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NEWSLINE

Forest Products Laboratory

Standing Up to Mother Nature:

Wood-frame building holds its own against the world's largest earthquake test

By Rebecca Wallace, Public Affairs Specialist

This past July, a six-story wood-frame condominium tower rocked to the motions of an earthquake so powerful it only occurs every 2,500 years. And the building stood—with little damage—showing that midrise wood-frame buildings can be constructed to withstand major earthquakes.

The 40-second, 7.5 magnitude quake was simulated by the world's largest earthquake shake table near Kobe, Japan. It was the largest in a series of tests, known as the NEESWood Capstone tests, led by Colorado State University along with Simpson Strong-Tie and other collaborators, including the Forest Products Laboratory.

The results are good news for the wood products industry. Currently, the mid-rise construction market is dominated by the steel and concrete industry. By demonstrating the ability of wood-frame buildings to survive a major earthquake, wood-frame construction can become an economic option in seismic regions in the United States and around the world.

John van de Lindt, principal investigator on the test and civil engineering professor at Colorado State University, explains that the objective of the project was to apply a design standard, known as performance-based design, to wood structures, not just to steel and concrete as has been the focus in recent years.

"We aimed to safely increase the height of wood-frame buildings in seismic zones by designing them to perform a certain way in earthquakes," says van de Lindt. "This building performed even better than we expected."

According to Doug Rammer, research general engineer at the Forest Products Laboratory, buildings have typically been designed solely for strength. Using performance-based design, researchers were able to focus on other properties that are key to a structure surviving an earthquake.

"In this case, the design focused on increasing the building's ability to withstand displacement, which occurs during a seismic event, rather than on strength alone," explained Rammer.

Rammer was on hand to help set up the instrumentation pattern in the test building and provide technical feedback as needed. Three hundred sensors collected data during the test, and Rammer is now involved in the post-data analysis and further development of the performance-based design criteria.

Photo courtesy of Colorado State University.

"We are still learning how we can further refine the design philosophy for wood-frame buildings," says Rammer. "But the test did illustrate that wood can do well in earthquakes when the building is designed properly."

According to van de Lindt, the next step of this project is to begin implementation of these new design standards.

"Now that we've had a successful test, we can take the information to technical committees and encourage jurisdictions to allow the construction of a six-story wood-frame building in areas where only four stories are currently allowed," says van de Lindt. "With proper seismic design it can be done."

Van de Lindt adds that he also plans to encourage performance-based-design retrofitting of existing wood-frame buildings to increase their performance during an earthquake.

The seismic testing was the culmination of a four-year $1.4 million grant from the National Science Foundation to develop a new performance-based design approach for taller wood-frame buildings in earthquake-prone areas. The grant is a collaboration between five universities—Colorado State University, Texas A&M University, Rensselaer Polytechnic Institute, SUNY–Buffalo, and University of Delaware.

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Check out our website at http://www.fpl.fs.fed.us

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Upcoming Events

Going Green Without Going Crazy—Green Building Workshops Series

October 28, 2009: University Quality Inn, Lansing, MI

November 5, 2009: Hilton Garden Inn, Maple Grove, MN

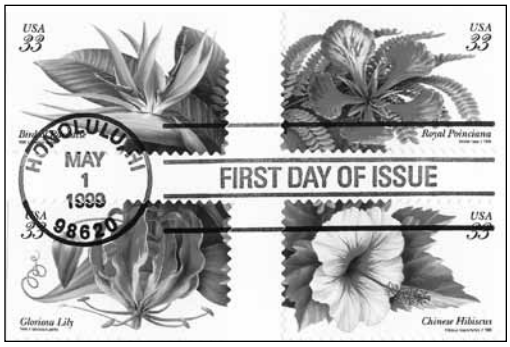
November 5, 2009: Concurrent Online Seminar

> "*Everyone's talking "green" – but do they really know what they are talking about? If you want to be someone who can speak with authority and confidence about green building – then you should attend this workshop.*"
>
> –Dr. Jim Bowyer, Director of Responsible Materials Program, Dovetail Partners

Green Building Workshops provide invaluable insights into a range of vital topics that include selling to green customers, the impact of green building programs on demand for certified wood products, engaging in Chain-of-Custody certification, and understanding green building programs. These workshops are a great resource for anyone interested in and working with green building issues. You can view the program and register at http://www.forestprod.org/greenbuilding/index.html.

Wood You Believe...

- A cord of wood (a stack of logs 4 feet × 4 feet × 8 feet) could yield 2,700 daily newspapers; 4,300,000 postage stamps; or 7,500,000 toothpicks.
- The average person in the United States uses about 1,600 pounds of wood every year.
- A healthy, mature tree has about 200,000 leaves.



