percent.

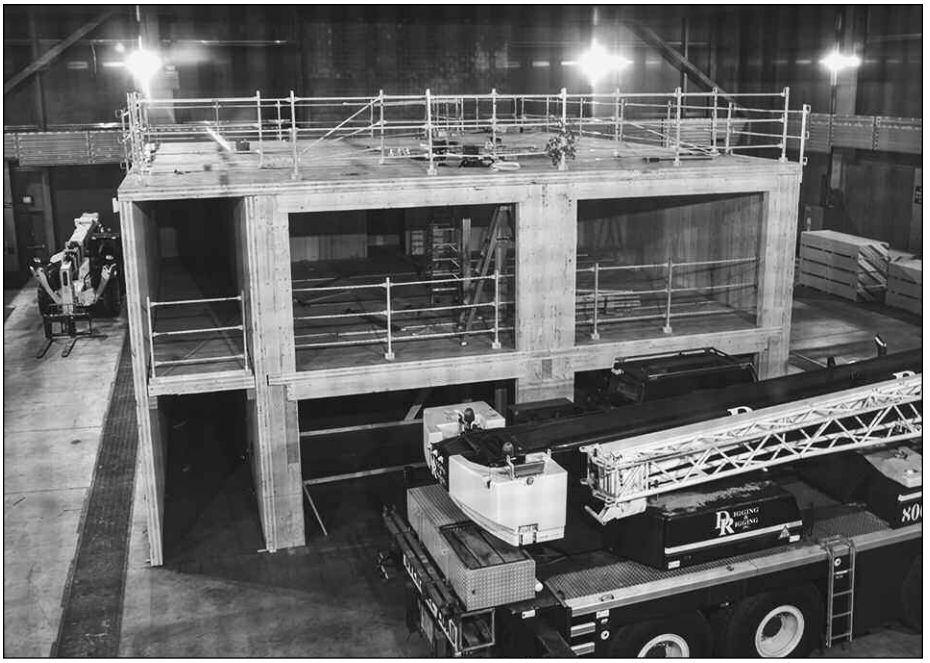

PHOTO COURTESY OF FOREST PRODUCTS LABORATORY

FPL researchers conducted a series of fire tests on a full-sized two-story CLT structure that showed it is possible to build a fire-resistant building using CLT.

ming goggles from fogging.

Long-time FPL partners at Purdue University found that adding cellulose nanomaterials to concrete can improve its tensile strength by 30 percent. Engineers and scientists at Oregon State University then helped bring the research to reality by conducting practical tests with a concrete truck and pours into various sized vessels to observe the material's properties. This research paved the way for the next step: a bridge recently built in California to test and demonstrate the capabilities of the material in a real-world application.

One aspect of research in FPL's Center for Wood Anatomy Research relates to the forensic identification of wood, which can also be important for forest products markets. According to FPL botanist Alex Wiedenhoeft, forest products derived from illegal logging are estimated to depress prices in the American forest products market by more than $1 billion per year. "The use of forensic wood anatomical techniques can be an integral part of forest product supply chain management and can help ensure the validity of certified forest products, as well as helping protect the global market from influxes of illegally logged material," says Wiedenhoeft.

FPL is working to capitalize on the wide range of research to support markets and implementation. Through the Forest Products Marketing Unit (FPMU) and the Forest Service Wood Innovations network, market development efforts include applied research, outreach, technical assistance, and various special initiatives. Beyond the research work in CLT and cellulose nanomaterials, FPMU is working to expand existing and emerging technologies and markets for torrefaction, biochar, wood energy for heat and power, thermal modified lumber, biofuels, and biochemicals.

These and a host of other research projects are conducted with the goals of healthy forests and healthy economies in mind. FPL research stimulates economic resilience in many sectors, including bioenergy, housing, tourism, and packaging and paper, all while helping remove barriers for innovative ideas to reach the marketplace. By producing high-quality, science-based innovation, FPL research quite literally improves the safety, comfort, and well-being of every American, every day. ◆

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