Recyclable stamp using FPL-developed pressure sensitive adhesives.

Facts from http://www.woodmagic.vt.edu/html/Activities/tree2.htm.

FPL Scientist Profile: Chuck Frihart, Research Chemist

Chuck Frihart

By James T. Spartz,
University of Wisconsin–Madison
Graduate Student in Life Sciences Communication

Author's note: Periodically News-Line features an FPL researcher who has made significant contributions in their area of research. In this issue we meet Charles "Chuck" Frihart, a research chemist who has been with the FPL since 2001.

Chuck conducts research on wood adhesives as part of the Performance Enhanced Biopolymers unit. Research in performance enhanced biopolymers focuses on three areas: advanced structures, advanced composites, and nanomaterials. Improving the performance of wood and wood-based structures requires basic and applied research in each of these three highly interdependent areas. It also helps to ensure that newly developed materials and structural components are durable, cost-effective, compatible with other materials, and more easily recycled.

Research projects Chuck has been involved with include developing soy-based adhesives in partnership with other FPL researchers, Heartland Resource Technologies, and Ashland Hercules. The success of this laboratory work, including the issuance of several patents, has led to applications including those for plywood and composite wood products that meet the stringent California Air Resources Board standard on reduced formaldehyde emissions from wood products.

Chuck has also been working with FPL's Jim Beecher, Department of Defense personnel, and an ammunition manufacturer to study gum arabic, a natural product from the tree Acacia senegal, for use as a binder in the manufacture of small and medium caliber ammunition primer pellets. Variations in gum arabic's physical, chemical, and mechanical properties can lead to the misfiring of bullets. The Department of Defense turned to the FPL because of its expertise in carbohydrate chemistry, adhesives, and analysis to solve this ammunition problem.

Chuck received his undergraduate degree in Chemistry from the University of Wisconsin (1969) and his M.S. (1971) and Ph.D. (1973) in Bio-organic Chemistry from the University of Illinois.

Questions:

Hello Chuck, can you tell us about your job as a research chemist and how you came to be at the Forest Products Laboratory?

After completing my PhD, and post-doc work at Columbia University in New York City working on bio-organic chemistry and inorganic chemistry, I went to work in New Jersey for a forest products company called Union Camp. I worked there for 23 years on chemical processes, process improvement, and new product development until the research labs closed when Union Camp was bought out by International Paper. Along the way I learned a lot about polymers and adhesives. After that I got a job for a few years with a different company until they went through a downsizing. At that time, in 2001, a position opened at the Forest Products Lab. I was the project leader in the wood adhesive group until it was merged with two other groups. The merger of adhesives, paints and finishes, and wood modification is now known as Performance Enhanced Biopolymers.

Since I've been at FPL, I've worked in two main areas. One is in fundamental research on understanding why wood adhesives work and don't work, and the other is working with outside companies on soy adhesives. These two projects help one another because without understanding fundamentals you can't work efficiently on an application program. And without having an application program, you don't understand what's important about fundamentals. I enjoy being able to work on both very fundamental and very applied work.

What do you feel have been some of your career highlights so far?

Before I came to the FPL, the most successful project was developing an ink resin for a high-performance line of ink-jet printers. I worked closely with a company making the printers and the printer was basically designed around the ink resin. It was a tree-based ink in that it uses fatty acids that are by-products of pulping. I was working in a group that focused on finding improved processes for using the fatty-acids and rosins. This also led to subsequent programs on associative oligomers for a variety of applications. Since I've been at the FPL, we've reached the point where we have developed models to help explain why wood adhesives work and why they fail. I think we've made significant advancements that help us understand the observations we've made in the soy adhesives program.

Using soy adhesives to decrease dependence on petrochemicals sounds like a very earth-friendly option. How did you come to discover this advancement in soy-adhesive technology?

It's a concept that a number of people have worked on. Heartland [Resource Technologies] and Ashland Hercules have put much effort behind developing it and getting us to the point where we understand what happens when you change process variables. The resources these companies have put in are the main reasons for its success. There are five non-FPL people currently working here on the project as part of a Cooperative Research and Development Agreement. It works, in this case, because the FPL and the outside companies have emphasized cooperation. We have helped the team understand how wood and adhesives need to work together. This program is also being leveraged by grants from the United Soybean Board that Chris Hunt and I have

(continued on pg. 4)

been able to obtain. Having the FPL composites group here to help develop the products provides a great advantage. These companies would have had a difficult time gathering needed information had they been working anyplace else. I'm very big on team efforts and not very big on individual heroics. Jim Wescott, of Heartland Technologies, is a leader who believes in that, too. He believes, like I do, in understanding fundamentals while advancing the application technology.

Regarding another project, can you explain to NewsLine readers what a natural product like gum arabic has to do with ammunition?

For small caliber ammunition, there's a primer cup containing the primer at the end of each cartridge. That's what fires the bullet. So, what's in the primer has to be very explosive. It also has to hold together. The use of gum arabic as a binder started a long time ago. It's a very efficient binder but the military has had problems with misfiring. Military artillery shoot at a very fast rate in very different climates. This creates a potential for misfiring, which is not good when someone is shooting back at you. They came to us because they didn't have people with expertise in binder chemistry. Phase one of the project was to understand the dissimilarities between different gum arabics. So it was more of a characterization and getting better understanding of why gum arabic is an efficient binder. We learned a lot about gum arabic properties. Trees make gum when they're under duress; it's part of the trees' protection mode. The gum arabic from Sudan is generally better than that from other places. In the long term, the military would rather get material from a more stable country and use a more reproducible material. In this program, the FPL's Analytical Chemistry and Microscopy Laboratory, and Jim Beecher in particular, have been close partners.

The Defense Department wants a synthetic material to replace the gum arabic. With a synthetic material you normally have more control and it's easier to characterize. The problem is that it's very hard to do experiments and do testing because the primer is very explosive. So Jim and I created an inert binder formulation. We selected materials to be as close as we could to the explosive material but be of low reactivity so we could make our own pellets and test their friability. In our inert formulation, we saw that gum arabic was a very good binder. Now we have a few other materials which are similar in their ability to hold the pellets together. We had to go from 33 potential materials down to five for the next stage of testing at the manufacturer and only two at the live-explosive stage. So we've gone from a large number of polymers to a limited the number of materials for testing. We're now at the stage where we are selecting materials for testing in a live-explosive situation.

You've had success bridging the gap between research and the practical application of technology. Why does some research get picked up by industry and other seemingly good ideas do not?

Most people don't like the unknown. People in manufacturing would rather stay with the devil they know than the one they don't know, so to speak, because when something goes wrong they have learned by experience how to fix it. What you have to do is understand the motivation of everybody along the product chain. The manufacturing manager is not going to try something different unless he's forced to by management or regulations or by a major problem in doing what he's currently doing. For that manager, profitability of the plant is not as important as getting saleable product out the door. Profitability is hard to measure, given price fluctuations. This I learned earlier in my career from a plant manager in England: If you have a year in which you screw up on a lot of things, but prices are good; you're profitable. In other years you can run everything perfect, but if prices are down; you're unprofitable. So you have a lot of things that are important to the manufacturing manager which don't depend on what the [new] technology is. I've seen plant managers turn down more profitable processes because they're afraid of that unknown.

There has to be a business motivation to incite change. And the research depends on what the deliverables and hurdles are. You have to know the hurdles—and they are not always the same—but you can't ignore the hurdles. With the soy project right now, the biggest thing is that the companies want the best low-cost technology to meet the California Air Resources Board (CARB) reduced-formaldehyde emissions standards. That is the driver; encouraging companies to move away from a well performing, low-cost, but formaldehyde-emitting adhesive to a soy-based adhesive. All this goes back to what the motivations of the customer are. This soy project actually got a boost because one of these companies thought they could get a lock on the market by creating a bio-based product, which also aligned with the CARB standards being developed. So the main driver now is to develop products that will meet those standards.

As a research scientist how do you strike a balance between a technology push and a market pull?

If, say, we're making a better adhesive, our target companies are not necessarily the adhesive companies. The best target is the people who are actually using the adhesives. So sometimes you have to go past your immediate customer and get somebody else to buy into the technology, your customer's customer. A market pull is always better than a technology push. Instead of trying to force something on people, you want to try and create a demand. Your immediate customer may not know that demand exists, but maybe their customers really want new products. For example, if you're trying to sell an adhesive to make particleboard that is more environmentally friendly, and you're in Europe, you go and convince IKEA that this is the best way of making the product. OK, so they say, "This is what I want" and they're going to come back to the manufacturers of the particleboard or the medium density fiberboard and these companies, in turn, will go back to the adhesive company. You've gone past the immediate manufacturer and created a demand for your adhesive.

You work with people both inside the FPL and in outside industry, what is your approach to making those partnerships work?

First, you have to respect and gain the respect of other people. People do things because they trust another person. My whole goal is to get myself replaced. If I can work with good people to help them develop to handle the current programs, then I can free myself up to tackle other challenging

problems. Jim Wescott, with whom I collaborate, takes this approach, too. He and I are very well matched on being able to talk about the business and the technical aspects. We have very different philosophies on some things, but well-matched on the basic drivers of encouraging others to develop to make the most productive team.

You've got to try and understand people. There needs to be trust. We do most chemical reactions and testing once. So you've got to know and trust that they're done right in the development processes. We're supposed to do technical plans but, well, I like the common expression for war which says a battle plan is great until the first shot is fired. That's the way it is in the lab, you can have great plans and then the first experiment kills them because you didn't understand the material or process well enough. So you have to develop plans both for failure and for success.

That's a great approach. Is there anything you'd like to add?

I think a strength the FPL has is that there are a lot of people here with different areas of expertise. We can serve as consultants to each other when working outside of our domain of understanding. The other strength of the FPL is that we can do fundamental and applied research that has a longer time frame than what the universities generally can do. There are a lot of loose ends with any research project and students are generally there to get their degree and get out. So their programs generally can't do things like develop a fundamental understanding of wood adhesives because it's a longer term program. Industry's not going to do it because it doesn't bring an immediate dollar value.

It benefits the FPL to work with outside people, those who are doing the application programs. Teamwork with industry is a good thing. You need to listen carefully to what the outside people say because they often don't clearly know what they need to be successful. The dialog will get you to the problem that the customer really needs solved. That's the thing with working with people; when they have a complaint, it's often not the thing that's really bothering them. You have to really listen, and work together, to solve the real problems.

Decoding Decay Fungi through Genome Sequencing

By Rebecca Wallace, Public Affairs Specialist

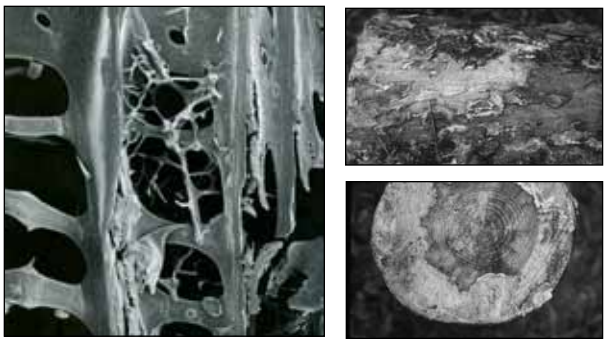
Decay fungi probably seem like fairly simple creatures to most people, their mention conjuring up an image of a mushroom on a fallen log. But we humans are still trying to grasp the complex chemical mechanisms decay fungi use to break down wood, with high hopes of harnessing those mechanisms for bioenergy and biofuels production.

To further our understanding of how decay fungi work, Daniel Cullen, research microbiologist at the Forest Products Laboratory (FPL), has been studying the genetic make-up of several important species. Recently his work on two decay fungi species, *Postia placenta* and *Phlebiopsis gigantea*, has been accepted for large-scale genome sequencing by the Department of Energy (DOE) Joint Genome Institute (JGI).

Postia placenta is a brown rot fungus that is a common inhabitant of forest litter and plays an important role in carbon cycling. FPL research has focused on such brown rot fungi for more than 50 years because they are the principal cause of decay in wood structures. Researchers hope that a better understanding of how these fungi work may lead to the development of effective, yet environmentally sound, wood preservatives. Now, Cullen is studying the decay mechanisms of this particular fungus with bioenergy in mind.

"*Postia placenta* aggressively degrades cellulose and modifies lignin but does not remove it," says Cullen. "The DOE is interested in utilizing lignocellulose for bioenergy and biofuels production, and this fungus is important because it is so effective at breaking down wood into smaller units that can be used to make products like ethanol."

Cullen has also been studying *Phlebiopsos gigantea* along with a large group of cooperators, including Bob Blanchette from the University of Minnesota and Sarah Covert from



***Phlebiopsis* can colonize freshly cut wood. Photo courtesy of Robert A. Blanchette (University of Minnesota).**

the University of Georgia–Athens. When breaking down wood, this white rot fungus degrades cellulose and degrades and removes lignin, but it has also has a unique trait.

"Most wood decay fungi colonize dead and downed logs," says Cullen. "*Phlebiopsos gigantea* is unique because it rapidly colonizes even freshly cut conifer sapwood and degrades the extractives as well as the cellulose and lignin."

This unique ability to colonize freshly cut wood potentially expands the range of types of biomass available for biofuels production.

Cullen's projects are two of 71 new sequencing projects selected to be characterized for bioenergy, climate, and environmental applications by JGI for its 2010 Community Sequencing Program. The program is the largest genomic sequencing effort in the world focused on nonmedical organisms.

Cullen has had five sequencing projects accepted by the JGI since its inception in 2000, including *Phanerochaete chrysosporium*, the first basidiomycete fungus to ever be sequenced.

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